Preliminary Survey of Factors Associated with Promoting Evidence-Based Practice Among Occupational Therapists Working in Convalescent Rehabilitation Wards

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Abstract: In recent years, the concepts of value-based practice (VBP) and shared decision-making (SDM) have become popular as methods of clinical decision-making and consensus-building. Moreover, the underlying decision-making is commonly known as evidence-based practice (EBP). EBP is the necessary knowledge and skills for clinical practice of occupational therapy, but at the same time, the difficulties of EBP have been reported.
Purpose: The purpose of this study was to explore the structure of EBP-promoting factors, including clinical, educational, and research experiences, among occupational therapists.
Methods: A questionnaire survey using a postal method was conducted among 30 occupational therapists working in Japanese convalescent rehabilitation wards.
Results: Factors associated with the implementation of EBP and self-efficacy regarding EBP included the following: (1) experience of learning in graduate school, (2) experience of receiving education on research methods, (3) positive experience with research, (4) experience of working in professional teams, (5) experience as a clinical practice supervisor for students, (6) frequency of database use, (7) outcome expectancy, (8) work environment, (9) intrinsic motivation, and (10) barriers. The number of years of clinical experience of occupational therapists was not associated with the implementation of EBP and self-efficacy regarding EBP.
Conclusions: Research experience, working in professional teams, and being clinical practice supervisors for students and others were more important factors than years of clinical experience to promote the implementation of EBP and self-efficacy regarding EBP among occupational therapists. The structures of these factors interacted with each other.

Keywords: evidence-based practice, evidence, occupational therapist, convalescent rehabilitation wards, survey

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Introduction

Until the early 1990s, medical care was often provided, relying solely on opinion and experience [1]. Medical care that relied solely on opinion and experience often resulted in poor decision-making [2]. In this context, in the mid-1990s, when evidence-based medicine (EBM) became widespread, the rate of treatment without evidence clearly decreased due to the implementation of EBM [3]. In addition, it was reported that physicians' practice and patients' outcomes significantly improved by using various medical guidelines developed by applying EBM methods [4].

"The practice of EBM means integrating individual clinical expertise with the best available external clinical evidence from systematic research." It also means "the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients" [5]. EBM is the process of STEP 1, asking an answerable clinical question based on the health needs of a specific client; STEP 2, finding the best available evidence by searching the literature; STEP 3, critically appraising the literature (check for validity,

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clinical relevance, and applicability); STEP 4, applying the evidence in clinical practice; STEP 5, evaluating STEPS 1−4 [6]. Subsequently, EBM has been widely disseminated throughout health care as evidence-based practice (EBP) since 2000.

However, it has been pointed out that EBP does not provide a specific methodology for STEP 4. Therefore, value-based practice (VBP) was proposed as a concept to develop EBP, focusing on the "value" of clients, their families, and medical professionals [7]. In addition, shared decision-making (SDM) has gained worldwide attention as a method for clinical decision-making and consensus-building against the backdrop of the growing social demand to respect the values of clients in medicine and the trend toward EBP [8].

Thus, in recent years, the concepts of VBP and SDM have become increasingly popular, and the underlying decision-making is commonly known as EBP. EBP is said to help develop the knowledge and skills necessary for the clinical practice of occupational therapy [9]. In addition, the number of occupational therapists who have a positive attitude toward EBP is increasing because advances in information technology have made it easier to access high-quality evidence, and various medical guidelines have become more widely used. However, the implementation of EBP is challenging because it requires a variety of knowledge and skills, such as effective search skills, critical appraisal, understanding of individualization, and skills in understanding the context of clients [10]. If occupational therapists can implement EBP, which is the foundation of decision-making in medicine, it can lead to VBP and SDM, and it can avoid poor decision-making and providing treatments without evidence, which can efficiently and effectively realize meaningful outcomes for clients.

Therefore, to promote EBP among occupational therapists, in recent years, there have been increasing reports that training sessions and workshops have been held mainly in Europe and the United States to improve the knowledge of and skills required for EBP. In addition, scales have been developed to measure the knowledge and skills of occupational therapists regarding EBP as an indicator of the effectiveness of EBP education [11]. This scale is the self-efficacy regarding EBP based on the self-efficacy theory [12]. In our previous study, it was clear that the most important factor in the implementation of EBP was self-efficacy regarding EBP [13].

Therefore, what kinds of clinical, educational, and research experiences are necessary to promote the implementation of EBP and self-efficacy regarding EBP? In addition, how are the factors that promote EBP structured? There are no previous studies that have clarified these research questions. To clarify these research questions, we conducted an empirical survey of occupational therapists working in convalescent rehabilitation wards in Japan. The main survey is a large-scale study using a questionnaire-based postal method. The main survey aims to solve these research questions through multivariate analysis, such as factor analysis and structural equation modeling.

This preliminary study was conducted to exploratively examine the structure of factors that promote EBP, including clinical, educational, and research experiences, to promote EBP among occupational therapists.

Methods

Structure of the questionnaire

The questionnaire consisted of two parts: basic information and questions about EBP.

The basic information included the number of years of clinical experience, sex, and clinical, educational, and research experiences related to EBP facilitators, such as final educational background (graduation from vocational school, university, or graduate school), post-graduate education on EBP methodology, education on research methods, positive experience with research, work experience in professional teams, such as by disease or intervention methods, experience as clinical practice supervisors for students, and frequency of use of academic databases (0: never to 10: often) [14].

First, to develop the EBP questions, we referred to EBP scales whose reliability and validity had been confirmed in previous studies [15]. In addition, factors related to EBP were extracted from previous studies. Next, based on behavioral theories, three researchers examined the structure of the questionnaire, and a total of 42 items consisting of six major categories were created: "Implementation of EBP (Implementation)," "Self-efficacy regarding EBP (Self-efficacy)," "Outcome expectancies for EBP (Outcome expectancies)," "Workplace environment that encourages EBP (Workplace environment)," "Intrinsic motivation for EBP (Motivation)," and "Barriers to EBP (Barriers)." For each question, responses were requested on 10-point scales (0: Strongly Disagree to 9: Strongly Agree).

Survey procedure

In this preliminary survey, we first selected one occupational therapist from each of the three convalescent rehabilitation wards in the Tokyo metropolitan area using the snowball sampling technique, and we asked them to work together as the preliminary survey leader. These three preliminary study leaders were selected on the condition that they belonged to a hospital with an average of ≥ 18 occupational therapists working there.

This selection criterion took into account the staffing of occupational therapists in convalescent rehabilitation wards throughout Japan. Next, the three preliminary survey leaders selected ten occupational therapists each at their hospitals and distributed the explanatory documents and questionnaires. In this way, a total of 30 occupational therapists participated in the present preliminary study.

To determine the sample size, G*Power 3.1.9.2 for Windows was used. We set the effect size at 0.5, the risk ratio at 0.05, and the power at 0.8, resulting in a required sample size of 26 participants. Considering the interruption or withdrawal of the survey, we decided to ask 30 occupational therapists to cooperate in this survey.

The questionnaires were collected by the preliminary survey leaders, and we requested them to be returned in a self-addressed envelope. The implementation period was set at 1 month, from January 22 to February 21, 2020.

Ethical considerations

Consent for this study was obtained from the research participants by answering and returning the questionnaire. This study was conducted in compliance with the ethical guidelines of the World Medical Association (Declaration of Helsinki, 1964 and Declaration of Tokyo 1975, revised 2013). In addition, this study was approved by the Research Ethics Committee for Human Sciences, University of Tsukuba (No. East 2019-76).

Data analysis

First, the median and quartiles were calculated for the response scores to the EBP questions. The item means within each scale were calculated for participants, and the median was calculated as a subscale score.

Next, to provide insight into the research question of "what kinds of clinical, educational, and research experiences are necessary to promote the implementation of EBP and self-efficacy regarding EBP?" the effect of basic information on "Implementation" and "Self-efficacy" score was compared using the Mann−Whitney's U test, and effect size (r) was calculated. In addition, to provide insight into the research question of "how are the factors that promote EBP structured?" Spearman's rank correlation analysis was conducted for correlations between each scale, years of clinical experience, and frequency of use of academic databases.

IBM SPSS for Windows, ver. 26.0 J was used for statistical analysis, and the significance level was set at < 5%.

Table 1 Basic information about participants (n = 29)

Basic information		n (%)
Years of clinical experience	1–5 years	8 (27.6)
	6–10 years	9 (31.0)
	11–15 years	9 (31.0)
	More than 16 years	3 (10.3)
Sex	Male	12 (41.4)
	Female	17 (58.6)
Final educational background	Vocational School or University	21 (72.4)
	Graduate School	8 (27.6)
Experience with post-graduate education on EBP methodology	No	14 (48.3)
	Yes	15 (51.7)
Experience with education on research methods	No	10 (34.5)
	Yes	19 (65.5)
Positive experiences with research	No	9 (31.0)
	Yes	20 (69.0)
Work experience in a professional team, such as by disease or intervention method	No	14 (48.3)
	Yes	15 (51.7)
Experience as clinical practice supervisor for students	No	8 (27.6)
	Yes	21 (72.4)
Frequency of use of academic databases (0: never to 10: often)	0–2 points	3 (10.3)
	3–5 points	6 (20.7)
	6–8 points	15 (51.7)
	9–10 points	5 (17.3)

Results

Responses were obtained from all 30 participants. Of these, 29 (12 males and 17 females, years of clinical experience: median 7.0 years) who answered all the questions were considered valid responses. Basic information about the participants is shown in Table 1.

The response scores for the EBP questions are shown in Table 2. Questions 01−05 included in "Implementation" were all 6.0. Question 06 included in "self-efficacy" had a high score of 7.0, while questions 07 and 10−14 had relatively low scores of 4.5−5.0. Questions 15−21 included in "Outcome expectancy" were all above 6.0. Questions 23−28 and 31 included in "Work environment" had high scores of 7.0, while questions 22 and 30 had relatively low scores of 5.0. Questions 32−36 included in "Motivation" were all above 7.0. Question 38 included in "Barriers" had a high score of 7.0, while question 40 had a low score of 2.0. The highest score for each subscale was 7.4 for "Motivation," followed by 6.6 for "Outcome expectancy," 6.4 for "Implementation," 6.3 for "Workplace environment," 5.3 for "Self-efficacy," and 4.5 for "Barriers."

Table 3 shows the effects of basic information of

Table 2 Response Scores to EBP Questions (n = 29)

	EBP Questions	Median (IQR)
01	I actively make use of the evidence described in clinical practice guidelines (e.g., the guideline for the management of stroke) in clinical practice of occupational therapy.	6.0 (5.0–7.8)
02	I actively make use of the best evidence in clinical practice of occupational therapy.	6.0 (4.3–7.0)
03	I incorporate intervention methods with established evidence in clinical practice of occupational therapy.	6.0 (5.0–7.0)
04	I use academic databases (such as PubMed and the ICHUSHI database) when selecting effective interventional methods for clients.	6.0 (4.0–7.0)
05	I help clients make their own choices and decisions, while taking the evidence into consideration.	6.0 (5.0–7.0)
	Implementation of EBP (Implementation)	**6.4 (4.8–7.0)**
06	I can assess clients' needs, values, and preferences for intervention methods.	7.0 (5.0–8.0)
07	I can integrate the best research findings, my clinical judgment, as well as the client's values and preferences to determine appropriate intervention plans.	5.0 (5.0–7.0)
08	I can pose appropriate questions relating to queries and issues when performing occupational therapy.	6.0 (5.0–7.0)
09	To resolve queries and issues, I can use academic databases (such as PubMed and the ICHUSHI database) to effectively conduct literature searches to obtain research findings on the best intervention methods.	6.0 (4.0–7.0)
10	I can critically appraise the strengths and weaknesses of study methods (e.g., the adequacy of study design, criteria for the study, data collection, and analytical methods etc.).	5.0 (3.0–6.0)
11	I can critically appraise the characteristics (i.e., reliability and validity, sensitivity, specificity, etc.) of standardized assessment scales that are being considered for use in clinical practice.	4.5 (3.0–6.0)
12	I can critically appraise the validity and generalization of study results.	5.0 (3.0–6.0)
13	I can determine whether research findings are applicable to clients.	5.0 (4.0–7.0)
14	Based on the results, I can carry out an ongoing assessment of the impact of intervention plans.	5.0 (4.3–7.0)
	Self-efficacy regarding EBP (Self-efficacy)	**5.3 (4.3–6.4)**
15	I believe the implementation of EBP will improve the effectiveness of occupational therapy.	7.0 (6.0–9.0)
16	I believe that by the implementation of EBP, I can avoid selecting ineffective methods of intervention.	6.0 (4.0–7.0)
17	I believe that the implementation of EBP can support the decisions made by clients.	7.0 (5.0–7.8)
18	I believe that the implementation of EBP will make it easier to develop the trust of clients.	6.5 (5.0–7.0)
19	I believe that the implementation of EBP will improve client satisfaction.	7.0 (6.0–7.0)
20	I believe that the implementation of EBP will allow me to keep up-to-date on occupational therapy assessments and interventions.	7.0 (5.3–8.0)
21	I believe that the implementation of EBP will improve cost-effectiveness.	6.0 (5.0–7.0)
	Outcome expectancy for EBP (Outcome expectancy)	**6.6 (5.3–7.7)**
22	My workplace works and liaises with university teaching staff and researchers to implement and carry out occupational therapy research.	5.0 (2.3–7.0)
23	Senior staff in my workplace have a positive attitude toward EBP.	7.0 (6.0–8.0)
24	In my workplace, there are senior staff and colleagues who ask about research.	7.0 (5.0–8.0)
25	In my workplace, I am expected to implement EBP as part of my role as an occupational therapist.	7.0 (5.0–7.0)
26	My workplace environment is such that I can view academic databases and journals.	7.5 (6.0–9.0)
27	In my workplace, there is a system that supports presentations at scientific meetings and the writing of academic papers related to occupational therapy.	7.5 (7.0–8.8)
28	In my workplace, there is a system for conducting research related to clinical practice of occupational therapy.	7.0 (4.0–7.0)
29	In my workplace, there is a research department and development department, both of which occupational therapists actively participate.	6.0 (2.3–7.0)
30	In my workplace, there is a culture of having opportunities to learn about research and holding study sessions to read and discuss research papers.	5.0 (4.0–7.0)
31	In my workplace, there is a database of clients and a system for accumulating data.	7.0 (4.0–8.0)
	Workplace environment that encourages EBP (Workplace environment)	**6.3 (4.8–7.1)**
32	I wish to implement EBP.	7.0 (7.0–8.8)
33	I wish to learn about EBP.	8.0 (7.0–9.0)
34	I enjoy reading research papers closely related to occupational therapy to investigate whether they could be applied to my clients.	7.0 (5.0–8.0)
35	I think it is very important to implement EBP.	7.0 (6.0–9.0)
36	I think that EBP must be incorporated into occupational therapy.	7.0 (6.0–8.8)
	Intrinsic motivation for EBP (Motivation)	**7.4 (6.0–8.2)**
37	I have no time to incorporate EBP into occupational therapy.	4.5 (2.0–6.0)
38	Ongoing educational costs will be required to implement EBP.	7.0 (4.3–8.0)
39	Experience-based practice is more effective than EBP.	4.0 (3.0–5.0)
40	I do not believe that EBP is worthwhile in occupational therapy.	2.0 (0.0–3.0)
41	I do not have sufficient education and training to implement EBP.	5.0 (4.3–7.0)
42	I believe that EBP puts too much pressure on my role as an occupational therapist.	4.0 (2.0–5.8)
	Barriers to EBP (Barriers)	**4.5 (3.7–5.0)**

IQR: interquartile range
0: SD (Strongly Disagree) – 9: SA (Strongly Agree)

Table 3 Influence of basic information about participants on the implementation of EBP and self-efficacy for EBP (n = 29)

Basic information		n	Implementation of EBP			Self-efficacy for EBP		
			Median (IQR)	*P*-value	ES (r)	Median (IQR)	*P*-value	ES (r)
Sex	Male	12	7.0 (6.4–7.8)	.006	.49	6.3 (5.4–6.8)	.007	.48
	Female	17	5.2 (4.4–6.4)			4.8 (4.1–5.6)		
Final educational background	Vocational School or University	21	5.4 (4.4–6.8)	.003	.52	4.8 (4.1–5.6)	.003	.53
	Graduate School	8	7.3 (6.7–7.7)			6.7 (6.2–6.9)		
Experience with post-graduate education on EBP methodology	No	14	5.2 (3.4–6.8)	.041	.38	5.1 (4.3–5.6)	.07	.34
	Yes	15	6.8 (6.2–7.0)			6.2 (4.8–6.7)		
Experience with education on research methods	No	10	4.8 (2.8–6.0)	.003	.52	4.4 (2.9–5.4)	.004	.51
	Yes	19	6.8 (6.4–7.6)			6.1 (5.1–6.7)		
Positive experiences with research	No	9	5.2 (2.8–6.6)	.022	.42	5.1 (2.9–5.3)	.026	.40
	Yes	20	6.8 (5.5–7.6)			5.9 (4.6–6.7)		
Work experience in a professional team, such as by disease or intervention method	No	14	4.8 (3.4–6.6)	.001	.59	4.6 (3.4–5.6)	.003	.52
	Yes	15	7.0 (6.4–7.8)			6.5 (5.3–6.9)		
Experience as clinical practice supervisor for students	No	8	4.6 (2.8–6.5)	.024	.41	3.8 (2.6–4.8)	.001	.56
	Yes	21	6.8 (5.5–7.6)			5.9 (5.2–6.7)		

IQR: interquartile range
ES: Effect Size, $.10 \leq r < .30$ (Small), $.30 \leq r < .50$ (Medium), $.50 \leq r$ (Large)

the participants on "Implementation" and "Self-efficacy" (r: effect size). As clinical, educational, and research experiences affect both "Implementation" and "Self-efficacy," (1) experience of learning in graduate school, (2) experience of receiving education on research methods, (3) positive experience for research, (4) experience of working in professional teams, such as by disease or intervention methods, and (5) experience as clinical practice supervisor for students all showed significant effects ($p < .05$). In particular, the effect sizes of (1), (2), and (4) were larger depending on the experience ($0.5 \leq r$).

The results of the correlation analysis between years of clinical experience, frequency of database use, and each scale are as follows. There were no significant correlations between the number of years of clinical experience and "Implementation" and "Self-efficacy", but (6) frequency of database use had a significantly high correlation with "Implementation" ($r = .88$, $p < .001$) and "Self-efficacy" ($r = .72$, $p < .001$). Inter-scales correlations showed significant correlations between "Implementation" and "Self-efficacy" and (7) Outcome expectancy, (8) Workplace environment, (9) Motivation, and (10) Barriers ($r = .39$–$.75$, $p < .05$) (r: correlation coefficient).

Discussion

Factors to promote "Implementation of EBP" and "Self-efficacy regarding EBP"

First, responses to the EBP questions were requested on 10-point scales (0−9). A score of 0−2 can be interpreted as "low score," 3−6 as "middle score," and 7−9 as "high score." In each subscale score, "Motivation" was 7.4, while "Self-efficacy" was 5.3, showing a difference of more than two points. This can be interpreted as a state of low confidence in the specific knowledge and skills for EBP, while feeling a desire to implement EBP. The results suggest that there is a gap between the perceptions of "I want to" and "I can." Self-efficacy theory states that "Self-efficacy becomes a primary, explicit explanation for motivation" when "large discrepancies between self-efficacy and ability can create motivational problems for the individual" [12]. In other words, if self-efficacy is low, there is a possibility that "Implementation" and "Motivation" will be reduced. To solve this issue, it is considered necessary to improve confidence in knowledge and skills related to STEPS 3−5 of EBP, such as questions 07 and 10−14 included in "Self-efficacy."

Further, the results of the intergroup comparison and correlation analysis suggest that clinical, educational, and research experiences related to EBP, such as items (1) to (6), and the implementation of EBP-related scales, such as items (7) to (10), are more important fac-

tors in promoting "Implementation" and "Self-efficacy" than years of clinical experience of occupational therapists. These are possible structures that interact with each other. In particular, if we rely on the self-efficacy theory [12], it can be expected that successful experiences in situations that require knowledge about the research, such as (1), (2), and (4), where the effect size was higher depending on the experience, will improve "Self-efficacy" and promote "Implementation."

In the previous study [13], self-efficacy was found to be the factor most associated with the implementation of EBP. The novelty of this study was that it provided specific suggestions on clinical, educational, and research experiences to promote "implementation of EBP" and "self-efficacy regarding EBP" and the structure of EBP-promoting factors.

Limitations and future prospects

Since this preliminary survey was an exploratory study conducted prior to the main survey, we considered the following as limitations of this study: (1) the small number of research participants, (2) the existence of selection bias due to research cooperation by snowball sampling technique and the target area is limited to the Tokyo metropolitan area, (3) insufficient examination of reliability and validity of EBP questions. To solve these limitations, we believe two things are necessary: to conduct a large-sample survey study of occupational therapists who work in convalescent rehabilitation wards throughout Japan and conduct statistical analysis after examining reliability and validity.

In the future, we will consider adding or deleting questions and making additions or revisions based on the results of this preliminary survey. In addition, we plan to organize the content regarding specific clinical, educational, and research experiences to promote EBP among occupational therapists from multiple perspectives and then move on to the main survey. After examining the reliability and validity of the questionnaire items through factor analysis, the main survey will structure the factors that promote EBP and build a practice model to promote EBP among occupational therapists.

Summary and Conclusion

This study was the preliminary survey conducted prior to the main survey with the aim of providing answers to the research questions, "what kinds of clinical, educational, and research experiences are necessary to promote the implementation of EBP and self-efficacy regarding EBP?" and "how are the factors that promote EBP structured?" The participants were 30 occupational therapists working in three convalescent rehabilitation wards in the Tokyo metropolitan area.

As a result of the analysis based on the research questions, the following clinical, educational, and research experiences were identified as factors related to the implementation of EBP and self-efficacy regarding EBP: (1) experience of learning in graduate school, (2) experience of receiving education on research methods, (3) positive experience for research, (4) experience of working in professional teams, such as by disease or intervention methods, (5) experience as clinical practice supervisor for students, and (6) frequency of database use. In addition, the following factors were identified: (7) Outcome expectancy, (8) Workplace environment, (9) Motivation, and (10) Barriers. Experience in research, working in professional teams, and being clinical practice supervisors for students and others were more important factors than years of clinical experience to promote the implementation of EBP and self-efficacy regarding EBP among occupational therapists. The structures of these factors interacted with each other.

Conflict of interest

The first author and co-authors have no conflicts of interest related to this study that should be disclosed.

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■ORIGINAL ARTICLE

Predictors of Occupational Dysfunction in Community-Dwelling Female Older Adults

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Abstract: Background: Occupational dysfunction (OD) can become a major health problem for community-dwelling older adults. OD can be experienced by older adults despite the absence of an apparent medical diagnosis or disability. Therefore, OD may be a new health indicator in the field of preventive medicine.
Objectives: This study investigated possible predictors of OD in community-dwelling older adults.
Methods: Fifty-four participants (aged 63–94) in Japan completed a demographic questionnaire, the Classification and Assessment of Occupational Dysfunction Scale (CAOD), assessments of functional health (Five Times Sit-to-Stand Test, Timed Up & Go, Automatic Thoughts Questionnaire-Revised, and Japan Science and Technology Agency Index of Competence), and responded about their subjective health (self-rated health). Only seven participants were men; therefore, male data were excluded from the analysis. Independent t-test and analysis of multiple regression model was performed to identify the predictors of OD.
Results: The results of the independent samples t-test shows that the OD group correlated to a significant younger age, more negative automatic thoughts, and better social engagement in older women. The results of the multiple regression analysis showed that negative automatic thoughts was a significant predictor of OD among older women.
Conclusion: Negatively evaluating stressful events related to occupational engagement may be associated with OD. It may be useful to assess, maintain, and improve negative automatic thoughts to prevent OD. The results of this study can provide an assessment perspective and intervention strategy focusing on occupations to occupational therapists active in the field of preventive occupational therapy.

Keywords: occupational dysfunction, older adults, community-dwelling, preventive occupational therapy

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Introduction

Several preventive occupational therapy interventions have been reported as beneficial for community-dwelling older adults [1–4]; these are worth noting as the world's population ages rapidly. Occupational dysfunction (OD), which can be experienced despite the absence of an apparent medical diagnosis or disability [5], may be a new health indicator for community-dwelling older adults, who are the primary clients of preventive occupational therapy.

OD was a concept proposed by Kielhofner [6, 7] in the Model of Human Occupation and is defined as a negative experience arising from the inability to engage in daily activities properly. OD may be the result of disturbing dynamic interaction among multiple factors that generate occupational engagement. Teraoka et al. [8] identified the four most common experiences in OD: occupational marginalization, imbalance, alienation, and deprivation. Occupational marginalization is defined as not having the opportunity to engage in desired daily activities, occupational imbalance describes a loss of balance in engagement in daily activities, occupational alienation occurs when individual needs relating to daily

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activities are not satisfied, and occupational deprivation refers to a lack of options in daily activities due to factors outside the individual's control [9].

Teraoka and Kyougoku [10] reported that for healthcare workers with psychological issues such as stress, burnout syndrome, and depression, the reduction of OD might be a target for more effective preventive occupational therapies. In older adults, however, only an association between OD and metabolic syndrome has been reported [11]. To enhance their health through the occupational therapy approach, it is necessary to explore how therapists could help prevent OD or improve the occupational health of older adults.

Since the aging process is one of the important factors affecting occupational engagement [12], we focused on the relationship between OD and the decline of functional health that older adults frequently experience during the aging process [13]. Functional health is operationally defined by the International Classification of Functioning, Disability and Health, known more commonly as ICF, from different functions that constitute health, including body function and body structure, to activities of daily living and participation in society [14]. In addition, although objective health is generally positively associated with subjective health, the association is known to diminish with age [15]. Subjective health refers to how individuals evaluate their own health status [16]. Araújo et al. [16] reported that mental health aspects rather than physical health variables could predict subjective health status in older adults. As noted above, though the subjects were not older adults, it has been shown that OD is associated with psychological problems [10].

Therefore, we predicted that functional and subjective health would affect the development of OD in community-dwelling older adults. In this proposed study, we aimed to examine the hypothesis that functional and subjective health could be predictors of OD in community-dwelling older adults. The results of this study may provide occupational therapists with assessment perspectives and intervention strategies to prevent and improve older adults' OD as a new health outcome.

Materials and Methods

Participants and Recruitment

This cross-sectional study examined the predictors of OD in community-dwelling older adults in Japan. Participants were recruited from two community-based preventive care centers for older adults in Hokkaido, Japan from September to November 2018. Researchers both verbally and on paper invited members of the center to participate in the study, and almost all members agreed to participate. Fifty-four community-dwelling older adults participated in our study; however, only seven participants were men. Therefore, male data were excluded from the analysis. All participants met the following criteria: aged 60 years or older, living independently in the community, and equipped with the requisite cognitive and Japanese language skills to respond to questionnaires without assistance. While participants were completing the questionnaire, two researchers made the rounds to see if they could continue to complete it on their own. A man, who took a significantly longer time compared to the other participants, had difficulty answering on his own and gave up participating in this study. All participants provided oral and written informed consent. The study protocol was approved by the Research Ethics Committee at the authors' affiliated institution.

Measures

The participants completed a demographics questionnaire that recorded data concerning their gender, age, height, and weight. Body mass index (BMI) was calculated based on self-reported weight and height. To identify the predictors of OD in the functional health of community-dwelling older adults, occupational dysfunction, functional assessments, and subjective health were measured. It took about 15 min in total to complete the questionnaires, and about 10 min to perform the functional assessments.

Occupational Dysfunction

The Classification and Assessment of Occupational Dysfunction Scale (CAOD), a self-reported questionnaire, was used to assess OD status. This assessment comprises four items for each of the following four domains of OD: occupational imbalance, deprivation, alienation, and marginalization [17, 18]. All 16 items are scored on a 7–point Likert scale, with 1 representing *not at all* and 7 representing *all the time*. The CAOD has been tested for reliability and validity in terms of item characteristics, structural validity and internal consistency with university students, healthcare professionals, community-dwelling older adults, people with mental disabilities, and people with physical disabilities [19]. The scale's Cronbach's alpha was .902 in the previous study, indicating acceptable internal consistency [18]. The cutoff score was set at 52, where a score of more than 52 reflects a greater risk of OD and a more likely occurrence of physical and mental disorder [19]. The higher the CAOD score is, the greater the risk of OD appearance. However, classification into healthy and clinical groups on the basis of a single value, has the disadvantage of the possibility of false positives and

false negatives [20, 21]. The cutoff value could not estimate the various conditions of the clients and to take detailed approaches according to the severity of OD [22]. A statistical model that overcomes these problems is the Latent Rank Theory [23], which is theory for step-by-step and sequential evaluation of abilities [24]. CAOD used the latent rank theory to estimate the severity of OD [22]: rank 1, healthy group; rank 2, preliminary group that appears to have difficulties in daily life; rank 3, mild group; rank 4, moderate group; rank 5, severe group.

Functional Assessments

Physical functions were assessed with the Five Times Sit-to-Stand Test (FTSST) and Timed Up & Go (TUG). The FTSST was used to assess functional lower extremity strength, transitional movements, balance, and the risk of falling. In this assessment, participants are asked to stand up straight and sit back down as quickly as possible, five times in a row, without resting in between. TUG is a measure for evaluating balance and fall risk. In this timed activity, participants are asked to stand up from a chair and move as quickly as possible through a 3-meter path, walk back, and return to a sitting position with their back resting on the back of the chair. FTSST and TUG were measured visually by inspectors using a digital stopwatch. The time (seconds) needed to accomplish these tests was recorded. Participants with poor performance on these tests have a significantly higher risk of developing disability than participants who had better lower extremity functioning. The FTSST and TUG are reliable and valid clinical tools [25]. For falling risk, cutoff points of 12 to 15 seconds for the FTSST and 14 to 15 seconds for the TUG have been suggested [25].

Psychological function was assessed using the Automatic Thoughts Questionnaire-Revised (ATQ-R). This questionnaire assesses the frequency of automatic positive (10 items) and negative (30 items) statements about oneself [26]. According to Beck [27]'s cognitive theory for depression, negative automatic thoughts could result in depression. ATQ has been clarified to differentiate dysphoric and nondysphoric in both clinical and non-clinical clients [28, 29]. Therefore, we adopted ATQ-R, which could also assess the psychological status before depression, instead of Center for Epidemiologic Studies Depression Scale, which was used in a previous study [10]. The 40 items are scored on a 4–point Likert scale simplified for older adults, where 1 represents *not at all* and 4 represents *all the time*. The total scores of positive and negative automatic thoughts are 120 and 40, respectively. Higher scores reflect a greater number of positive and negative automatic thoughts. The Japanese version's reliability and validity have been verified [30, 31]. The Cronbach's alpha was 0.969 [31].

The Japan Science and Technology Agency Index of Competence (JST-IC) [32, 33] was used to assess the functional capacity of participants in their activities and participation. The JST-IC is an instrument that can measure the competence of older adults living alone, not only to live independently in the community, but also to live more actively in accordance with modern lifestyles. The instrument includes four domains: technology usage, information practice, life management, and social engagement, with each domain consisting of four items. The 16 items are scored on a binary scale with 1 representing *Yes* and 0 representing *No*. The total score is 16 points. The higher the score, the higher the activity competence of each area and the more active the community life. Using data from community-dwelling older adults, the reliability coefficients (alpha coefficient) for all 16 items was $\alpha = .86$, and the reproducibility of the 4-factor structure (cross validity) and its association with other important endpoints (criterion-related validity) were high.

Subjective Health

Subjective health was measured through self-rated health score constructed from a single item asking "How do you feel about your health condition?" Response options included *very good* (1), *good* (2), *fair* (3), *poor* (4), and *very poor* (5). A higher score represents lower self-rated health status. This index is a simple five-point scale that can be easily answered by older adults [34]. It is also used in the "Basic Survey of Living Conditions of the People" by the Ministry of Health, Labour and Welfare of Japan [35].

Data Analysis

We used descriptive statistics, including means and standard deviations, for each demographic and outcome variable. Participants were divided into healthy group (rank 1) and OD group (ranks 2–5) according to the estimating latent rank of OD conducted by software Exametrika Ver 5.5 [36]. The independent samples t-test was used to identify if variables differed according to the ranks of CAOD. A multiple regression model was also created with the CAOD total value as dependent variables, and the variables that were significantly different by group comparison as independent variables, using a forced entry method. All statistical analyses were performed using SPSS Statistics 26.0 (IBM SPSS Inc., Chicago, IL, USA).

Table 1 The comparison of each variable between rank groups.

Variable	Healthy group (N = 35)	OD group (N = 12)	Statistics	
	Mean (SD)	Mean (SD)	t value	P value
Demographic variables				
Age (years)	78.200 (6.135)	73.250 (7.187)	2.309	0.026*
BMI (kg/m^2)	22.720 (2.726)	23.153 (3.140)	−0.457	0.650
Functional assessments				
FTSST (sec)	7.568 (1.532)	7.108 (1.601)	0.887	0.380
TUG (sec)	6.007 (1.241)	5.623 (0.924)	0.980	0.332
Automatic thoughts				
Positive automatic thoughts	22.657 (7.207)	21.667 (6.228)	0.424	0.673
Negative automatic thoughts	41.200 (10.726)	49.583 (14.438)	−2.134	0.038*
JST-IC				
Technology usage	3.057 (1.235)	3.500 (0.905)	−1.138	0.261
Information practice	3.343 (1.027)	3.250 (0.866)	0.280	0.781
Life management	3.057 (1.211)	3.250 (1.422)	−0.455	0.651
Social engagement	1.857 (1.556)	3.000 (1.348)	−2.266	0.028*
Total score	11.314 (3.169)	13.000 (3.516)	−1.547	0.129
Subjective health				
Self-rated health	2.486 (0.818)	2.917 (0.900)	−1.536	0.132

BMI: Body Mass Index; FTSST: Five Times Sit-to-Stand Test; TUG: Timed Up & Go; JST-IC: Japan Science and Technology Agency Index of Competence.
*P < 0.05.

Table 2 Factors affecting OD for community-dwelling women (N = 47).

	Partial regression coefficient	Standardized partial regression coefficient (β)	Significance (P)	95% confidence interval	
				Lower endpoint	Upper endpoint
Intercept	37.675		0.177	−17.687	93.037
Age	−0.496	−0.199	0.114	−1.116	0.124
Negative automatic thoughts	0.755	0.550	< 0.001	0.425	1.085
Social engagement	1.289	0.121	0.308	−1.230	3.807

Adjusted R^2 = 0.407.
Standardized error of the estimate = 12.875.
OD: Occupational dysfunction.

Results

The participants were 47 community-dwelling women whose ages ranged from 63 to 94 years. The average ages were 78.20 ± 6.14 years in the healthy group and 73.25 ± 7.19 years in the OD group. CAOD scores ranged from 16 to 92, and twelve participants (25.5%) were estimated into OD group (Four people were included in Rank 2 and 3 each, one in Rank 4, and three in Rank 5), which showed higher risk of OD. Participants in both groups had the functional capacity to perform more than 70% of the 16 performance indicators set by the JST-IC for living actively in the community. The results of the independent samples t-test shows that the OD group showed a significant younger age (t = 2.309, P = 0.026), more negative automatic thoughts (t = −2.134, P = 0.038), and better social engagement of JST-IC (t = −2.266, P = 0.028). No significant difference was observed for any other variable. Table 1 summarizes the results of the comparison of each variable between groups.

Table 2 presents the results of the multiple regression analysis of OD. Negative automatic thoughts was identified as a significant variable (t = 4.614, P < 0.001, 95% confidence interval (CI) [0.425, 1.085]). Age and social engagement were not significant variables (t = −1.615, P = 0.114, 95% CI [−1.116, 0.124], t = 1.032, P = 0.308, 95% CI [−1.230, 3.807], respectively). Overall, this model accounted for 40.7% of the variance.

Discussion

This study investigated factors associated with OD in community-dwelling older women using the analysis of multiple regression model. Negative automatic thoughts was identified as a significant predictors of OD.

Although the age and social engagement were significantly younger and better in OD group, they were not significant predictors of OD. The analysis suggested that OD among community-dwelling older women might be prevented by decreasing negative automatic thoughts.

Negative automatic thoughts were identified as a predictor of OD. Automatic thoughts were first studied as a type of cognitive bias that bolsters cognitive distortions [27], and the concept has positive and negative aspects. While no previous study has directly demonstrated the relationship between automatic thoughts and OD to support our results, there is evidence that automatic thoughts and OD are both associated with depression. For example, Kwon and Oei [37] reported that changes in automatic thoughts led to changes in depressive symptoms. Likewise, OD factors have been demonstrated to significantly contribute to depression [10]. In our results, we first demonstrated that negative thoughts predicted OD. Beck [27] also noted that negatively evaluating stressful events (a pattern of thought) resulted in depression, as opposed to it being an inherent negative side effect of the event itself. Combining these two results, we expected to find a relationship in which negative thoughts influenced an individual's daily occupations, causing OD in older adults, and further leading to depressive symptoms. However, whether there are other factors influencing this result or other paths leading to the observed results should be verified in future studies. Furthermore, the participants included in this analysis were women. Previous studies have found that a decrease in depression and anxiety could be linked to a decrease in negative thoughts, rather than an increase in positive thoughts [38]. Concerning the gender difference, it has been reported that there is a higher prevalence of anxiety disorders and depression in women than men [39, 40]. This well-known gender difference continues into old age. A review analyzed 85 studies found substantial support for the same gender differences in depression in individuals under 60 years of age [41]. Thus, negative thoughts might be more frequent among women than among men, and compared with men, community-dwelling older women might have higher risk experiencing OD. Therefore, to prevent or improve OD status, and further prevent depression for community-dwelling older women, approaches on negative automatic thoughts might be effective.

According to the t-test, the OD group showed younger age compared to healthy group. This result is consistent with the following previous study. Miyake et al. [11] reported that in community-dwelling Japanese adults (mean age 70.6 ± 9.4 years), the group with the highest CAOD scores (≥ 31) had significantly lower age than the other groups (CAOD scores of 16–19 or 20–30). However, the results of multiple regression analysis in this study showed that age was not a significant predictor of OD. Among older people, age may affect OD differently for younger- and older-older adults.

The participants' ages in this study ranged from 63 to 94 years (Mean 76.94 ± 6.70). Despite reduced functional capacity and increased psychological distress, people older than 80 years have been found to exhibit less pessimistic self-rated health, especially when compared with younger-older people [42]. In addition, Araújo et al. [16] reported the impact of downward social comparisons on self-rated health. According to the study, by comparing themselves to their peers who are in poor health, older adults seem to be able to maintain positive self-rated health. The older they get, the more likely they are to interact with people their own age who are in poorer health, which is considered an important and common mechanism for older adults to evaluate their own health [43]. Similarly, OD may be less likely to occur as people age because they are more likely to meet peers with poorer OD conditions. Moreover, for younger-older adults who are just beginning to experience functional decline, they may expect higher occupational performance. As a result, younger-older adults might assess the aging process more pessimistically and experience OD. We believe that future studies would need to investigate the impact of age on OD, distinguishing between younger- and older-older adults.

Another variable "social engagement" among the subcategories of JST-IC showed significant difference between healthy group and OD group, and the OD group showed higher score, which means better social engagement. However, social engagement was not identified as a significant predictor of OD.

"Social engagement" of the JST-IC asked about participation in four types of social activities, such as local festivals, events, and volunteer activities. The OD group had better social engagement. In other words, women of the OD group are engaging in more social activities than the healthy group. However, the OD group had higher risk of experiencing OD, which presented a possibility that those social activities might be too many or compelling for them. Having social activities to engage in is expected to improve participants' OD in terms of occupational deprivation and alienation. In contrast, if the number of social engagements measured by JST-IC increases and it is felt to be too much for the individual, it may cause occupational imbalance of OD. It is important to have an optimal occupational balance for the individuals, not simply to have more activities to engage in [44, 45]. In addition, the individuals may experience occupational marginalization of OD if they feel compelled to participate in the activity, unrecognized

during the activity, or neglected by others [46]. For this reason, there is a need for a more careful assessment of the individual's perception regarding social engagements. The following four most common experiences in OD often occur simultaneously and they interact to constitute the problem of OD: occupational marginalization, imbalance, alienation, and deprivation [47]. In future research, it may be useful to explore which of the four are the most likely occupational dysfunctions among community dwellers.

Finally, the results showed that our female participants had higher daily competence, based on instrumental activities of daily living measured by the JST-IC [33]. Compared with the participants in the national-level survey using the JST-IC [32], our participants were a group of community-dwelling high-functioning older adults who had few difficulties in daily occupational performance. Nevertheless, it is worth noting that some participants did experience OD. The results of this study suggest that OD among community-dwelling older women might be prevented by decreasing negative automatic thoughts. In order for occupational therapists to focus on occupational dysfunction in older women in the area of care prevention and to provide occupation-based support, assessment of their negative automatic thoughts and approaches to them may be useful.

Limitations

Our study has several limitations. First, the number of male participants in the sample was small, and we had to exclude their data from the analysis. We recruited participants from two community-based aging centers in a district of Japan, but only seven male participants attended. Milligan et al. [48] reported that older men generally have poorer health-seeking behaviors than women and are often more reluctant to engage in generic social activities. Our results might highlight a challenge in developing acceptable health-promoting interventions for older men in the community, based on their distinct characteristics. Different recruitment strategies may also need to be implemented.

Second, participants in the study had comparatively higher functioning in daily life than expected. This study's results might be referenced for other older adults who have similar higher daily functioning as our participants. However, there are a large number of older adults who experience inactivity and might be more vulnerable to OD. Future studies should target older adults with lower daily physical activity and/or lower daily competence to clarify the predictors of OD.

Third, this study explored potential predictors of OD by focusing on functional health and subjective health as measured by subjective questionnaires, with the exception of FTSST and TUG, which partially measure physical functions. Factors such as medical conditions that are objectively assessed in determining the status of older adults' health might be also associated with OD. In addition, factors that commonly cause health disparities, such as financial burdens, environmental hardship, and access to health care, may also be associated with OD in older adults.

Fourth, the results of this study showed that negative automatic thoughts was a significant predictor in older women. Strong negative automatic thoughts may suggest an association not only with pre-depressive states but also with depressive symptoms themselves [27]. In future studies, it may be beneficial to consider using an assessment tool that can assess depressive symptoms themselves. In the field of preventive occupational therapy, OD as a new health indicator is just beginning to be explored. Further investigations are necessary into the relationship between diversified health and OD among community-dwelling older adults.

Last, CAOD total score was used in this study for analysis. However, the four most common experiences of OD (occupational marginalization, imbalance, alienation, and deprivation) might be characteristic for specific groups. Future studies would be necessary to explore which experience is the most likely to occur in community-dwelling older adults, to better prevent or improve their OD.

Conclusions

To explore the predictors of OD in community-dwelling older adults, an investigation focusing on functional and subjective health was conducted. Negative automatic thoughts was a significant predictor in older women. This was the first study to determine predictors of OD in community-dwelling female older adults. In addition, this is a noteworthy result, even for older adults who appear to maintain a high degree of activity. Age, physical functions, as measured by FTSST and TUG, and activity and participation, as measured by JST-IC, were not significant factors. In contrast, the psychological factor of negative automatic thoughts was identified as significant. Negatively evaluating stressful events related to an occupation may cause OD. In order to prevent OD in community-dwelling older women, it may be useful to evaluate, maintain, and improve negative automatic thoughts to prevent OD. The results of this study can provide an assessment perspective and intervention strategy focusing on occupations to occupational therapists active in the field of preventive occupational therapy.

Conflict of Interests

The authors declare that there is no conflict of interest.

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Trail Making Test-Japanese Edition (TMT-J) Scores in Early Stages of Mild Ischemic Stroke

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Abstract: Background: The Trail Making Test (TMT) is widely used as a measure of attention and executive functions. The time needed to complete TMT (TMT score) is prolonged in the presence of attention and executive dysfunction in patients with brain diseases. Thus far, there have been few reports examining the TMT score in the early stages of mild ischemic stroke.
Methods: We evaluated the TMT-Japanese edition (TMT-J) score 8–14 days after onset in patients with mild ischemic stroke. When the TMT-J Part A or Part B score was high, re-evaluation was performed 29–35 days after onset.
Results: In a total of 54 patients, 1 and 4 patients could not complete TMT-J Part A and Part B, respectively. The average Part A and Part B scores were 65 and 119 seconds, respectively. Part A and Part B scores were higher than one standard deviation above the age-specific average scores in 51 and 47% of patients, respectively. In these patients, Part A and Part B scores improved in 81 and 69% of the patients on re-evaluation, respectively.
Conclusions: This study demonstrated that a significant proportion of mild ischemic stroke patients exhibited a high TMT-J score 8–14 days after onset, and scores improved over time in the majority of patients.

Keywords: attention, executive function, mild ischemic stroke, Trail Making Test-Japanese edition (TMT-J)

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1. Introduction

The Trail Making Test (TMT) is widely used as an evaluation scale for attention and executive functions [1–9]. Attention and executive dysfunction are typically associated with frontal lobe impairment [2]. However, the time needed to complete TMT (TMT score) is prolonged in association with involvement of not only the frontal lobe, but also various brain regions including the temporal lobe, insular cortex, caudate, globus pallidus, posterior parietal lobe, occipital cortex, cerebellum [3], and brainstem [4]. In a clinical setting, TMT for brain disease patients has been used to identify unsafe drivers. Previous studies reported that brain disease patients showing a TMT-B score > 147 seconds [5] or 180 seconds [6] were considered unsafe drivers.

In previous studies of stroke patients, Barker-Collo et al. examined the TMT score within 4 weeks after the onset of ischemic stroke, 6 weeks after the onset, and 6 months after the onset, and reported that the TMT-B, but not TMT-A score improved over time [2]. Wolf et al. reported that in patients with mild stroke, there was no significant change in the TMT score within 3 weeks after discharge and 6 months after onset [7].

There have been few reports examining TMT scores in the early stages of ischemic stroke [8, 9]. In patients with mild ischemic stroke, however, an early evaluation of TMT is required because they are often discharged early and hope to return to a life similar to the previous one. A previous study demonstrated that 40% of patients with acute lacunar stroke showed abnormal TMT Part A scores (> 60 seconds) between days 2 and 7 of their

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Table 1 The average score and standard deviation (SD) by age group in TMT-Japanese edition (TMT-J) [1].

Age group	Part A		Part B	
	Average score (seconds)	Standard deviation	Average score (seconds)	Standard deviation
40s	30.3	7.5	49.0	11.9
50s	33.7	6.2	60.4	14.0
60s	34.9	7.2	62.6	12.7
70s	46.5	10.5	88.8	24.7
80s	51.1	9.2	103.8	24.3

stay in the stroke unit [8]. Nevertheless, whether these abnormal scores improve later remains unclear, and this study did not investigate the Part B score.

Prior to 2019, Japan had neither standardized inspection sheets nor evaluation methods for TMT. However, the TMT-Japanese edition (TMT-J) [1] was published in 2019, after the publication of our previous study [9]. TMT-J adopts vertical inspection sheets and includes the average score and standard deviation (SD) by age group (Table 1). The present study was aimed to investigate the TMT-J score and its serial changes in the early stages of mild ischemic stroke.

2. Methods

Between January 2019 and August 2020, 319 patients were admitted to the Department of Neurology within 14 days after the onset of ischemic stroke and were evaluated in the Department of Rehabilitation. We evaluated TMT-J and Hasegawa Dementia Scale-Revised (HDS-R) scores 8–14 days after onset in patients who met all 3 of the following criteria: (1) Aged 20–89, (2) National Institutes of Health Stroke Scale (NIHSS) score of 7 points or less, (3) Diffusion-weighted brain MRI showing acute ischemic stroke.

Re-evaluation of both Part A and Part B was performed 29–35 days after onset when the initial TMT-J Part A or Part B score was high (higher than 1 SD above the age-specific average scores). Because we investigated the patients in this study as a regular medical examination, re-evaluation was not done when the initial TMT-J Part A or Part B score was not high.

Patients with any of the following 3 criteria were excluded: (1) A history of brain disease, (2) Showing progression, recurrence, or complications of ischemic stroke after admission, (3) Receiving carotid endarterectomy, carotid stent placement, or percutaneous carotid artery vasodilation before evaluation of TMT-J, (4) Showing aphasia or hemispatial neglect.

The classification of ischemic stroke was based on the clinical categories of ischemic stroke described in the report from the National Institute of Neurological Disorders and Stroke [10]. In patients whose NIHSS score was not described in the medical records, NIHSS was evaluated retrospectively based on the description in the medical records [11]. With this evaluation method [11], it is possible to calculate a score close to what would have been the original NIHSS score.

TMT-J is usually performed by the dominant hand. However, when the dominant hand is affected by paralysis or ataxia associated with stroke, any associated writing disturbance may incidentally increase the TMT-J score. Therefore, when an evaluator judged that there was paralysis or ataxia of the dominant hand that would affect the TMT-J score, patients were asked to use their non-dominant hand. In a previous study [12], there was no clear difference in the Part A score between dominant and non-dominant hands, but the Part B score increased by about 5 seconds when using the non-dominant hand.

In the present study, we judged the result of Part A or Part B as “not completed” when the patients could not complete Part A within 180 seconds or Part B within 300 seconds. If a patient could not complete Part A, the more difficult Part B was not evaluated in this patient.

Comparisons of median values of initial and second Part A scores were made using the Wilcoxon signed-rank test, as the second Part A scores did not show a normal distribution. The average values of initial and second Part B scores were compared using the paired-samples t-test. A value of $P < 0.05$ was regarded as significant. Statistical analyses were conducted using Dr. SPSS II for Windows 11.0.1J. This study was approved by an ethics committee of a hospital.

3. Results

The patient selection and exclusion criteria are shown in Fig. 1, and the clinical information of the 54 patients is shown in Table 2. The average age of the 54 patients was 70.4 years. Clinical classifications of ischemic stroke were: 23 cases of lacunar infarction, 14 of atherothrombotic infarction, 6 of cardiogenic embolism, and 11 of other infarctions. Out of the 54 patients, 39 were discharged from the acute ward to their homes, 13 were transferred from the acute ward to our rehabilitation ward, and 2 were transferred to another hospital from the acute ward. The average length of hospitalization of patients who were discharged home from the acute ward was 13.8 days.

In 20 out of the 54 patients, the NIHSS score at admission was not described in the medical records, and so it was determined retrospectively based on descriptions in the records [11]. In 7 out of the 54 patients, TMT-J was performed with their non-dominant hand. The

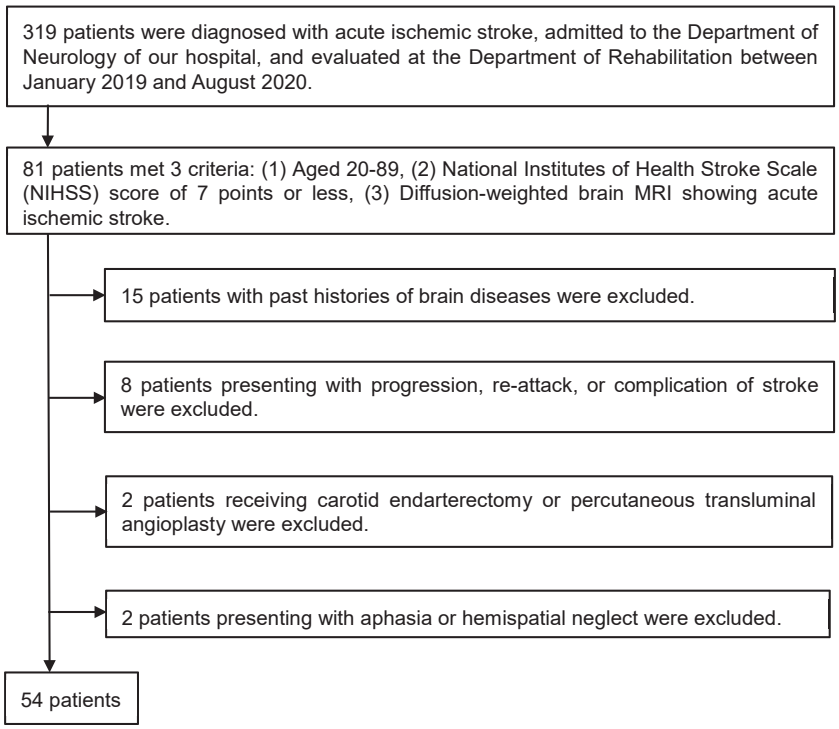

Fig. 1. Tree diagram showing inclusion and exclusion of patients.

HDS-R scores were 21 or higher (not abnormally low) except for in 1 patient (patient 47).

In 32 out of the 54 patients, the Part A or Part B score was higher than 1 SD above the age-specific average, and re-evaluation was performed 29–35 days after onset. In 19 out of these 32 patients, the second evaluation was performed after discharge, and it was conducted in the remaining 13 during hospitalization.

Analysis of the 54 patients

In one out of the 54 patients, Part A could not be completed (patient 47). This patient was also unable to complete Part A on re-examination. In 4 out of the 54 patients, Part B could not be completed (patients 6, 14, 38, and 42). Among these 4 patients, 2 were able to complete Part B on re-evaluation (patients 6 and 38).

Excluding 1 patient who could not complete Part A, the average score for Part A of 53 patients was 65 seconds, and Part A scores were high (higher than 1 SD above the age-specific average scores) in 27 of the 53 patients (51%).

Excluding 1 patient who was not examined with Part B (patient 47) and 4 patients who could not complete Part B, the average score for Part B of 49 patients was 119 seconds, and Part B scores were high in 23 of the 49 patients (47%).

In 31 patients with both initial and second Part A scores, the median Part A scores on initial and second evaluations were 74 and 56 seconds (Table 2), respectively. This change was significant (Fig. 2). In these 31 patients, 25 (81%) showed improvement in the Part A score.

In 26 patients with both initial and second Part B scores, the average Part B scores on initial and second evaluations were 155 and 130 seconds, respectively (Table 2). This change was significant (Fig. 3). In these 26 patients, 18 (69%) showed improvement in the Part B score.

4. Discussion

Thus far, there have been few reports examining the TMT score in the early stages of mild ischemic stroke [8, 9]. One may consider that in patients with ischemic stroke, TMT should be performed in the chronic stage when symptoms are completely fixed. However, patients with mild ischemic stroke are often discharged early and hope to return to a life similar to the previous one. Therefore, we believe that an early evaluation of TMT for mild stroke patients has a certain value.

The present study showed that TMT-J scores were high in a significant proportion of patients in early stages of mild ischemic stroke. Although the lesion location of ischemic stroke varied among the patients, the stroke might have impaired the attention and executive functions that are required for the performance of TMT-J. In-

Table 2 Clinical information on the 54 patients.

Case, Sex, Age (years)	Clinical category	Lesion location	NIHSS	HDS-R	TMT-J			
					Part A (seconds)		Part B (seconds)	
					1st	2nd	1st	2nd
1*, M, 79	OI	Lt FL	1	26	76	63	215	176
2, M, 83	ATI	Lt FL, Lt TL, Lt OL, Lt CR	3 (R)	21	57	NE	93	NE
3, M, 73	LI	Lt Pu	3	24	34	NE	104	NE
4*, F, 69	LI	Lt Pu, Lt CR	3	27	64	61	237	109
5, F, 84	OI	Lt Pu, Lt CR	3	26	67	71	244	178
6*, M, 80	LI	Lt Pu, Lt IC	3	27	159	117	NC	164
7, F, 49	LI	Lt Th	1 (R)	30	33	NE	54	NE
8, M, 70	LI	Lt IC	3 (R)	29	24	NE	67	NE
9, M, 53	LI	Lt IC, Lt Th	2	24	23	38	120	135
10*, F, 70	ATI	Rt FL	1 (R)	24	89	48	179	98
11, M, 72	ATI	Rt FL	3	29	53	NE	74	NE
12*, M, 78	OI	Rt FL	1	27	68	50	82	64
13, M, 78	OI	Rt FL	0 (R)	27	47	NE	88	NE
14, M, 81	CEI	Rt FL	0	23	98	132	NC	NC
15, M, 69	ATI	Rt FL, Rt TL	1 (R)	29	33	NE	50	NE
16*, F, 83	ATI	Rt FL, Rt PL	0 (R)	26	64	53	190	162
17, F, 74	ATI	Rt FL, Rt TL, Rt OL	0 (R)	29	44	NE	73	NE
18, M, 51	ATI	Rt FL, Rt TL, Rt OL	1 (R)	29	32	NE	53	NE
19*, M, 67	OI	Rt FL, Rt PL, Rt OL	2	30	33	23	87	62
20*, M, 74	CEI	Rt FL, Rt PL, Rt OL	3	28	93	58	164	168
21*, F, 71	ATI	Rt TL, Rt PL, Rt OL	4	24	74	59	139	182
22, M, 74	CEI	Rt OL	1	28	49	NE	79	NE
23, M, 56	LI	Rt Pu, Rt CR	3	29	37	44	80	71
24, M, 80	ATI	Rt Pu, Rt GP	3	25	47	NE	112	NE
25, M, 60	OI	Rt Pu, Rt CR, Rt GP	0	29	36	NE	67	NE
26, F, 87	LI	Rt Pu, Rt CR, Rt IC	2 (R)	28	50	NE	114	NE
27, M, 72	LI	Rt Pu, Rt CR	3	24	108	36	156	155
28, M, 73	LI	Rt GP, Rt IC	3 (R)	30	41	NE	59	NE
29, F, 66	LI	Rt CR	4	29	49	56	85	69
30, M, 73	ATI	Rt CR	1 (R)	30	37	NE	43	NE
31, M, 81	LI	Rt CR	1 (R)	30	58	NE	67	NE
32*, M, 58	LI	Rt IC	3	28	44	27	51	117
33*, F, 54	LI	Rt Th	2 (R)	30	46	27	59	44
34, F, 82	LI	Rt Th	2	27	135	102	227	167
35*, M, 72	CEI	Bi FL	1	23	91	58	175	175
36, F, 80	ATI	Rt FL, Rt TL, Rt PL, Lt CN	6	21	150	134	246	257
37*, F, 51	OI	Bi FL, Bi OL, Bi Ce	3	30	74	35	110	41
38, M, 83	CEI	Lt Mi, Lt Ce	0	27	104	95	NC	190
39, M, 57	LI	Rt Mi	1	30	27	NE	34	NE
40*, M, 70	ATI	Rt Mi, Rt Po	1 (R)	28	57	NE	73	NE
41, F, 49	OI	Lt Ce	0 (R)	30	26	NE	57	NE
42*, M, 76	OI	Bi Ce	5	21	125	68	NC	NC
43, M, 74	LI	Lt Po	2	24	81	62	138	153
44*, F, 81	LI	Lt Po	4	21	98	54	300	NC
45*, F, 77	ATI	Lt Po	0 (R)	27	72	40	251	209
46, F, 68	LI	Rt Po	4	30	56	42	98	97
47, M, 81	OI	Rt Po	5	19	NC	NC	NE	NE
48*, M, 82	CEI	Rt Po	2 (R)	29	77	53	96	94
49, M, 84	LI	Rt Po	5	26	66	114	222	164
50, M, 61	OI	Rt Po, Rt Me	5 (R)	27	172	82	267	114
51, F, 51	LI	Lt Me	1 (R)	30	25	NE	48	NE
52, F, 53	LI	Lt Me	0	30	34	NE	45	NE
53, M, 67	LI	Lt Me	4	27	42	NE	74	NE
54*, M, 62	ATI	Rt Me	2	23	41	33	103	105
Average score				27	82	62	155	130
Standard deviation				3	36	30	66	53
Median score				27	74	56	148	126
Maximum score				30	172	134	267	257
Minimum score				19	23	23	51	41

ATI: atherothrombotic infarction, Bi: bilateral, CC: corpus callosum, Ce: cerebellum, CEI: cardioembolic infarction, CN: caudate nucleus, CS: central semiovale, CR: corona radiata, F: female, FL: frontal lobe, GP: globus pallidus, IC: internal capsule, LI: lacunar infarction, Lt: left, M: male, Me: medulla oblongata, Mi: midbrain, NC: not completed, NE: not evaluated, OI: other infarction, OL: occipital lobe, Po: pons, PL: parietal lobe, Pu: putamen, R: retrospective NIHSS score, Rt: right, Th: thalamus. TL: temporal lobe, Patients who were reevaluated after discharge are indicated with an asterisk. Patients evaluated with the non-dominant hand are underlined. TMT-J scores higher than 1 SD above age-specific average scores are underlined. Average, median, maximum, and minimum Part A scores in this table were calculated from data of 31 patients for whom an initial and second evaluations could be performed. Similarly, average, median, maximum, and minimum Part B scores in this table were calculated from data of 26 patients for whom an initial and second evaluations could be performed.

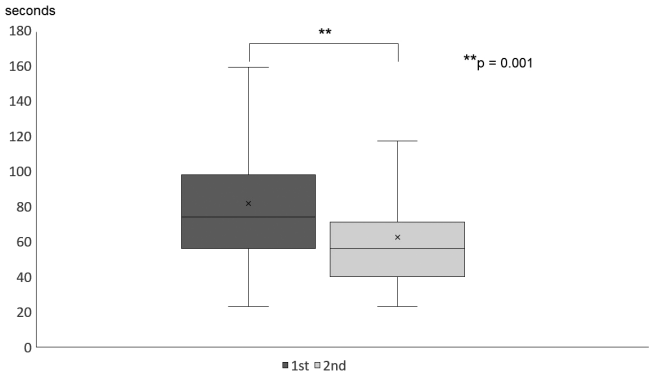

Fig. 2. Serial changes in TMT-J Part A scores.

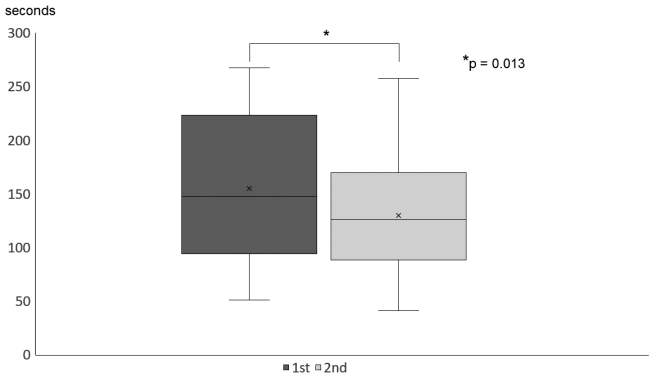

Fig. 3. Serial changes in TMT-J Part B scores.

terestingly, all 7 patients with isolated pontine infarction (patients 43–49) showed high Part A or Part B scores on initial evaluation. Patients with pontine infarction may be likely to show high TMT-J scores in the early stages even if the stroke itself was mild.

In patients showing high TMT-J scores in this study, the score improved over time in more than 60% of patients. This improvement may be associated with the restructuring of neural networks related to the performance of TMT-J as well as a learning effect due to repeated evaluation [13].

There are some reports that TMT can identify patients who should not drive a car [5, 6] Considering the results of these and our studies, if the TMT score is very high in patients with mild ischemic stroke 8–14 days after onset, it may be reasonable to refrain from driving and re-conduct TMT 29 days or later after onset. If the TMT score is not so high, medical staff should judge the pros and cons of driving a car by combining other evaluations including other inspection batteries, driving simulator evaluations, and actual in-vehicle evaluations.

This study has several limitations. Firstly, because healthy control elderly were not evaluated, the extent of improvement on repeated TMT-J could not be compared between the patients and healthy elderly. A previous study demonstrated that the mean values of Part A scores in healthy adults decreased from 29.3 to 24.9 seconds in 2–3 weeks, and those of Part B scores from 70.1 to 61.4 seconds [13]. Secondly, 20 patients did not have an NIHSS score at admission and were retrospectively evaluated based on the medical records. Thirdly, patients with very mild ischemic stroke who were not hospitalized could not be included. Fourthly, TMT-J scores in the chronic stage could not be evaluated. Fifthly, we could not show effect size or minimal clinically important differences in serial changes in TMT-J score. Further studies are needed to clarify the factors affecting the TMT score as well as appropriate time of conducting TMT after mild ischemic stroke.

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Conflict of Interest

The authors declare no conflict of interest.

Statement of Authorship

MY: analysis of the data, ZK: conceptualization, design, writing the original draft, review, and editing. KK: analysis of the data, KI: analysis of the data, MH: analysis of the data, KT: analysis of the data, YN: review and editing. HT: review, SS: review

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■ORIGINAL ARTICLE

Factors Relating with Excessive Daytime Sleep in Elderly Stroke Patients Undergoing Inpatient Rehabilitation

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Abstract: Background: Patients in rehabilitation facility have enormously long free time and often fall asleep during daytime. Excessive daytime sleep (DS) was reported to decrease rehabilitation efficiency resulting in poor functional recovery. In general population, insomnia, obesity, depression, dementia and the use of sleeping pills are known to be important risk factors of excessive DS. However, the causes of excessive daytime sleep in patients undergoing inpatient rehabilitation have not been clearly identified. Therefore, the current preliminary study aimed to explore factors underlying excessive DS in elderly patients undergoing inpatient rehabilitation following acute stroke.
Methods: Subjects were 17 patients without dementia with more than 65 years of age who were admitted to our rehabilitation wards following acute stroke. In all the patients, daytime and nighttime sleep states were monitored with wrist actigraphy consecutively for five days. Relationships of DS duration with insomnia, obesity, depression, apathy, hypnotic administration, motor functional ability, recreational activities and self-exercise were investigated.
Results: All the patients had more or less DS, the duration of which widely ranged from 43 to 550 min/day with mean value 210 ± 122 min/day. This DS duration was 3 - 4 times longer than that in general elderly population. The majority of patients had sufficiently long nighttime sleep (NS). There was no correlation between DS duration and NS duration. DS duration had no relationship with obesity, depression, apathy, hypnotic administrations, or motor functional ability. DS duration was, however, significantly shorter in patients performing self-exercise (n = 10, 157 ± 82 min) than in those without self-exercise (n = 7, 285 ± 135 min) ($p = 0.03$). Recreational activities did not shorten DS duration.
Conclusion: Patients in rehabilitation facility tend to have long DS because of enormously long free time and consequent idleness. Taking up the free time with self-exercise appears to be useful for preventing excessive DS.

Keywords: nap, stroke, elderly, self-exercise, activity, occupational therapy

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1. Introduction

In Japan, the time for inpatient rehabilitation including occupational, physical and speech therapy is limited to 180 min per day because of medical insurance regulation connected with the three-hour rule [1]. In our rehabilitation facility, patients get up at 6:00 am and go to bed at 10:00 pm. Thus, our rehabilitation inpatients have the total of 16 daytime hours every day and spend only three hours or less for rehabilitation therapy. According to a fact-finding survey performed in our rehabilitation facility prior to the current study, many patients complain of idleness and tend to fall asleep during daytime. Several studies also reported that patients in rehabilitation facility had long daytime sleep [2, 3]. In general, adequate DS is thought to be beneficial. Short naps less than 30 min were reported to reduce drowsiness

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and raise activity [4, 5]. On the other hand, excessive DS increases fatigue [6] and decreases physical and mental functions. Previously, Alessi et al. studied sleep condition of elderly stroke patients undergoing inpatient rehabilitation using wrist actigraphy and found that they had enormously long DS which was connected with poor functional recovery [2, 7]. Excessive DS is, thus, a seriously disturbing problem for patients in rehabilitation facilities. Unfortunately, however, Allessi et al. did not investigate why those patients had excessive DS and what kind of factors were contributing to the excessive DS. Various factors may be involved with mechanisms of excessive DS. Insomnia, obesity, depression, apathy, dementia and administration of hypnotics are known to be important risk factors of excessive daytime sleepiness in general population [8]. Several workers using wrist actigraphy reported that nursing home residents had long DS [9, 10]. Nursing home is the environment similar to rehabilitation facility, since the residents are generally old and have enormously long free time with limited enjoyment. Idleness may be one of important risk factors for long DS in nursing home residents. Unfortunately the causes of excessive DS in patients undergoing inpatient rehabilitation have not yet been precisely investigated. In order to clarify this point clear, the current preliminary study was designed to explore factors relating with excessive DS in elderly patients undergoing inpatient rehabilitation. Stroke is the most common condition in rehabilitation facilities. Therefore, we restricted participant materials to those with rehabilitation following acute stroke.

2. Participant Materials and Research Methods

Participants and Recruitment

Participants were selected from 48 stroke patients admitted to our rehabilitation facility during the period from June 1, 2018 to September 30, 2018. Inclusion criteria were 65 years of age or more, a score of 24 or higher on the mini-mental state examination (MMSE), and the admission within 60 days following acute stroke. Exclusion criteria included severe immobilization, consciousness disturbance and no doctor`s permission due to the association of serious complications. Nineteen patients met the inclusion criteria and agreed to participate with the study. Informed consent was obtained from all the patients. Two of them were, however, excluded from the study because of the following reasons: one was transferred to other hospital during the study period and the other could not retain a wrist actigraphy throughout the study period. The study protocol was approved by local ethical committee of A Hospital in Japan.

Data collection and Measures

Basic characteristics

The information concerning the gender, age, administration of hypnotics, body mass index (BMI) and MMSE scores of the patients were obtained from the participants' medical records.

Sleep duration

The study was initiated more than a week after the admission in order to obtain such a circumstance that the patients became acclimatized to the hospitalized life. All the patients were requested to wear a wrist actigraphy (Life Microscope, Hitachi, Tokyo) for five-day study period. Actigraphy was developed to monitor the sleep condition of children and adults, and its validity was confirmed repetitively by numerous studies [2, 3, 9–12]. When comparing actigraphy's ability to assess sleep parameters to the gold standard of polysomnography, the excellent concordance was shown in the measurement of total sleep duration among healthy subjects with a sensitivity more than 90% [9–12]. The actigraphy was then chosen to be a tool for measuring sleep duration in the current study. In many previous studies using actigraphy, the measurements were carried out for one week. However, in rehabilitation institutes, there are commonly family visits on Saturday and Sunday which likely prevent daytime sleepiness of patients. Therefore, in the current study, the actigraphy measurements were initiated and ensued for five weekdays excluding the weekends. The actigraphy was attached to the non-paralyzed side wrist and kept unremoved all day long except for a bath time. That was because it not water proof. The actigraphy automatically detected sleep and arousal using an automated discrimination algorithm and identifies the time falling asleep and waking up. Using this device, sleeping data were collected over three consecutive days from the second to the fourth day of five-day study period. The data obtained at the first day and last day were excluded from the analysis for the following reasons. At the first day, the patients are likely to be tense for actigraphy measurements and may tend to keep awake during daytime. At the last day, the patients may make effort to keep awake in order to improve the actigraphy records.

The patients were also asked to hand-record the time going to bed at night, waking up in the following morning and taking DS every day throughout the study period. The recorded data were used as reference of sleep conditions.

The NS was assumed to be the main sleep period over a 24-hour cycle. The total time spent for every sleep during the daytime was defined to be DS duration. DS was further divided to three periods such as,

morning sleep (from wake-up time to 13:00), afternoon sleep (from 13:00 to 15:00) and evening sleep (from 15:00 to bedtime at night). The Meterological Agency in Japan defines the time from 15:00 to bedtime at night to be evening. NS efficiency (%) and nocturnal waking frequency were determined from the measurements of actigraphy data. Average NS duration and average DS duration per day in each patient obtained from three-day measurements were calculated.

Motor functional ability and locomotive independency

At the beginning of the study, motor functional ability of patients was assessed with the motor subtotal rating score of functional independence measure (FIM) [13]. FIM is a reliable and valid assessment of motor function widely used in the field of rehabilitation [14–16]. The FIM consists of 13 motor items with a 7-point scale for independence, which provides a detailed numerical assessment on the patient's motor function. FIM was assessed by physical therapists and occupational therapists at the first day of the study. Apart from FIM evaluation, the patients were divided into two groups according to the locomotive faculty, either independent or dependent. The former can freely move around the wards by themselves, and the latter needs someone's help to move around.

Mental function

Mental function was evaluated using Zung's self-rating depression scale (SDS) [17] and apathy scale (AS) [18, 19]. SDS consisting of 20 questions with wide range scores from 20 to 80 points allows to assess the grade of depressive moods in detail within a short time. It is commonly used to assess the mental function of stroke patients and the elderlies [20, 21]. Scores 40 or more were judged to be depressive. Apathy scale (AS) is also used commonly to evaluate apathetic moods of stroke patients [19, 20, 22]. Patients can answer simple questions of AS within a short time and feel little physical or mental burden. Scores 16 or more were judged to be apathetic.

Time of recreational activities and self-exercise

Patients undergoing inpatient rehabilitation commonly spend the free time either enjoying recreational activities, such as watching television, reading books, playing with artistic paper folding (Origami), or performing self-exercise, such as walking around the wards by oneself or stretching the legs. Through the study period, all the patients were requested to record the time spent for such recreational activities and/or self-exercise before going to bed. At the end of the study, average time spent for the recreational activities or self-exercise per day was calculated.

Data analysis

The relationship of DS duration with gender, hypnotic medication, obesity, depression, apathy, locomotive independency, recreational activities or self-exercise, was compared using unpaired t-test. The relationship between DS duration and NS duration was analyzed with Pearson's correlation coefficients. P values < 0.05 were considered statistically significant.

3. Results

Basic characteristics of 17 patients are listed in Table 1. There were 12 men and five women with ages ranging from 66 to 89 years. Three patients were taking hypnotics, whereas the other 14 had neither hypnotics nor drugs inducing sleepiness. BMI ranged from 18.1 to 29.3; only three patients were overweight. All these three patients showing BMI values 25–30 were regarded mildly obese. MMSE scores ranged from 25 to 30; none of them was demented. Motor FIM scores ranged from 14 to 89. As for locomotive faculty, seven patients were able to move independently (independent group), and the other 10 needed the aid of someone else to move around (dependent group). All the independent group patients showed motor FIM scores 76 or above, whereas all the dependent group patients exhibited motor FIM scores below 76. Thus, the locomotive independency was closely connected with motor FIM levels.

Table 2 demonstrates DS duration, NS duration, SDS scores, AS scores, the time spent for recreational activities or self-exercise of the 17 patients. All the patients had more or less DS which ranged from 43 min to 550 min. Mean DS duration was 210 ± 122 min. Mean durations of morning sleep, afternoon sleep and evening sleep were 70 ± 47 min, 24 ± 21 min and 116 ± 67 min, respectively. When these were adjusted to the time per hour, the durations of morning sleep, afternoon sleep and evening sleep were 10.4 ± 6.8 min/h, 12 ± 11 min/h, and 16 ± 9 min/h, respectively. Thus, evening sleep was the longest of all DS durations.

DS duration was compared between males and females. There was no gender difference in DS duration (Table 3). DS duration in three patients with hypnotics was not longer than that in 14 patients without hypnotics (Table 3). DS duration in three patients with mild obesity was almost the same as that in 14 non-obese patients (Table 3). When compared from the aspect of locomotive independency, DS duration in the dependent group did not differ significantly from that in the independent group (Table 3).

The majority of patients had a sufficiently long NS,

Table 1 Basic characteristics of 17 patients.

Case No	Gender	Age years	Hypnotics Administration	BMI	MMSE score	Motor FIM score	Locomotive independence
1	M	66	no	22.8	30	89	yes
2	M	68	no	18.9	29	77	yes
3	F	88	yes	18.8	29	64	no
4	M	66	no	19.2	28	73	no
5	F	83	yes	29.3	30	76	yes
6	M	83	no	18.2	26	79	yes
7	M	83	no	20.9	28	67	no
8	F	75	no	18.1	28	37	no
9	M	78	no	22.2	29	59	no
10	M	67	no	23.9	28	56	no
11	M	77	no	20.9	28	82	yes
12	M	85	no	26.0	28	54	no
13	M	76	no	21.0	26	14	no
14	F	80	no	24.6	28	80	yes
15	M	66	yes	22.2	30	75	no
16	M	81	no	26.9	26	88	yes
17	F	89	no	21.1	25	65	no

M: male F: female
BMI: body mass index
MMSE: mini-mental state examinations
Motor FIM: motor subtotal rating of functional independence measure

Table 2 Results of measurements in 17 patients.

Case No	DS duration min	NS duration min	SDS score	Apathy Scale score	Recreational Activities min	Self-exercise min
1	43	354	27	5	150	150
2	81	411	42	6	210	120
3	87	527	34	14	120	5
4	120	515	47	17	180	35
5	144	363	45	6	70	20
6	145	452	36	6	0	120
7	161	338	30	11	360	0
8	163	535	67	18	231	3
9	171	460	39	26	120	0
10	218	572	37	13	0	0
11	225	364	38	8	180	30
12	240	338	43	16	180	0
13	270	469	36	18	508	30
14	291	525	44	6	210	15
15	312	501	40	8	60	0
16	342	489	35	17	30	0
17	550	444	48	9	120	0

DS: daytime sleep
NS: nighttime sleep
SDS: self-rating depressive scale

the duration of which ranged from 338 min to 572 min with mean value 451 ± 76 min. Mean NS efficiency was 87.7 ± 7.6%, and mean nocturnal waking frequency was 5.6 ± 3.2 times, although the values were not listed in Table 2. There was no significant correlation between DS duration and NS duration (r = 0.157, p = 0.547) (Table 4). DS duration also did not correlate with NS efficiency (r = 0.169, p = 0.515) or nocturnal waking frequency (r = −0.221, p = 0.395) (Table 4).

The results of SDS showed eight patients to be depressive and the other nine not depressive (Table 2). DS duration in the depressive patients (237 ± 151 min) was somewhat longer as compared with that in the non-depressive patients (185 ± 91 min). However, the difference was not significant at all (p = 0.39) (Table 3). According to AS, six patients were apathetic, and the

Table 3 Comparison of daytime sleep duration with various influential factors.

Factors	DS duration (min)	
	Mean ± SD	*p*
Gender		
males (n = 12)	194 ± 91	0.43
females (n = 5)	247 ± 185	
Hypnotics		
yes (n = 3)	181 ± 117	0.67
no (n = 14)	213 ± 126	
Obesity		
obese (n = 3)	242 ± 99	0.63
not obese (n = 14)	203 ± 128	
Locomotive independence		
independent (n = 7)	182 ± 109	0.45
dependent (n = 10)	229 ± 132	
Depressive state		
depressive (n = 8)	237 ± 151	0.39
non-depressive (n = 9)	185 ± 91	
Apathy state		
inactive (n = 6)	217 ± 82	0.85
active (n = 11)	205 ± 143	
Self-exercise		
Yes (n = 10)	157 ± 82	0.03*
No (n = 7)	285 ± 135	
Recreational activities		
long (n = 8)	194 ± 74	0.63
short (n = 9)	223 ± 156	

*: $p < 0.05$

Table 4 Correlations between daytime sleep duration and various factors.

Factors	r	*p*
Age	0.35	0.17
Motor Subtotal Rating of FIM	−0.140	0.592
Nighttime sleep duration	0.157	0.547
Nighttime sleep-efficiency	0.169	0.515
Nocturnal waking frequency	−0.221	0.395

other 11 were not apathetic (Table 2). DS durations in the apathetic patients (217 ± 82 min) and the non-apathetic patients (205 ± 143 min) were almost the same (Table 3).

During the study period, all the patients except for two enjoyed recreational activities, although the time spent for the activities widely varied from 30 min to 508 min. The recreational activities included watching television, reading books, listening to music and playing with artistic paper folding (Origami). The 17 patients were then divided into two groups according to the duration of recreational activities, i.e. a group with long activities for three hours or more (long recreational activity group) and the other with short activities for less than three hours (short recreational activity group). Two patients without recreational activities were included into the short activity group. There was no significant difference in DS duration between the two groups. During the study period, 10 patients performed self-exercise, whereas the other seven had no self-exercise (Table 2). DS duration in the patients with self-exercise (157 ± 82 min) was significantly shorter than that in the patients without self-exercise (285 ± 135 min, $p = 0.03$). Of the 10 patients with self-exercise, six patients (60%) had locomotive independency. Of the seven patients without self-exercise, only one (14%) had locomotive independency. Thus, more than a half of the patients with self-exercise had locomotive independency, while the majority patients without self-exercise had no locomotive independency.

4. Discussion

All the patients in the current study had more or less DS, the average of which was 210 min. DS duration in healthy elderly subjects was reported to be approximately 60 min [23]. DS duration in our patients is 3 - 4 times longer as compared with that in healthy elderly subjects. Stroke patients are known to have longer DS as compared with subjects without stroke [24, 25]. While the prevalence rate of excessive daytime sleepiness in stroke patients widely ranges between 18% and 72%, daytime sleepiness may persist for more than 6 months after stroke [24, 25]. This may be one reason for the enormously long DS of our patients. Previously, Alessi et al. also studied sleep conditions in elderly stroke patients undergoing inpatient rehabilitation [2]. In their patients, DS duration was also very long reaching 126 min in average. It, thus, seems that elderly stroke patients undergoing inpatient rehabilitation tend to have excessive DS irrespective of nationality.

Sleep physiology studies suggest that DS for less than 30 min may be beneficial because of minimizing the negative influence of sleep inertia which can lead to the prolongation of NS [4, 5]. On the other hand, the longer DS likely brings about the onset of slow-wave sleep which may cause the feeling of fatigue, the decrease of work efficiency and the lower quality of NS [6]. As reported by Allessi et al., excessive DS decreases rehabilitation efficiency leading to poor functional recovery in patients undergoing inpatient rehabilitation [2]. Therefore, DS should be avoided as much as possible in order to increase efficiency of rehabilitation.

DS duration in our patients widely varied from 43 min to 550 min despite staying in the same rehabilitation facility. The fact suggests that multiple factors may affect with long DS of patients in rehabilitation facility. In general, insufficient NS, obesity, depression

apathy, dementia and administration of hypnotics are considered to be important risk factors of excessive daytime sleepiness [8, 24]. The majority of patients in the current study, however, had sufficiently long NS, and none of them complained of insomnia during the study period. Mean NS efficiency 87.7% also suggest that the majority of our patients were free from insomnia. Furthermore, there was no significant correlation between DS and NS durations in our patients. The results are taken to indicate that insufficient NS is not the major factor of excessive DS in our patients. Obesity is another important risk factor of excessive DS. Obesity is commonly associated with obstructive sleep apnea which likely brings about insufficient NS and excessive daytime sleepiness [24]. In the current study, only three patients had mild obesity. DS duration in these three patients with mild obesity was the same as that in the other patients without obesity. Thus, obesity is apparently not the cause of excessive DS in our patients. Daytime sleepiness is known to be an important symptom of depression. In the current study, eight patients were judged depressive on the basis of SDS. Yet, DS duration in the depressive patients was not significantly different from that in the non-depressive patients. The results suggest that depression is not the major factor causing excessive DS in our patients. Prior to the beginning of the current study, we assumed that the locomotive faculty might be an important factor causing excessive DS. Locomotive dependency was likely connected with inactiveness which might easily lead patients to fall asleep during the daytime. Yet, DS duration in 10 patients with locomotive dependency was the same as that in seven patients with locomotive independency. It must be concluded that locomotive dependency was not the major factor causing excessive DS in our patients.

Rehabilitation facility is a closed environment in which the patients have to spend 24 hours for eating meals, going toilets, working on rehabilitation tasks and sleeping at night. It is unfortunate that therapist-guided rehabilitation is performed only for a few hours. Several workers previously investigated the hospital life of patients in rehabilitation facility [2, 3]. Quite a few patients spent a long non-therapeutic time for lying on beds. The posture lying on beds easily leads patients to fall asleep unless the effort is made to keep awake. Thus, the circumstance with enormously long free time but nothing to do may be the major causative factor of excessive DS in patients undergoing inpatient rehabilitation as assumed by us prior to the current study. How can we prove the validity of this assumption? Idleness during the long non-therapeutic time may be distracted by two types of actions, one recreational activities and the other the self-exercise. Provided either one or both of them shortens DS duration, then it can be declared that idleness is the major causative factor of excessive DS in patients. On the basis of such a consideration, we attempted to clarify whether two types of actions can shorten DS duration.

Ten of our patients performed self-exercise such as walking around the wards by themselves, whereas the other seven had no such self-exercise. DS duration in the self-exercise group (157 min) was significantly shorter as compared with that in the non-self-exercise group (285 min). The results suggest that self-exercise may be effective for preventing DS. In order to confirm the validity of this view, we further looked into more details of 10 patients with self-exercise, since the self-exercise time largely varied among them. Three patients had quite a long self-exercise for two hours or more (long-self-exercise group) and the other seven had only a short self-exercise for three to 30 min (short self-exercise group). Mean DS duration in the long self-exercise group (90 min) was considerably shorter than that in the short self-exercise group (188 min), although no statistical analysis was undertaken. Mean DS duration was, thus, the shortest in the long self-exercise group (90 min) followed by the short self-exercise group (188 min) and the longest in the non-self-exercise group (285 min). These results strongly support the view that self-exercise plays important role in the prevention of excessive DS. It should be noted here that more than a half of the patients with self-exercise had locomotive independency, while the majority of patients without self-exercise had no locomotive independency. The patients with locomotive independency are more advantageous than those without locomotive independency for conducting self-exercise because of more freedom to choose the time and location of exercise. Locomotive independency and self-exercise seem to be closely related with each other. Yet, it is still true that four patients without locomotive independency conducted self-exercise in spite of the restriction of time and place for exercise. The locomotive independency is an important factor but not a prerequisite for self-exercise.

The majority of our patients spent the time for recreational activities. We then divided the patients into two groups according to the duration of recreational activities, one a group with short recreational activities for less than two hours and the other a group with long recreational activities for more than two hours. Yet, no significant difference in DS duration was found between the two groups. The results suggest that the recreational activities are not effective for preventing daytime sleepiness. According to the study of Yan et al., low intensity activities provided little effects on daytime sleepiness [26]. All the recreational activities chosen in

the current study consume small amount of energy. Such low intensity activities may not be as powerful as high intensity activities for the prevention of daytime sleepiness. Personal space of hospitalized patients is limited to the bed and the surrounding area. This environmental limitation forces the patients to choose the recreational activities in a lying or sitting position, such as listening to music or watching television. Occupational therapists are encouraged to improve the hospital environment taking patients to meeting rooms or areas other than personal bed area so that patients can engage in more active leisure activities.

The mean duration spent for self-exercise (31 min) was considerably shorter than that spent for recreational activities (162 min). Nevertheless, the self-exercise was seemingly more effective for preventing excessive DS than the recreational activities. The reason for this difference is not quite clear. The self-exercise likely consumes higher amount of energy as compared with the recreational activities. Higher intensity activities may be more effective than lower intensity activities for the prevention of daytime sleepiness regardless of the duration as suggested by Yan et al. [26]. Recreational activities, such as watching television and listening to music, can be classified passive-type entertainment which does not require strong enthusiasm. On the other hand, self-exercise, such as walking around the wards, is classified active-type performance, which needs strong motivation. Such a difference in enthusiasm may underlie in DS preventive mechanisms between the recreational activities and the self-exercise.

Limitations of study

There were some limitations in the current study. First, a long single nap and a few shorter naps were not distinguished in the current study; only the total time of daytime sleep was analyzed as DS duration. A single long nap may be detrimental, while a few shorter naps may be beneficial. These two types of naps would be better analyzed separately in the future study. Second, the present study was performed as a preliminary study with small samples to explore possible factors contributing to the excessive DS in elderly stroke patients undergoing inpatient rehabilitation. Because of small sample size, some influential factors may have been dismissed due to statistical insignificance. Further investigation with larger sample size using more detailed analysis is needed to confirm the present results in the future. We are preparing such a study.

Conclusions

Patients undergoing inpatient rehabilitation have extremely large amount of free time and are suffering from idleness, which leads them to excessive DS. The self-exercise appears to reduce idleness and effectively prevent excessive DS. Therapists are encouraged to provide self-exercise menu matched for each patient and to check whether the patients can continue self-exercise properly.

Statement Regarding Informed Consent

Informed consent was obtained from all individual participants included in the study.

Statement Regarding Ethical Approval

The study was approved by the ethics committee of A Hospital (Committee approved number: 2018-06). All procedures performed in the study involving human participants were in accordance with the national research committee as well as these of the 1964 Helsinki declaration and its later amendments.

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■ORIGINAL ARTICLE

Neurobehavioral Impairment Scale of the A-ONE J: Rasch Analysis and Concurrent Validation

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Abstract: Background: The ADL-focused Occupation-based Neurobehavioral Evaluation (A-ONE) is used to evaluate both performance of ADL tasks and neurobehavioral impairments (NBIs) that interfere with ADL performance of clients with neurological disorders. Its Japanese translation is referred to as A-ONE J. This study examined the psychometric properties of the Neurobehavioral Impairment (NB) Scale of A-ONE J for persons with cerebral vascular accident (CVA).
Methods: Rasch analysis was performed on NB scale data from 185 participants with CVA, as well as from right CVA (RCVA) and left CVA (LCVA) data separately. The values of the obtained Rasch indicators were compared with results from previous A-ONE studies.
Results: Unidimensionality was obtained for 55 item CVA scale for the entire group as well as for 55 item RCVA scale and 53 item LCVA scale. Separation reliability for item and person calibrations was high for all three scales. Most comparisons of Rasch indicators concurrently met set criteria.
Conclusion: The psychometric properties of the NB scale of A-ONE J were determined. The obtained unidimensionality of the NB scale items for Japanese people with CVA provides an opportunity for quantitative measurement of a wide range of NBIs interfering with their ADL performance.

Keywords: activities of daily living, assessment, cerebral vascular accident, occupational therapy, outcome

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Introduction

One of the most common types of evaluation used by occupational therapists to evaluate patients who have had a cerebral vascular accident (CVA) is that of activities of daily living (ADL) [1–3]. In the ADL evaluation, it would be of benefit to assess not only ADL performance, but also impairments, such as motor, sensory, cognitive, and perceptual impairments that limit performance of the ADL. Evaluation of these impairments is usually performed separately from ADL assessment [1]. However, deficit specific tests of neurological functions and neuropsychological test batteries intended to evaluate presence of impairments do not reflect the impact of the impairments on occupational performance such as ADL performance. Further, such tests have been reported to present with low to moderate ecological validity [4]. Thus, the importance of assessing neurobehavioral impairments (NBIs), which interfere with ADL performances in natural contexts, has gained support in the rehabilitation literature [5].

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The ADL-focused Occupation-based Neurobehavioral Evaluation (A-ONE) was the first instrument developed in the field of occupational therapy to assess the impact of NBIs on occupational performances. It was further the only assessment providing opportunity to evaluate a wide range of NBIs that interfere with ADL performance in naturalistic contexts [6].

The A-ONE is an ADL instrument developed by an Icelandic occupational therapist, Guðrún Árnadóttir in 1990 [1]. By administering this tool, occupational therapists can identify the level of clients' ADL ability and NBIs that interfere with ADL performances through naturalistic ADL observation. When NBIs are identified by use of the A-ONE, clinical reasoning and neurological knowledge are applied. The A-ONE comprises two scales representing two different hypothetical constructs. Both scales, i.e., the Functional Independence scale (FI scale) and the Neurobehavioral Impairment scale (NB scale), were developed as criterion-referenced ordinal rating scales [1, 7, 8].

The original purpose of the A-ONE was not to measure the clients' ability by using total scores, but to set goals and plan interventions by using the descriptive information obtained from the ordinal rating scales [1]. Ordinal scale scores cannot be used to generate total scores as if they were measures based on interval scores [8, 9]. To avoid misuse of ordinal scores, Rasch analysis based on modern measurement theory, has been used in rehabilitation medicine to examine the properties of existing ordinal-level instruments and validate their measurement potential. Application of Rasch analysis thus provides a potential for converting the total score to measures [10]. Consequently, Rasch analysis was applied in several studies to examine the potential for using both the FI and the NB scales of the original A-ONE as outcome measures. The results of those studies revealed that the ordinal scale scores of both FI [1, 8, 14] and NB scale items could be converted to valid measures [1, 5, 11, 12]. Four of these publications include reviews of the psychometric properties of the NB scale of the A-ONE for persons diagnosed with CVA. These include a CVA-NBI scale [1, 12], as well as two additional scales, one for persons with RCVA and the other persons with LCVA [1, 5, 11,].

Rasch analysis is used to estimate an individual's ability to assess the difficulty of items expressed in log odds units (logits) on a single continuous scale. The term unidimensionality refers to the concept that the items included on the scale comprise a single construct. Unidimensionality of items needs to be examined before constructing a measure [10, 11]. It is also possible to use Rasch analysis to examine whether the hierarchical order of scale items represents sequential item difficulty [10].

For validating the measurement potential of a scale unidimensionality can be examined by different types of analyses. Goodness-of-fit analyses is used to evaluate fit of all people and items, to the Rasch model. It includes evaluation of infit mean-square (MnSq), outfit MnSq, as well as standardized z (Zstd) values, indicating the degree of matching between actual and expected responses [10]. Principal component analysis (PCA) of Rasch based residuals is another type of possible analysis of unidimensionality used to examine the assumption that all data can be explained by the latent measure. This is different from PCA in classical test theory, which is a correlation model to identify factors in the scale [11, 13].

Finally, in Rasch analysis the person and item reliability need to be explored. The person reliability index represents the reproducibility of the ordering of the individual's ability logit score if the same sample of persons were given another set of parallel items. The item reliability index shows the repeatability of the ordering of items along a path when the items are given to another sample of the same size that behaves in the same way [10].

In Japan, the Japanese A-ONE study group translated the Japanese version of the A-ONE (A-ONE J) from the original A-ONE items and definitions, simultaneously addressing cultural differences [14]. This process is described under Instrumentation. Subsequently, we examined the psychometric properties of the FI scale of the A-ONE J by using Rasch analysis [12]. However, the NB scale of the A-ONE J has not yet been examined by application of Rasch analysis. The purpose of the present study was thus to examine the psychometric properties of the NB scale of the A-ONE J for people with CVA and to confirm whether a total score can be generated as an outcome measure for that diagnostic group. An additional purpose was to qualitatively compare the obtained Rasch indicators of the study to previous results from the original Rasch analyses of the NB scale of the A-ONE.

Methods

Participants

This was a multicenter study conducted between October 2015 and June 2019. The participants were recruited from nine different acute and rehabilitation hospitals in Japan to which the A-ONE-trained occupational therapists belonged. Each participant or their family gave informed written consent before participating in this study. The study was approved by the School of Comprehensive Rehabilitation Osaka Prefecture Univer-

Table 1 Demographic Information of Participants.

	ALL (n = 185)	RCVA (n = 87)	LCVA (n = 76)	BCVA (n = 22)
Age (years)				
M	71.8	72.2	71.9	69.8
SD	12.5	12.6	12.8	11.6
Range	39–96	41–96	39–93	46–87
Sex				
Male	116	58	44	14
Female	69	29	32	8
Diagnosis				
Infarction	110	54	42	14
Hemorrhage	75	33	34	8
Days after onset				
M	77.3	80.1	68.5	96.5
SD	55.4	58.9	49.8	56.1
Range	2–298	2–298	4–215	25–187

ALL = all participants; RCVA = participants with right cerebral vascular accident; LCVA = participants with left cerebral vascular accident; BCVA= participants with bilateral cerebral vascular accident.

sity (approval number: 2016–209) as well as the Research Ethics Committees of each participating hospital.

Ten therapists and their attending physicians selected participants for inclusion based on (a) the presence of cognitive or perceptual dysfunction as a result of CVA, as revealed by a medical examination, and (b) the person's medical readiness for an ADL evaluation. Individuals who were not medically stable or not able to perform any ADL task were excluded.

The total number of participants who were selected according to above criteria was 185. Eighty-seven were diagnosed with right CVA (RCVA), 76 with left CVA (LCVA), and 22 with bilateral CVA. The CVA resulted from infarction in 110 participants and from hemorrhage in 75. The mean time from the onset of stroke was 77.3 days. Detailed participant demographic information is presented in Table 1. A sample size of at least 30 was required in each diagnostic group for Rasch analysis, as this number would be sufficient to provide a 95% confidence interval for the stability of the estimated item difficulty calibrations within an absolute value of 1.0 logit [11, 15, 16].

Instrumentation

The A-ONE is commonly used for adults that have acquired central nervous system dysfunction. As noted earlier, the A-ONE comprises two scales, the FI scale and the NB scale. The FI scale consists of 20 ADL items in four domains: dressing (D), grooming and hygiene (G), transfer and mobility (T), feeding (F) and two communication (C) items. A rating scale with categories ranging from 0 to 4 is used to score the observed level of assistance needed. The NB scale is used to evaluate the impact of NBIs that interfere with ADL task performance. It contains two subscales, the Neurobehavioral Specific Impairment subscale (NBSIS) comprised of 46 rating scale items, with scores ranging from 0 to 4 (0 = absence of errors, 4 = maximum physical assistance to overcome errors), and the Neurobehavioral Pervasive Impairment subscale (NBPIS), comprised of 31 dichotomous items. The NBSIS items are evaluated for each ADL domain (e.g., D-motor apraxia, G-motor apraxia, T-motor apraxia, F-motor apraxia). It is scored based on the type of assistance required to overcome the performance errors (NBI) during ADL performance. The NBPIS items are evaluated only once, based on errors observed in at least one ADL task. The A-ONE manual contains conceptual and operational definitions of all items and detailed criteria for scoring. To use A-ONE in clinical practice and research, a five-day training course where therapists practice clinical reasoning and differentiation of impairments is required. [5, 8, 11, 14]. Further information on A-ONE training courses for occupational therapists can be obtained from https://www.a-one.is/.

All the items of both the FI and NB Scales of the A-ONE J had been translated to Japanese, as well as all the conceptual and operational definitions of the neurobehavioral terms. The details of the translation process were described in a previous study [14]. Two changes were made to the FI scale of the original A-ONE to accommodate Japanese culture. The item "Wash face and upper body" was simplified to "Wash face and hands" and the item "Use knife to cut and spread" was changed to "Use chopsticks to manipulate and carry food." As the impact of NB items on the A-ONE is scored based on task performance on the FI scale, this change may potentially affect the NB scores in the grooming and hygiene domain as well as in the feeding domain. There were no other item changes made from the original A-ONE.

Procedures

At each hospital, the therapists who had completed the 5-day A-ONE training course evaluated the participants according to the standardized procedure described in the manual. The raw scores were analyzed using the WINSTEPS Rasch computer software program (Version 4.5.0) [17]. In line with the preceding Rasch studies of the NB scale of the A-ONE [1, 5, 11], the five-level rating scale of the NBSIS items was dichotomized prior to data analysis such that 0 = absent and 1 to 4 = present. Dichotomization was used so that all items would be scored consistent with the current scoring of the NBPIS items. For item inclusion, we used 55 items which were the same items as used for Rasch analysis in the previous studies [1, 5]. The 55 items are listed in Table 2.

Table 2 Retained Scale Items for the Rasch Analysis

Item						
Motor apraxia	D	G	T	F		
Ideational apraxia	D	G	T	F		
Unilateral body neglect	D	G	T	F		
Spatial relations	D	G	T	F		
Unilateral spatial neglect	D	G	T	F		
Motoric	D	G	T	F		
Organization and sequencing	D	G	T	F		
Perseveration	D	G	T	F	C	
Topographical disorientation			T			
Sensory aphasia					C	
Anomia					C	
Paraphasia					C	
Dysarthria					C	
Expressive aphasia					C	
Lability						P
Apathy						P
Depression						P
Irritability						P
Frustration						P
Restlessness						P
Insight						P
Judgment						P
Confusion						P
Attention						P
Distraction						P
Initiative						P
Motivation						P
Performance Latency						P
Working memory						P
Confabulation						P
Number of items				55		

Item domains: D = dressing, G = grooming and hygiene, T = transfers and mobility, F = feeding, C = communication. P = Pervasive scale items.

We then proceeded to analyze the data using the simple Rasch model for dichotomous data. The analysis progressed in two phases. In the first phase, we examined the psychometric properties of a total CVA scale including all the CVA participants. We examined unidimensionality by means of goodness of fit and omitted items one at a time until all items demonstrated acceptable goodness of fit. In accord with the preceding studies [1, 5, 11], fit statistics of MnSq > 1.4 associated with Zstd > 2.0 were taken as an indication of an item misfit. We decided to remove the items based on infit MnSq and infit Zstd values. Infit statistics are an information-weighted indicator of misfit. Outfit statistics are not weighted and are relatively sensitive to the impact of out-of-range scores (individual performance away from the item's location). Abnormal infit statistics usually cause more concern than do large outfit statistics [10]. As in the previous study, we only used infit statistics in the present study [14]. In the second phase, we divided participants into those with RCVA and those with LCVA and analyzed these subgroups separately in accord with the preceding study [5]. As noted before, for applying Rasch analysis, at least 30 participants are required [11, 15, 16], therefore, data for participants with bilateral CVA were not analyzed, due to the small number of participants in this group. For RCVA and LCVA we examined, by the same methods as the first phase, the psychometric properties using simple Rasch analyses.

Data Analysis

Structural Validity and Reliability

Unidimensionality.

Unidimensionality was examined by goodness-of-fit analyses based on the Rasch model and PCA of Rasch based residuals [13]. When applied to the NB scale of the A-ONE J, in accord with the Rasch analysis of the original NB scale of the A-ONE in the previous study [5, 11], the Rasch model was based on the following two assertions. First, the more neurobehaviorally disabled a participant is, the more profound errors (NBIs) will be scored as present; second, errors that emerge with mild NBIs are more likely to be scored as present for all participants than are those that emerge only with severe NBIs.

First, unidimensionality was examined by the goodness-of-fit analyses with above mentioned criteria. We also evaluated unidimensionality by means of PCA of Rasch based residuals by using the five-level quality criteria described by Fisher [18], to determine whether additional factors were likely to be present. According to the criteria, the proportion of unexplained variance accounted for by the first contrast (the largest secondary dimension) needs to be less than 15% to be classified as "fair" [18]. The variance explained by the measures in a PCA of Rasch based residuals has further been used for evaluating unidimensionality in the past [18]. The criterion for the proportion of the variance explained by the measures was more than 50%. However, this criterion was revised because the variance explained by the measures changes with the targeting of the items on the persons. Thus, at present, there is no published set range of values useful for assessing scale functioning [18]. Therefore, in terms of PCA of Rasch based residuals, we applied only the part of the criteria referring to the proportion of unexplained variance accounted for by the first contrast.

Reliability

Both person and item reliability were analyzed. The relevant indicator is the reliability of these separation indexes, which indicates the degree of confidence in the reproducibility of these estimates [10]. The value of the

coefficient varies from 0 to 1 (a value greater than 0.8 is considered good and that greater than 0.9 is considered very good) [18].

Finally, the obtained values of psychometric properties of the present study were compared with the findings of the original Rasch analyses indicators of the A-ONE NB scale. Several such analyses have been performed, exploring both combined diagnostic samples (CVA and dementia) as well as subgroups of those samples [1, 5]. Qualitative comparisons with the A-ONE NB scale were restricted to the CVA, RCVA and LCVA scales. The comparisons took aim of Fishers [18] quality criteria.

Results

Phase one: CVA scale

Unidimensionality

All the items of the CVA scale fitted the Rasch model. This finding indicates that there were no misfit items detected on the CVA scale. PCA of Rasch based residuals revealed that 45.9% of the variance could be explained by the Rasch dimension. Unexplained variance was 5.9%, which met the unidimensional criteria (Table 3). Item calibration values for all participants are presented in Table 4.

Reliability

The person separation index was 2.31, and the person reliability coefficient was 0.84. The item separation index was 6.03, and the item reliability coefficient was 0.97.

Phase two: RCVA and LCVA scales

Unidimensionality

For RCVA, in the goodness-of-fit analysis, all the items fitted the Rasch model. This finding indicates that there were no misfit items detected on the RCVA scale. PCA of Rasch based residuals revealed that 52.7% of the variance could be explained by the Rasch dimension. Unexplained variance was 7.1%, which met the unidimensional criteria (Table 3).

For LCVA, in the goodness-of-fit analysis, two items "Dysarthria" and "Paraphasia" did not fit the Rasch model and therefore these items were omitted. After omitting these items, all the items of the LCVA scale fitted the Rasch model. This finding indicates that there were no misfit items detected on the LCVA scale. PCA of Rasch based residuals revealed that 50.9% of the variance could be explained by the Rasch dimension. Unexplained variance was 5.3%, and it satisfied the unidimensional criteria (Table 3). Item calibration values for RCVA and LCVA hierarchies are presented in Table 4.

Table 3 Values of Principal Components Analysis (PCA)

	ALL	RCVA	LCVA
PCA: Rasch factor	45.9%	52.7%	50.9%
PCA: First contrast	5.9%	7.1%	5.3%

ALL = all participants; RCVA = participants with right cerebral vascular accident; LCVA = participants with left cerebral vascular accident.

Reliability

For RCVA, the person separation index was 2.52, and the target person reliability coefficient was 0.91. The item separation index was 3.21, and the item reliability coefficient was 0.91.

For LCVA, the person separation index was 2.38, and the target person reliability coefficient was 0.91. The item separation index was 3.19, and the item reliability coefficient was 0.91.

Comparison with the original A-ONE results

The Rasch indicators resulting from this study of the A-ONE J were compared with results from Rasch analyses of the original A-ONE. Before the qualitative comparison of Rasch indicators, results from all the studies were interpreted according to Fisher's quality criteria [18]. Table 5 summarizes comparisons of the results for all three scales.

Discussion

In this study, we confirmed by use of Rasch analyses the presence of unidimensionality for the NB scale of the A-ONE J when evaluating persons with CVA. On the A-ONE J CVA scale and RCVA scale all 55 items were retained in the analysis, and all but two items formed the 53 items LCVA scale. In other words, the NBIs that interfered with ADL performance can be arranged in a unidimensional hierarchy on the A-ONE J, finding that had been obtained previously in Rasch analyses studies of the original A-ONE [1, 5]. The reason for why the original RCVA and LCVA scales have fewer items (51 and 42 respectively) relates to use of more stringent criteria in previous studies. This includes that no item misfit was allowed resulting in item deletion. It also applied to the variance explained by the measures (Rasch factor < 60%) in the previous studies [5, 11], in accord with accepted statistical rules of the time, as opposed to use of no value criteria for the Rasch factor in the present study, this being based on Fisher's revised criteria [18]. The results of PCA of Rasch based residuals for the CVA scale, as well as for the RCVA and LCVA scales of the A-ONE J satisfied the unidimensional criteria.

We succeeded in constructing a valid and reliable

Table 4 Item Difficulty of All Items for Three Scales

CVA scale		RCVA scale		LCVA scale	
Item	Item Difficulty	Item	Item Difficulty	Item	Item Difficulty
Apathy	3.12	D-Ideational apraxia	4.61	G-Unilateral spatial neglect	4.21
F-Perseveration	2.70	T-Ideational apraxia	4.61	F-Unilateral body neglect	4.21
F-Unilateral body neglect	2.40	F-Ideational apraxia	4.61	Apathy	4.21
Confusion	2.42	C-Paraphasia	4.61	D-Unilateral spatial neglect	2.96
F-Ideational apraxia	1.97	C-Perseveration	4.61	F-Unilateral spatial neglect	2.96
Lability	1.82	Apathy	4.61	Confusion	2.96
Frustration	1.80	T-Motor apraxia	3.38	G-Unilateral body neglect	2.20
Restlessness	1.80	F-Perseveration	3.38	T-Spatial relations	2.20
Motivation	1.80	C-Broca aphasia	2.65	T-Unilateral spatial neglect	2.20
T-Ideational apraxia	1.65	Restlessness	2.65	T-Perseveration	2.20
T-Perseveration	1.65	G-Ideational apraxia	2.21	F-Spatial relations	2.20
C-Perseveration	1.65	Frustration	2.21	F-Perseveration	2.20
Confabulation	1.65	Confusion	2.21	Lability	2.20
Depression	1.52	Confabulation	2.21	Frustration	2.20
Irritability	1.40	F-Unilateral body neglect	1.88	Motivation	2.20
D-Ideational apraxia	1.01	Lability	1.88	G-Spatial relations	1.74
Initiative	1.01	Irritability	1.88	Confabulation	1.74
T-Motor apraxia	0.93	T-Perseveration	1.62	Depression	1.40
F-Spatial relations	0.85	C-Anomia	1.62	Irritability	1.40
Performance latency	0.85	Depression	1.62	Restlessness	1.40
F-Unilateral spatial neglect	0.77	Motivation	1.62	Initiative	1.40
C-Paraphasia	0.77	G-Perseveration	1.41	D-Unilateral body neglect	1.13
D-Unilateral spatial neglect	0.70	G-Motor apraxia	1.22	D-Spatial relations	1.13
G-Perseveration	0.57	F-Motor apraxia	1.22	T-Unilateral body neglect	1.13
D-Perseveration	0.51	C-Sensory aphasia	1.05	F-Ideational apraxia	1.13
G-Unilateral spatial neglect	0.51	Initiative	1.05	Performance latency	1.13
G-Ideational apraxia	0.39	Performance latency	0.90	T-Ideational apraxia	0.70
G-Unilateral body neglect	0.39	D-Motor apraxia	0.76	C-Perseveration	0.52
G-Spatial relations	0.18	D-Perseveration	0.76	D-Perseveration	0.36
C-Broca aphasia	0.18	T-Topographical disorientation	0.76	D-Ideational apraxia	0.07
D-Unilateral body neglect	0.08	F-Spatial relations	0.39	G-Perseveration	0.07
C-Anomia	0.08	F-Unilateral spatial neglect	0.08	T-Motor apraxia	−0.06
T-Spatial relations	0.03	D-Unilateral spatial neglect	−0.01	G-Ideational apraxia	−0.50
D-Motor apraxia	−0.15	F-Organization and sequencing	−0.01	F-Organization and sequencing	−0.50
T-Unilateral spatial neglect	−0.15	Distraction	−0.11	C-Anomia	−0.79
G-Motor apraxia	−0.32	G-Unilateral body neglect	−0.28	D-Motor apraxia	−0.97
T-Unilateral body neglect	−0.32	G-Spatial relations	−0.36	T-Topographical disorientation	−1.05
F-Motor apraxia	−0.32	G-Unilateral spatial neglect	−0.36	C-Broca aphasia	−1.05
T-Topographical disorientation	−0.36	D-Unilateral body neglect	−0.53	Distraction	−1.05
F-Organization and sequencing	−0.40	T-Spatial relations	0.60	F-Motor apraxia	−1.14
C-Sensory aphasia	−0.47	Insight	−0.90	G-Motor apraxia	−1.30
Distraction	−0.62	Working memory	−1.12	C-Sensory aphasia	−1.46
D-Spatial relations	−0.99	T-Unilateral body neglect	−1.19	Insight	−1.46
Insight	−1.18	T-Unilateral spatial neglect	−1.19	Attention	−1.46
C-Dysarthria	−1.33	C-Dysarthria	−1.19	Working memory	−2.12
Attention	−1.60	T-Organization and sequencing	−1.73	T-Organization and sequencing	−2.42
Working memory	−1.66	Attention	−1.73	Judgment	−2.72
T-Organization and sequencing	−2.10	Judgment	−2.20	G-Organization and sequencing	−2.95
Judgment	−2.45	D-Spatial relations	−2.33	D-Organization and sequencing	−3.28
G-Organization and sequencing	−2.83	G-Organization and sequencing	−2.68	F-Motoric	−3.93
D-Organization and sequencing	−3.06	D-Organization and sequencing	−2.98	G-Motoric	−4.52
F-Motoric	−4.00	F-Motoric	−4.73	D-Motoric	−4.82
G-Motoric	−4.67	D-Motoric	−5.23	T-Motoric	−5.61
D-Motoric	−4.81	G-Motoric	−5.45		
T-Motoric	−5.33	T-Motoric	−5.71		

Note: High positive scores refer to that the item is rarely seen impacting performance, and low negative scores refer to that performance errors/items are observed impacting performance more frequently.

Table 5 Comparison of the psychometric properties of the A-ONE J NB scales and the original A-ONE NB scales

	CVA Scale		RCVA Scale		LCVA Scale		Criteria	Comparison of results A-ONE J/A-ONE
	A-ONE J	A-ONE	A-ONE J	A-ONE	A-ONE J	A-ONE		
Persons (n)	185	215	87	108	76	114	30	Less than A-ONE
Items (i)	55	53	55	51	53	42	–	almost same
Number of categories	2	2	2	2	2	2	–	same
Item model fit MnSq	≤ 1.4	≤ 1.4	≤ 1.4	≤ 1.4	≤ 1.4	≤ 1.4	–	very good/very good*
PCA: Rasch factor	45.9%	79.2%	52.7%	89.7%	50.9%	91.1%	–	Less than A-ONE
PCA: First contrast	5.9%	1.7%	7.1%	1.6%	5.3%	1.3%	< 15%	Good/Excellent*
Person separation index	2.31	2.20	2.52	2.57	2.38	1.94	> 2	Fair/Fair · Poor*
R (persons)	0.84	0.83	0.91	0.87	0.91	0.79	> 0.8	Good/Good · Fair*
Item separation index	6.03	6.93	3.21	4.98	3.19	4.43	> 2	Very Good/Very Good*
R (items)	0.97	0.98	0.91	0.96	0.91	0.95	> 0.8	Excellent/Excellent*

*Interpretation based on Fisher's quality criteria.
Note: Comparison of psychometric qualities of Rasch analyzed versions of the Neurobehavioral Scale on the A-ONE J and the original A-ONE.

A-ONE J CVA scale meeting the previously set criteria. From a research perspective, the CVA scale could be useful for making comparisons between subgroups of CVA clients [5, 12]. However, the PCA (Rasch factor) for the A-ONE J CVA scale was less than for either the RCVA or LCVA scales. The wider the spread of the persons and items, the higher the Rasch factor becomes [19]. Thus, as the CVA scale has the narrowest spread of the three A-ONE J NB scales, it can be expected to be less precise than both the RCVA and LCVA scales. Therefore, depending on the purpose of measuring, when measuring change in impact of NBIs on ADL task performance over time, using either the RCVA or the LCVA subscales may turn out to be a more precise alternative than the CVA scale. The CVA scale on the other hand is useful when comparing performance of RCVA and LCVA persons.

Regarding the hierarchy, for all three A-ONE J NB scales, the logit value of the item labeled "Motoric" referring to impaired motor function was the lowest value on the hierarchy; thus, performance errors related to diminished motor function were the most likely errors to be detected during the ADL task performance. The participants in this study were diagnosed with CVA and hospitalized in acute and rehabilitation hospitals. This finding of impaired motor function such as paralyses is thus not surprising and consistent with the literature where impaired motor function has been identified as one of the most frequently detected impairment limiting ADL performance [20]. This finding is also consistent with results from previous studies of the NB scale of the A-ONE for the stroke population [1]. Subsequently, the right hemisphere functions such as unilateral spatial neglect and spatial relations were frequently apparent on the RCVA scale, and the frequency of items related to left hemisphere function such as ideational apraxia and aphasia was low. For the LCVA scale, motor and ideational apraxia as well as language impairments were commonly detected as opposed to neglect items that were very unlikely to be detected. These results were reasonable considering the characteristics of right and left hemisphere function [12].

For an overall analysis of the participants, we analyzed the data of 185 individuals; however, when we analyzed the RCVA and LCVA separately, the data was divided into 87 RCVA and 76 LCVA cases. Although the minimum sample size criterion was satisfactory, more stable results would be obtained by analyzing 150 participants for each of the RCVA and LCVA scales to obtain 99% confidence interval for estimated item difficulty calibrations remaining within the absolute value of 0.5 logit [15, 16]. Thus, it would be desirable to raise the number of participants in future studies.

Limitations and future considerations

Our right and left CVA samples were < 100 persons in each group. To obtain more stable results 150 participants are required [16, 17]. We therefore plan to enlarge the sample size to 150 participants and reanalyze the data including analyses of differential item functioning between RCVA and LCVA in future studies.

As pointed out in the previous study [5], the A-ONE and A-ONE J include only ADL tasks. Thus, the findings of this study cannot be generalized to the performance of other tasks, such as IADL, without further investigations. The original A-ONE was intended to be used for clients with different types of neurological diagnoses including, for example, dementia and head trauma in addition to CVA. In this study of the A-ONE J, the sample only included people with CVA as opposed to studies of the original A-ONE that also include analysis of performance of people with dementia. Therefore,

our recommendation for future studies is to include more diverse diagnostic categories in the analyses of the A-ONE J.

Finally, in this study, we chose to dichotomize all items in accord with the previous study [5]. However, the original NBSIS scale is a five-category rating scale, and this procedure may have reduced the separation of the participants. We further plan to explore the use the partial credit Rasch model with the five-category rating scale in future studies and compare the results with results from the dichotomous analysis.

Conclusion

In this study, we demonstrated that the NB scale of the translated A-ONE J can be used as an outcome measure. We converted the NB rating scale into a dichotomous scale and subsequently developed three separate scales, a 55 item RCVA scale and 53 item LCVA scale as well as a 55 item CVA scale. By using these Rasch analyzed NB scales of the A-ONE J, we confirmed the findings of earlier A-ONE studies regarding the possibility of quantitatively measuring the changes in a wide range of NBIs that interfere with ADL task performance.

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■ORIGINAL ARTICLE

Experiences of Male Stroke Survivors with Higher Brain Dysfunction after Discharge from a Rehabilitation Hospital: A Qualitative Study 6 Months after Hospital Discharge

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Abstract: Background: Stroke survivors face various problems after discharge from rehabilitation hospitals. This study aimed to clarify the post-discharge experiences of male stroke survivors with attention deficits, a form of higher brain dysfunction.
Methods: The subjects of this study were three male stroke survivors who were discharged from a convalescent rehabilitation ward and their spouses. Semi-structured interviews were conducted 1, 3, and 6 months after discharge. Data were qualitatively analyzed using Trajectory Equifinality Modeling to depict the post-discharge pathways experienced by stroke survivors.
Results: The Obligatory Passage Points of post-discharge pathways experienced by stroke survivors were as follows: feeling "difference" in daily life, becoming aware of higher brain dysfunction through interaction with others, and becoming able to "organize my thoughts" through an occupation and interacting with others. In addition, the Bifurcation Points were "increased occupation away from the wife" and "occupation with the wife continues," and the Equifinality Point was "select occupation autonomously."
Conclusion: Although the stroke patients were suspected of being attention deficit during the evaluation that performed during their hospitalization, they were unaware of it during their hospitalization and immediately after discharge. However, the stroke survivors became aware of their higher brain dysfunction through interactions with others other than their wives, and their insight into their disability increased as they participated in occupations. These results suggest the importance of including occupations that challenge stroke survivors and in which others, besides the wife, participate in the occupational therapy program.

Keywords: stroke, higher brain dysfunction, qualitative study, Trajectory Equifinality Modeling

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Introduction

Stroke is a disease that causes a variety of changes and losses due to acquired functional impairment [1]. The Japanese Ministry of Health, Labour and Welfare has defined "higher brain dysfunction" as a disorder that limits daily life and social activities due to cognitive dysfunction caused by organic brain pathology [2]. Higher brain dysfunction includes aphasia, apraxia, memory impairment, executive dysfunction, attention deficits, and psychomotor impairment [3]. Among these, attention deficits appear in 46%–92% of patients after acute stroke [4]. They are difficult to recognize, and such "hidden" symptoms may be misinterpreted by others as laziness [5]. A previous study reported that the discomfort patients felt, such as the feeling that their home "did not feel like home" after discharge from the hospital, may also be an effect of attention deficits [6]. Therefore, patients with attention deficits may experience difficulties after discharge from the hospital, even if they are independent in Activity of Daily Living (ADL) in

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the controlled hospitalization environment. In addition, family members may be confused and find it challenging to accept attention deficits and higher brain dysfunction that appear in daily life [7].

Therefore, it is crucial to clarify the experiences of stroke survivors with attention deficits after discharge from hospital such as how they start living at home and how they adjust to life at home. It has been reported that stroke survivors with attention and memory impairments struggled with anxiety in their daily lives one year after stroke onset, and leisure activities were necessary for coping with anxiety [5, 8]. However, these reports were cross-sectional surveys conducted one year after the onset. Longitudinal studies on how patients experience anxiety immediately after hospital discharge are necessary.

The present longitudinal study aimed to investigate how stroke survivors with attention deficits experience life after hospital discharge. We believe the findings will help provide post-discharge support and discharge guidance during hospitalization in rehabilitation hospitals.

Methods

Methodology

To describe the experiences of stroke survivors, we used Trajectory Equifinality Modeling (TEM) to visualize their experiences [9, 10]. TEM is a qualitative research methodology developed by Sato et al. that depicts the path of actions and choices experienced by people over time. Arrows indicate the flow of time as "Irreversible Time," characterized by the setting of important "points" in drawing the path of experience. The "Obligatory Passage Point (OPP)" is the point that most people are expected to experience action or choice, and the "Bifurcation Point (BFP)" is the point where the paths of each individual diverge due to the selection of different values in the flow of time. The point of convergence under the influence of various contexts is the "Equifinality Point (EFP)," and the point of value conflict with the EFP or not experienced is the "Polarized EFP (P-EFP). The "virtual path" is depicted as a theoretically possible path that has not occurred, allowing for a richer understanding of the diversity and complexity of experience. "Social Guidance (SG)" refers to the surrounding support and forces that promote individual choice and action toward EFP. In contrast, "Social Direction (SD)" refers to the restraining forces from the surroundings that inhibit individual choice and lead away from EFP.

Participants

Participants in this study were stroke survivors with attention deficits who were discharged home from a convalescent rehabilitation ward and their primary caregivers. In the present study, we included primary caregivers as participants to obtain a multidimensional view of the living conditions of stroke survivors [12]. To focus primarily on the impact of attention deficits on their lives, we required that participants were independent in ADLs during hospitalization. The inclusion criteria for stroke survivors were: (1) first stroke, (2) a score of 21 or higher on the revised Hasegawa Disability Test (HDS-R) at the time of discharge, (3) below the cutoff for each age group on the Trail Making Test (either part A or part B), (4) a score of 5 or higher on the motor item of the Functional Independence Measure at discharge, (5) no aphasia or apraxia and no communication problems, and (6) stroke survivors living with their spouse after hospital discharge. The inclusion criteria for the primary caregiver were: (1) spouse of a stroke survivor and (2) no communication problems.

Five stroke survivors and their spouses were included using these criteria; however, due to the spread of COVID-19, two subjects withdrew, and three were ultimately eligible. All participants were male stroke survivors. The Kobe Gakuin University Research Ethics Review Committee approved this study (No. 19–16).

Data collection

Information at the time of admission was collected from the therapist in charge. Interviews were conducted at home, where the research participants talked to the patient three times (one, three, and six months after discharge). A semi-structured interview guide was set up, and the participants were asked to freely talk about: (a) difficulties in their current life, (b) what they were doing well after discharge, and (c) how the rehabilitation at the hospital had been helpful. In response to abstract answers, we tried to deepen the content by asking follow-up questions such as "When did you experience that?" or "Why do you think so?". The interviewer was the first author. The interviewer mainly interviewed the stroke survivors. Their wives were also interviewed for supplementary information. The Barthel Index (BI) was used to assess the progression of ADLs in stroke survivors. Stroke patients responded to 10 items of basic ADLs on a scale consisting of "independent", "partially assisted", and "fully assisted". The Frenchay Activities Index (FAI) was used to assess Instrumental Activity of Daily Living (IADL). Respondents were asked to indicate the frequency of performing 15 items related to applied daily tasks and social life on a 4-point scale from 0 to 3. The total scores ranged from 0 (inactive) to 45 (active) [13]. The data collection period was between January 2019 and December 2020.

Table 1 Participant characteristics and data collection

Stroke Survivors		Mr. A	Mr. B	Mr. C
Diagnosis		CH, left hemiplegia	CI, left hemiplegia	CI, left hemiplegia
Age		40s	50s	70s
Employed at time of stroke (Contents of work)		Yes (Automobile selling)	Yes (Electrical construction)	No
First interview time after onset		4 months	4 months	5 months
HDS-R		29	26	29
TMT-J	A/B	139 sec/190 sec	116 sec/Not feasible	70 sec/131 sec
FIM	Motor/Cognitive	90/35	88/31	90/35
BI[1]	1 month	100	95	100
	3 months	100	95	100
	6 months	100	95	100
FAI[1]	1 month	24	3	22
	3 months	26	3	18
	6 months	27	5	33
Wife				
Age		40s	50s	70s
Work		full-time	part-time	homemaker

CI: Cerebral infarction; CH: Cerebral hemorrhage; TMT-J: Trail Making Test, Japanese edition; FIM: Functional Independence Measure. Maximum scores: HDS-R: Hasegawa dementia rating scale-revised = 30; BI: Barthel Index = 100; FAI: Frenchay Activities Index = 45.
[1] After the interview, the interviewer evaluated the stroke survivors according to the evaluation table.

Data analysis

A verbatim transcript was created from all interview data. The verbatim transcripts were imported into MAXQDA Analytics Pro 2020 for management and analysis. They were divided into semantic clusters and assigned a heading. Headed content clusters were compared and categorized based on similarities and relationships to create categories [14]. The categories were repeatedly modified using the MAXQDA tree structure. TEM diagrams were created at the end of each interview, and they were checked with the participants at the beginning of the next interview to ensure the accuracy of the results. After the second interview, the same procedure was used to create another TEM diagram, and the second TEM diagram was added to the TEM diagram obtained in the first interview. After the third interview, the same procedure was followed to complete a set of TEM diagrams. The sets of TEM diagrams of the three patients were then laid out, and the characteristics and commonalities of each path were used to generate OPP and BFP. The first author first prepared the TEM diagrams, and then the possible theoretical paths and concepts were entered into the TEM diagrams with the co-authors. The interview data were checked whenever a question arose.

Results

Characteristics of the participants, ADLs, and IADLs are shown in Table 1. The three stroke survivors received occupational therapy during their hospitalization, which included functional restoration training and instruction on how to cope with attention deficits in ADL situations. After discharge from the hospital, all three participants were almost independent in ADLs. Mr. B had not been performing household chores since before the onset of the disease, and his FAI was low. The following is a description of the post-discharge process of the three participants based on the TEM diagram (Fig. 1).

Mr. A's post-discharge process (total interview time 185 minutes)

He had a strong desire to return to work before his discharge from the hospital. He continued outpatient rehabilitation to recover his physical function after discharge. In his post-discharge life, he felt "differences" from his pre-disease life such as "it used to take me one or two minutes to change my clothes, but now it takes me five minutes" (OPP). As he discussed his return to work with his workplace supervisor and occupational physician, his anxiety grew because of the ambiguity of his work hours and the fact that he could not obtain permission to commute to work by private car (SD). This anxiety came to him as "waves".

Three months after discharge from the hospital, he returned to work but was too occupied to perform his duties. At work, he found that he was "confused" when his coworkers "said this and that" to him (OPP). Despite this confusion, he became accustomed to his job and accumulated daily tasks. He hoped to return to his old life in about one year. He also enjoyed coaching his youth baseball team, which he had been doing before his illness. However, when the team's coaches asked him to prioritize taking care of his body, he decided to quit

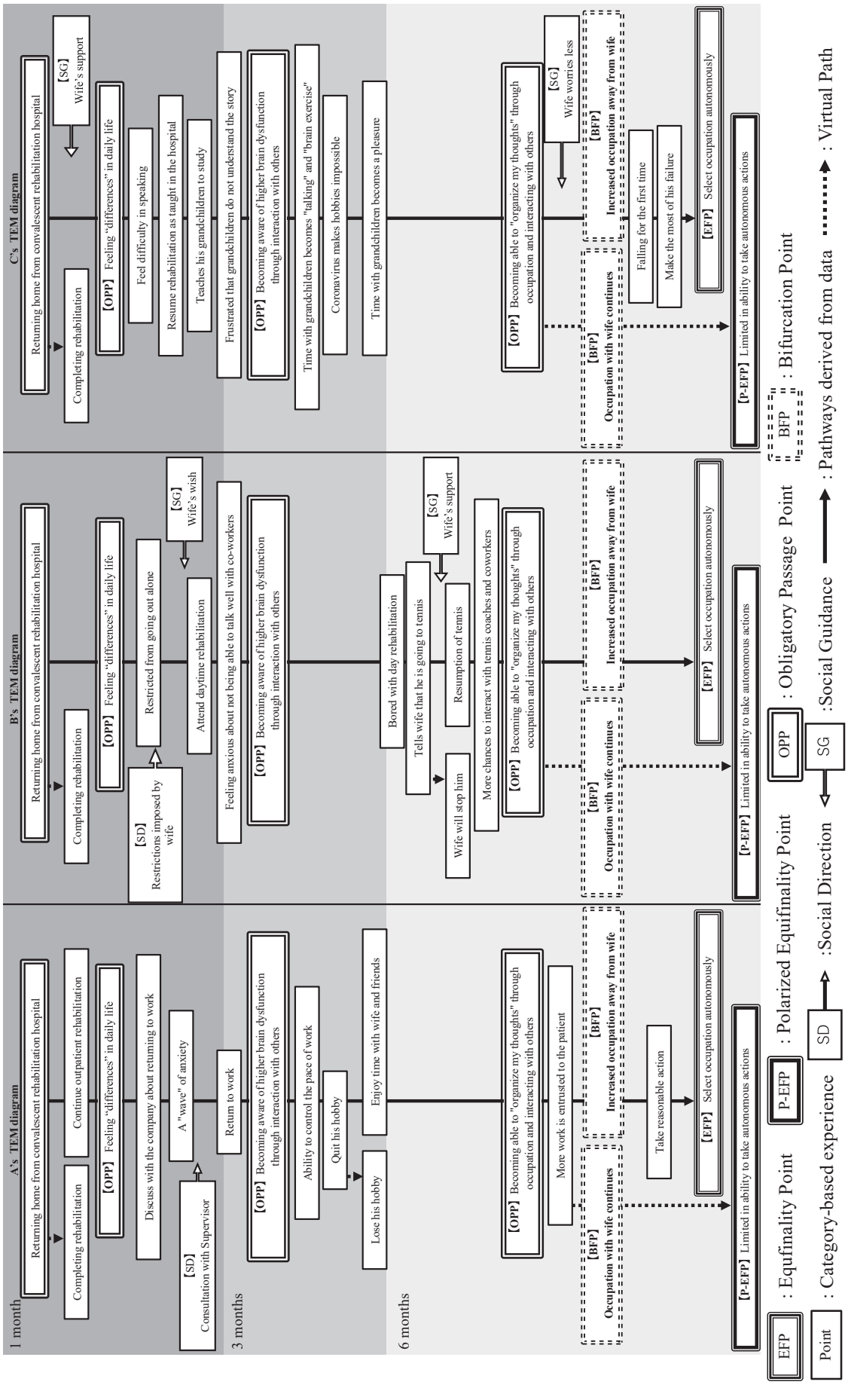

Fig. 1. TEM diagram of three people showing the route after discharge.

coaching. The loss of his role led him to take a trip with his wife and try boat fishing with his friends, which he said he wanted to do before he became ill again. At this time, he said, "I had more time to relax."

Six months after discharge from the hospital, he could "think of all the priorities in my head" at work (OPP). He said: "Even if I have something to do in between, I will also think about that." He was gradually entrusted with more and more work at his workplace and became involved with many other people, and the amount of occupation he did away from his wife increased (BFP). By this time, he had come to feel that he did not have to force himself to work, saying, "I think that I can quit my job anytime I want, and that makes me feel better." Rather than viewing his stroke experience pessimistically, he seemed to be choosing to take part in occupation autonomously (EFP) while accepting his condition. Through these experiences, he reached EFP.

Mr. B's post-discharge process (total interview time 156 minutes)

One month after discharge from the hospital, he said that he sometimes "gets stuck in his thoughts," but "nothing is troubling me." However, as the interview continued, he said, "When I went to the bathroom, my left shoulder hit the wall a little" (OPP). Moreover, his wife had restricted him from going out because it was dangerous for him to do so alone (SD).

Three months after being discharged from the hospital, he began attending day-care rehabilitation on his wife's advice (SG). He also noticed higher brain dysfunction (OPP) due to his experience of not being able to talk well with his co-workers and had vague concerns about whether he would be able to return to work.

Six months after discharge from the hospital, he became bored with the repetition at the day rehabilitation center (BFP). His only opportunities to go out were to attend rehabilitation and take walks with his wife. He became frustrated with these restrictions as well. He suddenly told his wife, "I'm going to play tennis tomorrow" (BFP). His wife was surprised, but she made a reservation at her old tennis club and resumed playing tennis (SG). Looking back on that time, his wife said, "I had told him not to because I was afraid, but I felt that for my husband's sake, I could not just forbid him to play." Around this time, he began to have more opportunities to talk with his friends who came to see him at home, his colleagues at work, and his tennis school coach. Through these relationships with others besides his wife, he could "organize my thoughts" and was no longer troubled by conversations (OPP). He also began to do more occupation away from his wife (BFP). During tennis practice, he used the metaphor of a ball flying from the left side as an invisible "magic ball" and said, "I don't force myself to return a ball that I can't catch up with. I give up." Despite previously saying he had no trouble, the patient gradually understood his condition and took action (EFP). Through these experiences, he reached EFP.

Mr. C's post-discharge process (total interview time 166 minutes)

During his hospitalization, his therapist pointed out that he was at risk of falling due to poor balance; however, he did not understand why. Therefore, his wife accompanied him on his walks after he was discharged from the hospital and reminded him to take a rest from time to time (SG). After being discharged from the hospital, he experienced difficulty encountering people suddenly during a walk and difficulty speaking with his wife. These experiences that he did not experience during his hospitalization made him "different" in how he viewed and communicated his illness (OPP). This led him to resume the rehabilitation he had been taught at the hospital. Furthermore, he resumed teaching his grandchildren who lived nearby how to study, which he had been doing for some time.

Three months after leaving the hospital, he found himself feeling "frustrated" (OPP) because he had difficulty communicating with his grandchildren. On the other hand, he also noticed that time with his grandchildren was an exercise in talking and "mental gymnastics." During this next period, because he could not go to his hobby of karaoke due to COVID-19 restrictions (SD), he looked forward to spending time with his grandchildren, saying, "teaching my grandchildren how to study is also good practice for my speech."

Six months after discharge, he was more relaxed in his daily life and "able to think and prioritize one thing while doing another" (OPP). Gradually, he began to walk by himself more often (BFP), and his wife felt comfortable letting him go out as long as he was close by (SG). When he went shopping alone at a local supermarket, he fell for the first time since being discharged from the hospital. However, he laughed as he recounted the incident and calmly analyzed the reason for his fall. Since then, he has been going out alone without another fall. He could analyze and act on his fall, which was an unexpected failure. The experience of being away from his wife allowed him to think about actions and choices that would lead to future successes (EFP).

Discussion

Post-discharge experience of male stroke survivors with attention deficits

Yasuda et al. reported that in an analysis of four ± one subjects, "diversity of experience is drawn" using TEM [11]. Diversity is the breadth of experience, and by drawing the paths of multiple people using TEM, we can see the diversity of paths among the patients and capture overlaps and common paths and points [11]. From our findings, we believe that our report was able to depict a small amount of post-discharge diversity in male stroke survivors with attention deficits. In this study, based on the post-discharge experience of male stroke survivors with attention deficits in a rehabilitation hospital, three OPP of passage were identified: *feeling "difference" in daily life, becoming aware of higher brain dysfunction through interaction with others, and becoming able to "organize my thoughts" through occupation and interacting with others*. Furthermore, "increased occupation away from the wife" and "occupation with the wife continued" were identified as BFP, and "select occupation autonomously" as EFP.

Feeling "difference" in daily life

In previous longitudinal studies after stroke, it has been reported that mild stroke survivors encountered "differences" from before [1, 6]. It has also been reported that stroke survivors with impaired attention and memory may differ from others' evaluations of their abilities and experience increased sensitivity and unpredictability to environmental conditions [5, 8]. The participants in this study commonly experienced that a month after discharge from the hospital as an OPP, they realized that they were "different" from before and that they could no longer do things the same way they had learned to do during their hospitalization.

Becoming aware of higher brain dysfunction through interaction with others

Experiences of "confusion (A)," "anxiety (B)," and "frustration (C)" in interactions with others were perceived to be the effects of higher brain dysfunction. Crosson et al. reported that there is a hierarchy of awareness in higher brain dysfunction, with intellectual awareness (basic knowledge of brain injury and its effects) at the bottom, and emergent awareness (the ability to recognize when a problem is occurring) and anticipatory awareness (the ability to anticipate the possibility of a problem occurring) at higher levels [15]. It is possible that the stroke survivors' intellectual and experiential awareness was enhanced by their involvement with others. In addition, creating "planned failures" has been recommended to promote such awareness [16]. However, Richardson reported that family members do not always point out a patient's errors because they do not want to hurt the person's feelings, and patients often do not accept these points [17]. This suggests that occupational therapists should design planned "failures" from the time of hospitalization and that reflecting on these failures with the stroke survivor promotes awareness. Furthermore, after discharge from the hospital, it is important to accumulate new experiences through interactions with familiar others. The three stroke survivors were also prompted to have "awareness" of their interactions with others other than their wives after discharge from the hospital, suggesting that, similar to the previous literature, attention deficits may be less likely to surface in habitual daily life.

Becoming able to "organize my thoughts" through occupation and interacting with others

The stroke survivors resumed specific occupations around three months after discharge, which included a new occupation for one patient (A: boat fishing with friends), and occupations that the participants had previously performed for two patients (B: tennis as a hobby, C: teaching his grandchildren how to study). A systematic review of the literature on the role of occupation of head trauma patients indicates that participation in occupation enhances insight into awareness of disability, and continued participation in occupation may not only enhance one's awareness but may also contribute to improved occupation capacity [18]. These experiences of interacting with others and engaging in an occupation were thought to have led to "organizing my thoughts," in which information was summarized, things were prioritized, and reflection took place.

Increased occupation away from the wife, occupation with the wife continues, select occupation autonomously, limited in ability to take autonomous action

In the present study, the BI and FAI of stroke survivors did not change significantly during the six months studied. However, from the interview analysis, we could capture a path of experience that BI and FAI could not capture. A cross-sectional study of community-based stroke patients reported that TMT assessment correlated with ADLs and IADLs, but recommended a combination of pen-and-paper and performance-based assessments for more accurate assessment [19]. This suggests that in addition to the various assessments, it is also important to consider qualitative analysis that focuses on the experiences of the parties involved.

After discharge from the hospital, the three OPP led to a BFP of increased occupation away from their

wives/continued occupation with their wives. In other words, the stroke survivors' experiences after discharge from the hospital may be viewed as a re-establishment of the relationship with their spouse. With this BFP, all three participants in this study increased their occupation away from their wives and their opportunities for self-selection, leading to EFP. Autonomy includes executional autonomy, in which one can act as one wishes, and decisional autonomy, in which one can make decisions without being constrained by external factors [20]. However, as Mr. B's wife said, if her husband was restrained by her, such as her telling him, "No, I'm afraid" or "It's prohibited," and he "continued occupation with the wife," there is a possibility that he would be "limited in ability to take autonomous action." By assuming this P-EFP, we could show the importance of supporting not only the autonomy of the stroke survivors but also the process of transformation by the primary caregiver and the patient.

Support for stroke survivors with attention deficits and their primary caregivers

We found that the subjects in this study experienced the same OPP simultaneously in different and diverse experiences. This can contribute to support for stroke survivors and primary caregivers. For example, after repeated practice in the same environment during hospitalization, the participants may be able to experience some of the "differences" expected after discharge from the hospital by performing tasks that incorporate "planned failures" in an environment similar to real-life situations. It has been reported that the effectiveness of errorless learning or trial-and-error learning for stroke survivors with higher brain dysfunction may depend on the nature of the task [21]. An important issue is what balance of "planned failure" to incorporate. In addition, around six months after discharge from the hospital, the patients could "organize my thoughts" and make self-selections through interactions with others close to them. The hypothetical pathway the three pairs did not go through this time was the pathway of continued behavioral restrictions from the wife to avoid danger or the stroke patient's inability to act independently from his wife, leading to P-EFP. All three wives were happy to have time to work on occupation. Mr. A tried to take it easy when he was alone, and Mr. C reflected on his fall and prepared for the next one. We believe that risk management and self-monitoring skills for dangerous environments that may be encountered as the occupation expands are important occupational therapy supports during this period.

Limitations of study

The first limitation of this study is the small number of study participants. Three pairs of male stroke survivors and their wives were included in the study, which is the minimum number to portray a diversity of experiences. A previous study reported that nine ± two people are needed to ascertain the typology of pathways [11]; thus, future research should be conducted with a larger sample size. Second, future studies are needed to compare the results with female stroke survivors because the stroke patients in the present study were all male. Third, the present study could not assess unilateral spatial neglect (USN) other than attention deficits in detail. Although marked USN was not suspected at the time of the interview, it can be inferred from Mr. B's narrative, such as his left shoulder hitting the wall, that he may have had symptoms of USN. A further detailed evaluation is needed.

Conclusions

This study qualitatively analyzed the life experiences of male stroke survivors with attention deficits from a rehabilitation hospital in the first six months after discharge using TEM. Attention deficits, which stroke survivors were largely unaware of during hospitalization, became apparent in activities involving interpersonal interaction immediately after discharge. The stroke survivors became aware of their higher brain dysfunction through interactions with others other than their wives. Each participant gained deeper insight into their disorder through participation in occupation. These results suggest the importance of involving others besides the wife through daily tasks in occupational therapy programs for stroke survivors.

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■ORIGINAL ARTICLE

Cross-Regional Validation of the Assessment of Positive Occupation 15: Differential Item and Test Functioning Analysis

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Abstract: Aims: This study aimed to validate the Assessment of Positive Occupation 15 (APO-15) by differential item functioning (DIF) and differential test functioning (DTF).
Method: Participants were to obtain research cooperation from individual clinics, community healthcare institutions, and home-visit rehabilitation services. The inclusion criteria for participants were people between the ages of 20 and 90 years who were diagnosed with mental illness, physical illness, or geriatric illness and agreed to participate in the study. In this study, the face sheet and APO-15 were distributed to the participants, and they were asked to respond.
Results: A total of 3003 participants were included in this study. The mean age was 67.41 (±16.63) years (≥ 75; 1168 and ≤ 74; 1835). Regarding the gender of participants, 1565 were males and 1438 were females. Considering illness, 1184 participants had a mental illness, 897 had a physical illness, and 922 had a geriatric illness. The results of the DIF and DTF suggested that the APO-15 did not differ in the response pattern of the scale due to the influence of subgroups (illness, gender, and age).
Conclusion: The APO-15 suggests the potential to provide measurement results with a good level of scale validity and robustness.

Keywords: well-being, occupational participation, evaluation scale, validity, occupational engagement

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Introduction

The occupational therapy field has emphasized the importance of promoting well-being through meaningful occupation for clients [1, 2]. Several self-report assessments have been developed to evaluate the relationship between occupation and well-being, including the Canadian Occupational Performance Measure and Occupational Self-Assessment [3, 4]. By using these evaluations in the occupational therapy process, occupational therapy practitioners and researchers can identify meaningful occupations for clients, develop occupation-based intervention plans, and enhance the well-being of clients. However, an occupation that enhances well-being includes participation in an occupation that is meaningful to the individual client and designed to improve or maintain well-being [5, 6]. Thus, occupational therapists need to be able to assess participation in an occupation related to the development, management, and maintenance of well-being in daily activities [7].

Well-being is defined as the perceived state of harmony in all aspects of one's life [1]. Dodge et al. (2012) [8] also define it as the balance point between an individual's resource pool (psychological, social, and physical) and the challenges faced (psychological, social, and physical). Therefore, well-being, as used in this study, is defined as a state of balance with the challenges faced in a good physical, mental, and social state, with or without illness. Furthermore, well-being is an important outcome according to the fourth edition of the Occupational Therapy Practice Framework: Domain and Process (OTPF-4), which establishes a common understanding of occupational therapy [9]. The

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OTPF-4 was developed to articulate the core concepts of occupational therapy and proposes the categories of occupations, including work, play, leisure, activities of daily living, instrumental activities of daily living, education, social participation, health management, rest, and sleep [9]. The OTPF-4 also suggests interventions to enhance well-being, including occupations, activities, interventions to support occupations, education, and training [9]. The OTPF-4 emphasizes the role of occupational therapy in achieving the outcome of well-being through these occupations. However, in the occupational therapy field, self-report assessments are focused on assessing meaningful occupations for individual clients in occupation-focused assessments. Therefore, the occupational therapy field needs to develop a scale that can measure participation in occupations that are designed to improve or maintain human well-being.

To contribute to the above challenges, we have developed the Assessment of Positive Occupation 15 (APO-15) to measure participation in occupations that promote human well-being [10–12]. The theoretical background of the APO-15 is the PERMA model in positive psychology. The PERMA model is a theory attempting to understand the state of well-being in individuals based on five domains: P (positive emotion), E (engagement), R (relationship), M (meaning), and A (achievement) [13]. The APO-15 is unique in that it uses occupations that promote well-being as scale items based on the findings of positive psychology. The APO-15 was examined for scale characteristics based on statistical evidence, validity [exploratory factor analysis, confirmatory factor analysis, and hypothesis testing (convergent validity, discriminant validity, and criterion validity)], reliability [internal consistency reliability and item response theory (IRT)], and interpretability [receiver operating characteristic and latent rank theory]. The APO-15 can be used in the areas of mental illness, physical illness, and geriatric illness [10–12].

In previous studies, differential item functioning (DIF) has been reported in occupation-related assessments used in occupational therapy, and cultural differences have been reported to be influential in causing this [14–17]. Culture is the integrated pattern of human behavior that includes thoughts, communications, actions, customs, beliefs, values, and institutions of a racial, ethnic, religious, or social group [18]. Additionally, factors that affect DIF are not only culture but also gender, age, and illness [14–17]. Because of the above factors, it is expected that the APO-15 will also allow DIF and differential test functioning (DTF), but this has not been verified. If DIF is found, it threatens validity because the scale may be measuring something different from the construct it is trying to measure. Methods for detecting DIF can be broadly classified into those based on IRT and those that are not [19]. Representative methods not based on IRT include the Mantel-Haentszel [20] and logistic methods [21]. On the other hand, representative methods based on IRT include the Lord method [22], the Raju method [23], and the likelihood ratio test method [24]. In the detection of DIF, the choice between the two methods is determined by the sample size. The method based on IRT is superior to the method not based on IRT in the interpretation of results because it detects DIF with high test power, but it requires a large sample size [19]. In addition, the one-dimensionality of the scale must be assumed when using IRT-based methods. Some of the measures that confirm one-dimensionality are, for example, confirmatory factor analysis, local independence, latent monotonicity, and polynomial correlation coefficients [25–28]. It is also important to check for DTF as well as DIF. DTF is important because it is based on the performance of the entire test, not just individual items [29, 30]. However, the APO-15 at this stage has not been translated into English, for example, so that it can be used by people from different cultures. Therefore, we first need to examine measurement invariance in Japanese clients to see if there are any differences in their tendency to respond to the constructs measured by the APO-15. Thus, this study aims to clarify whether the response pattern of APO-15 is affected by subgroups (illness, gender, and age) and clarify the validity of the scale by examining the DIF and DTF. More specifically, we aim to contribute to the validation of the usefulness of the APO-15 by answering the following research questions:

1. Do the APO-15 item difficulty calibrations differ in subgroups (illness, gender, and age)?
2. Does it affect the quality of the APO-15 measurement results (i.e., is there evidence of DTF)?

Methods

Ethics statement

This study was approved by the Ethical Review Committee of Zikei Hospital No.124 (29-2). This study was conducted by explaining the outline of the study at the conference and recruiting cooperating facilities. Those facilities that agreed to cooperate in the study were asked to introduce other cooperating facilities by purposive selection so that research cooperation could be obtained from many participants. Both written and verbal informed consent was provided by all participants before participation. Participation was voluntary, and participants had the right to withdraw from the research at any time without providing any reason. The study period was from May 2017 to August 2020. This study

was conducted in accordance with the Declaration of Helsinki.

Participants and procedures

In this study, data were collected from individuals who were diagnosed by doctors as having a mental illness, physical illness, or geriatric illness (e.g., angina pectoris, arteriosclerosis obliterates, hypertension, diabetes, renal insufficiency, cancer) and who use hospitals, institutions, and home-visit rehabilitation services. The selection criteria included (1) those who had been diagnosed with the above-mentioned illnesses, (2) those who were between 20 and 90 years of age, and (3) those who agreed to participate in this study. The exclusion criteria included (1) those who were having an unstable medical condition and those who were judged by the doctor or facility manager as impossible to cooperate and (2) those who did not agree with this study. For the recruitment of the subjects, posters showing the outline of the study were displayed in the hall and other easily visible places, and subjects were asked to participate of their free will. Also, subjects who expressed interest in the study were individually presented, a guide describing the study's content was reviewed with them, and their consent was obtained. The research assistants were registered, occupational therapists.

Measures

Demographic information

Demographic information, including age, gender, and living environment, was collected. The research collaborator wrote the participant's name of a diagnosis and level of care on the survey form.

APO-15

The APO-15 is a self-report assessment of occupational participation to promote well-being (Table 1). The APO-15 is a 15-item measure of the state of positive occupational participation based on four factors, namely, positive relationship (5 items), achievement (4 items), meaning (3 items), and engagement (3 items). Positive relationship is defined as deriving happiness and satisfaction from human relationships. Achievement is defined as an attempt to complete a target in life. Meaning is defined as significance found in activities and life. Engagement is defined as the flow experienced and the process leading to it. The APO-15 assesses 15 items on a 4-point Likert scale (1 = disagree and 4 = agree). High total scores are related to a higher degree of well-being through positive occupational participation [10–12].

Table 1 15 items of APO

1. I have the motivation to fulfill my hope
2. I have a goal that I want to achieve
3. I'm currently making efforts to achieve my goal
4. I can communicate well with people and work with them to achieve my goals
5. I can make an effort to achieve my long-term goals rather than my momentary profits
6. I feel supported by the people surrounding me
7. I can concentrate on my favorite activities
8. I live my life the to the fullest
9. I live my life according to my values
10. When I come across people who are in trouble, I want to help them immediately
11. I feel fulfilled when we can help each other with the people around me
12. I'm making an effort to be able to concentrate
13. I can concentrate on my hobbies
14. I always try to see the bright side of things
15. I take an active role in making decisions that shape my life

Note. The four factors of the APO-15 are positive relationship (items = 4, 6, 10, 11, 14), achievement (items = 1, 2, 3, 5), meaning (items = 8, 9, 15), and engagement (items = 7, 12, 13).

Statistical analysis

We conducted analyses to examine the validity of the scale in the APO-15 to (1) confirmation of one-dimensionality and (2) detect DIF and DTF based on IRT.

Sample characteristics

Regarding the age of the participants, the mean and standard deviation were calculated. Also, frequencies and percentages were calculated for participants' gender, illness, diagnosis, living environment, and care level. The statistical software used was HAD 16 (http://norimune.net/had).

Confirmation of one-dimensionality

In this study, we checked whether APO-15 meets the conditions for IRT-based DIF detection. IRT measures a single latent variable. Therefore, we checked whether the APO-15 met the conditions for one-dimensionality using confirmatory factor analysis (CFA), local independence, latent monotonicity, and polynomial correlation coefficient of item scores.

1) Structural validity

The one-factor solution of APO-15 was determined by performing CFA using a weighted least squares estimation with mean and variance (WLSMV), with missing data. WLSMV is suitable for the analysis of categorical data. We used three indices to assess the model fits of CFA based on APO-15 factor structures. The first index was the root mean square error of approximation (RMSEA), with critical values of 0.08–0.10, indicating

a mediocre fit, and those of < 0.08 indicated a good fit [31]. The second and third indices were the comparative fit index (CFI) and the Tucker-Lewis index (TLI), with critical values above 0.95 [32]. The statistical software lavaan 0.6–9 in R 3.2.3 (https://www.r-project.org).

2) Local independence

Local independence was estimated using Yen's Q3 statistic. Yen's Q3 statistic is the correlation between the residuals of categorical factor analysis. The judgment of the results is that the assumption of local independence is satisfied if the absolute value is less than 0.36 [33]. The statistical software mirt 1.34 in R 3.2.3.

3) Latent monotonicity

Latent monotonicity refers to a situation in which items are in a monotonic relationship with the construct, and each response category has the largest probability of selection on a unique interval. That is, we check to see if a situation is established in which people with higher characteristic values choose higher alternatives than people with lower values. In this study, we used manifest monotonicity to check latent monotonicity by mokken scaling analysis (MSA), a one-model of nonparametric IRT [34]. The judgment of MSA is that if the H coefficient is large and the rejection rate of the assumption of latent monotonicity is low, it indicates manifest monotonicity. The criterion values for the H coefficient are judged to be > 0.3 [weak], > 0.4 [medium], and > 0.5 [strong] [34]. The statistical software mokken 3.0.6 in R 3.2.3.

4) The polynomial correlation coefficient of item scores

Polynomial correlation coefficients of item scores determined that the scale was unidimensional if the criterion value was 0.2 or higher [28]. The statistical software used was Exametrika 5.3 (http://antlers.rd.dnc.ac.jp/~shojima/exmk/index.htm).

DIF and DTF detection

The COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) considers DIF as one of the validity studies [35]. In this study, the DIF detection based on IRT was performed using the statistical software EasyDIF (http://irtanalysis.main.jp) [36]. EasyDIF can be used for IRT parameter estimation with a graphical user interface so that users can use it without feeling the barrier of complicated analysis [36]. EasyDIF calculates the index K through the detection of DIF based on IRT [36]. Index K is the area of the region between the two sets (maximum and minimum) of item expectation category characteristic functions in multilevel data, weighted by the overall population distribution [36]. It represents the expected value of the difference in response patterns among subpopulations for each item. The criterion value for index K is as follows: (number of categories –1) × 0.1. Items exceeding this value are considered DIF items [36]. The index K shows a very high correlation with the conventionally used DIF detection methods, confirming the results as a reliable index [36].

In this study, the data collected by the APO-15 were analyzed for the detection of DIF based on IRT by dividing the data into three subgroups: illness (three pairs: mental illness, physical illness, or geriatric illness), gender (two pairs: male or female), and age (two pairs: ≥ 75 or ≤ 74). The reason why the age group is divided into 75 years old is that many people consider 75 years old or older to be elderly according to the survey by the Cabinet Office [37]. The APO-15 used in this study is divided into four categories, so if the index K is ≥ 0.3, it is considered a DIF item. In the detection of DIF based on IRT, it is difficult to obtain stable results unless the sample size is large [19]. Therefore, the sample size of the two groups combined should be > 500, and the sample size of the group with a smaller number of people should be > 100 [38]. The statistical software lordif 0.3–3 in R 3.2.3 was used to plot the DTF from the aggregated APO-15 total scores.

Results

Sample characteristics

Participants lived in seven of the eight Japanese regional categories. A total of 3003 participants were included in this study. The overall age was 67.41 ± 16.63 years: age ≥ 75; 1168 (38.89%) and age ≤ 74; 1835 (61.11%) (Table 2). As regards the gender of the participants, 1565 (52.11%) were males and 1438 (47.89%) were females. The participants were classified by illness: mental illness 1184 (39.43%), physical illness 897 (29.87%), and geriatric illness 922 (30.70%). In this study, the number of participants met the sample size required for the detection of DIF in all subgroups (illness, gender, and age). The other results are shown in Table 2.

Confirmation of one-dimensionality

1) Structural validity

The CFA of the one-factor solution in APO-15 provided a good estimate of the goodness of fit of the model (RMSEA = 0.063; CFI = 0.971; TLI = 0.966).

2) Local independence

The local independence of APO-15 met the criterion with Yen's Q3 statistic ranging from −0.222 to 0.360.

Table 2 Participant Characteristics (n = 3003)

	Characteristics	Mean (±SD)	Total (%)
Age	Overall	67.41 (±16.63)	
	≥ 75		1168 (38.89%)
	≤ 74		1835 (61.11%)
Gender	Male	63.39 (±16.01)	1565 (52.11%)
	Female	71.84 (±16.17)	1438 (47.89%)
Illness	Mental illness	55.28 (±14.61)	1184 (39.43%)
	Physical illness	66.94 (±12.22)	897 (29.87%)
	Geriatric illness	83.57 (±5.50)	922 (30.70%)
Diagnostics	Mental		1224 (40.76%)
	Cerebral nerve		698 (23.24%)
	Orthopedic		670 (22.31%)
	Internal		167 (5.56%)
	Neurology		166 (5.53%)
	Other		78 (2.60%)
Care level	No certification		1396 (46.47%)
	Support 1		251 (8.36%)
	Support 2		312 (10.39%)
	Care 1		336 (11.19%)
	Care 2		426 (14.19%)
	Care 3		175 (5.83%)
	Care 4		81 (2.70%)
	Care 5		26 (0.87%)
Living environment	Single life		509 (16.95%)
	Living together with family		1635 (54.45%)
	Hospital & Facilities		859 (28.60%)

Note. SD = Standard Deviation
By most common diagnoses; Mental (schizophrenia, mood disorder, pervasive developmental disorder), Cerebral nerve (cerebrovascular disease, cerebral contusion, subdural hematoma, spinocerebellar degeneration), Orthopedic (fracture, spinal canal stenosis, deformed knee joint), Internal (hypertension, diabetes, renal insufficiency, interstitial pneumonia, respiratory insufficiency, cancer), Neurology (myasthenia gravis, multiple sclerosis, Guillain-Barre syndrome), Other (rheumatism, hyperthyroidism, scleroderma, heart failure, angina pectoris, arteriosclerosis obliterates)

3) Latent monotonicity

The H coefficients of the APO-15 showed manifest monotonicity of > 0.3 for 3 items (item = 6, 10, 13) [weak], and > 0.4 for all other items [medium]. In addition, the proportion rejecting the assumption of latent monotonicity was 0.000 for all items. In other words, all items of the APO-15 were confirmed to be latent monotonicity.

4) The polynomial correlation coefficient of item scores

The one-dimensionality of the APO-15 was confirmed by the item score polyserial correlation coefficient, which showed that all items were > 0.2 (0.581 to 0.755). In other words, the APO-15 was shown to satisfy the condition of one-dimensionality.

DIF detection

The analysis showed that the APO-15 had no DIF items from the influence of subgroups (illness, gender, and age) in all items. Regarding illness, the results showed that all items of the APO-15 were item discrimination (mean: mental illness = 1.003, physical illness = 1.110, and geriatric illness = 1.052), item difficulty (mean: mental illness = −2.012 to 0.759, physical illness = −2.016 to 0.777, and geriatric illness = −1.963 to 0.831), and index K (0.066 to 0.290). There was no difference in the response patterns by illness (Table 3). Gender showed item discrimination (mean: male = 1.069 and female = 0.963), item difficulty (mean: male = −2.183 to 0.716 and female = −2.069 to 0.665), and index K (0.018 to 0.198) for all items of the APO-15. There was no difference in response patterns by gender (Table 4). Age showed item discrimination (mean: age ≥ 75 = 1.026 and age ≤ 74 = 0.995), item difficulty (mean: age ≥ 75 = −2.072 to 0.750 and age ≤ 74 = −2.149 to 0.726), and index K (0.045 to 0.291) for all items of the APO-15. There was no difference in response patterns by gender (Table 4). These results suggest that

Table 3 DIF detection (illness)

Item	K	Mental illness				Physical illness				Geriatric illness			
		slope	step1	step2	step3	slope	step1	step2	step3	slope	step1	step2	step3
item 1	.127	1.183	−1.525	−.402	.944	1.215	−1.637	−.536	1.001	1.111	−1.582	−.386	1.307
item 2	.290	.944	−1.767	−.689	.545	1.008	−1.738	−.691	.669	.801	−1.567	−.300	1.181
item 3	.154	1.132	−1.679	−.640	.744	1.280	−1.725	−.718	.672	1.065	−1.556	−.544	.939
item 4	.160	.905	−1.736	−.376	1.297	1.068	−1.790	−.614	.964	1.097	−1.706	−.567	.931
item 5	.066	1.174	−1.788	−.427	1.080	1.380	−1.657	−.477	.996	1.339	−1.526	−.401	1.028
item 6	.220	.731	−2.734	−1.528	.316	.765	−3.333	−2.243	−.144	.728	−3.321	−2.066	−.150
item 7	.243	.977	−2.350	−1.182	.193	.974	−2.510	−1.102	.435	1.023	−1.739	−.729	.592
item 8	.155	1.083	−2.101	−.969	.392	1.371	−2.043	−.904	.384	1.158	−2.619	−1.276	.207
item 9	.132	1.352	−1.740	−.626	.681	1.397	−1.932	−.603	.819	1.202	−2.190	−.890	.647
item 10	.146	.715	−2.760	−1.080	.898	.878	−2.486	−.925	.901	.967	−2.206	−.991	.491
item 11	.096	.855	−2.563	−1.238	.492	1.053	−2.363	−1.102	.656	1.217	−2.115	−.956	.487
item 12	.118	1.130	−1.710	−.562	.757	1.157	−1.648	−.428	.971	1.138	−1.545	−.387	.960
item 13	.226	.855	−2.000	−.785	.601	.785	−1.809	−.422	.999	.806	−1.525	−.441	.930
item 14	.206	.908	−1.871	−.182	1.481	1.170	−1.690	−.284	1.232	1.046	−2.069	−.495	1.039
item 15	.144	1.103	−1.853	−.526	.961	1.149	−1.877	−.505	1.096	1.075	−2.184	−.823	.892
Mean	.166	1.003	−2.012	−.747	.759	1.110	−2.016	−.770	.777	1.052	−1.963	−.750	.831

Note. slope = item discrimination, step = item difficulty, K = index K
The results of the analysis showed that the index K of all items of APO-15 was below the standard value (> 0.3) by illness.

Table 4 DIF detection (gender and age)

Item	K	male				female			
		slope	step1	step2	step3	slope	step1	step2	step3
item 1	.158	1.329	−1.652	−.583	.798	1.009	−1.711	−.464	1.245
item 2	.198	1.099	−1.810	−.746	.503	.707	−1.896	−.613	.916
item 3	.104	1.292	−1.697	−.740	.587	.968	−1.897	−.761	.839
item 4	.114	.977	−1.836	−.532	1.137	.988	−1.927	−.713	.874
item 5	.018	1.318	−1.885	−.532	.974	1.177	−1.708	−.551	.972
item 6	.167	.705	−3.261	−1.867	.224	.763	−2.962	−2.051	−.352
item 7	.096	1.009	−2.477	−1.240	.268	.878	−2.206	−1.046	.337
item 8	.109	1.207	−2.283	−1.070	.354	1.039	−2.486	−1.330	.109
item 9	.034	1.364	−2.032	−.778	.594	1.204	−1.994	−.821	.691
item 10	.164	.774	−2.759	−1.041	.929	.804	−2.684	−1.332	.450
item 11	.143	.937	−2.608	−1.179	.646	.983	−2.506	−1.388	.256
item 12	.088	1.148	−1.869	−.659	.779	1.071	−1.668	−.485	.839
item 13	.169	.817	−2.214	−.827	.669	.758	−1.680	−.531	.837
item 14	.065	.978	−2.155	−.392	1.337	1.014	−1.806	−.423	1.071
item 15	.034	1.078	−2.203	−.729	.945	1.087	−1.901	−.675	.885
Mean	.111	1.069	−2.183	−.861	.716	.963	−2.069	−.879	.665
Item	K	Age ≥ 75				age ≤ 74			
		slope	step1	step2	step3	slope	step1	step2	step3
item 1	.130	1.134	−1.617	−.440	1.211	1.189	−1.670	−.547	.824
item 2	.291	.837	−1.656	−.470	.986	1.020	−1.929	−.842	.397
item 3	.091	1.088	−1.711	−.670	.846	1.165	−1.781	−.739	.622
item 4	.070	1.015	−1.795	−.626	1.000	.925	−1.884	−.484	1.149
item 5	.045	1.277	−1.701	−.534	.985	1.180	−1.890	−.459	1.077
item 6	.069	.711	−3.213	−2.052	−.076	.752	−2.962	−1.742	.091
item 7	.228	1.044	−1.952	−.862	.511	.874	−2.763	−1.434	.116
item 8	.141	1.092	−2.630	−1.323	.215	1.158	−2.094	−.941	.390
item 9	.105	1.236	−2.180	−.892	.651	1.311	−1.848	−.627	.731
item 10	.098	.807	−2.689	−1.196	.641	.761	−2.680	−1.018	.892
item 11	.045	1.063	−2.433	−1.148	.492	.838	−2.640	−1.303	.541
item 12	.069	1.134	−1.624	−.487	.885	1.055	−1.924	−.608	.828
item 13	.173	.821	−1.688	−.510	.902	.735	−2.269	−.858	.646
item 14	.199	1.059	−2.047	−.512	1.081	.889	−1.928	−.175	1.553
item 15	.130	1.065	−2.147	−.843	.915	1.066	−1.978	−.479	1.033
Mean	.126	1.026	−2.072	−.838	.750	.995	−2.149	−.817	.726

Note. slope = item discrimination, step = item difficulty, K = index K
The results of the analysis showed that the index K of all items of APO-15 was below the standard value (> 0.3) by gender and age.

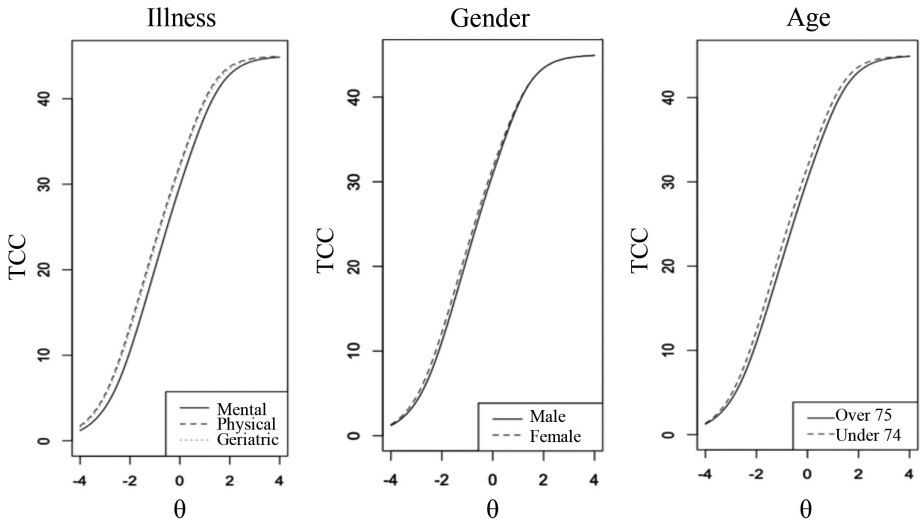

Fig. 1. DTF of APO-15.
Note. θ = latent ability level, TCC = Test Characteristic Curve
Test characteristic curves for all items of the APO-15 are shown for the subgroup (by illness, gender, and age). APO-15 is its focus on the level of participation in positive occupation. 0 more of the clients having a positive value is determined to be able to participate in the positive occupation. On the other hand, clients with a negative value of 0 or less are judged to be constrained from participating in positive occupations. The DTF for APO-15 confirmed that there was no difference between subgroups (by illness, gender, and age) according to the latent characteristic values of the clients, even when the overall performance of the test was used as a reference.

the APO-15 does not differ in response patterns for all items, even if there is an influence of subgroups (illness, gender, and age). Furthermore, we checked the DTF plot and confirmed that the total score of all APO-15 items was also measured without any subgroup effects (Fig. 1).

Discussion and implications

Consideration of one-dimensionality

In this study, we confirmed whether APO-15 can detect IRT-based DIF. Specifically, we used CFA, local independence, latent monotonicity, and polynomial correlation coefficients of item scores to check whether the APO-15 meets the condition of one-dimensionality. The results showed that the APO-15 satisfied the condition of one-dimensionality in all analyses. In other words, APO-15 was considered to be applicable for IRT-based DIF detection.

Consideration of DIF and DTF

This study aimed to determine whether the response patterns of the APO-15 were affected by subgroups (illness, gender, and age) and determine the validity of the scale by examining DIF and DTF. In other words, the study hypothesized that, regardless of client subgroup (illness, gender, and age), the tendency to respond to any item on the APO-15 would be the same.

The study results revealed that APO-15 did not show DIF items the reference value of index K (≥ 0.3) to the influence by subgroup (illness, gender, and age). The DTF of the APO-15 was also found to be adequate in the overall test performance without being affected by the subgroups. In other words, the APO-15 was likely able to capture the construct of "positive occupational participation" as the same concept across different subgroups. These results suggest that the APO-15 is composed of items that are not influenced by client subgroups (illness, gender, and age) as patient-reported outcomes and may not be region-dependent.

The reason for this may be that the DIF items were not found in the APO-15 because the clients who were participants in this study belonged to the same cultural background. Culture is an integrated pattern of human behavior that includes the thoughts, communication, behaviors, customs, beliefs, values, and institutions of a social group, as described above [18]. In occupational therapy, there is a belief that occupations have meaning, reflect cultural values, and shape an individual's identity, role, and perception of independence [39, 40]. That is, the participants in this study belonged to the same cultural background and did not differ in their perceptions of personal identity, role, and independence, which may have been reflected in their APO-15 response trends. Furthermore, the IRT-based DIF analysis results showed similar trends in item difficulty scores for all three subgroups (illness, gender, and age). In other words, the APO-15 scale items may be able to measure each client's state of participation in occupations that promote

well-being according to their abilities, beyond the influence of the three subgroups (illness, gender, and age).

Considering these factors, the measurement results of the APO-15, despite being limited to Japan at this stage of the investigation, may meet contemporary measurement standards while maintaining its integrity as an instrument for use in occupational therapy. That is, the APO-15 can be used as an occupation-focused assessment instrument that ensures fairness in testing in clinical and research settings.

Clinical implications

The results of this study support the absence of bias in APO-15 measurements by region, illness, age, or gender for occupational therapists using the APO-15 in Japan. In other words, the APO-15 suggests that the scale may have a good level of validity and robustness. Therefore, when the APO-15 is used in occupational therapy practice, it may contribute to clinical reasoning for supporting client participation in occupations that promote well-being according to the client's lifestyle.

Limitations

This study design has several limitations. First, only three different subgroups (illness, gender, and age) could be examined in the detection of DIF. Second, this study was conducted among rehabilitation clients living in Japan. Therefore, it is considered necessary to develop the APO-15 to be used for English-speaking clients in the future to consider international surveys.

Conflict of Interest

The authors declare there are no potential conflicts of interest with respect to the research, authorship, or publication of this article.

Acknowledgment

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■ORIGINAL ARTICLE

Discriminating Brain Activation State in a Patient with Duchenne Muscular Dystrophy Using Near-Infrared Spectroscopy for Communication: An Exploratory Case Study

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Abstract: Introduction: Maintaining means of communication is an extremely important issue in occupational therapy for patients with intractable neurological disease. A brain-computer interface (BCI) is a device control technology for utilizing physiological signals, and is eagerly awaited for application in occupational therapy as a communication aid for patients with severe motor dysfunction. As an exploratory study for the development of BCI, we examined the accuracy of discriminating brain activation state using near-infrared spectroscopy (NIRS) signals and the effects of cognitive tasks on subjective burden through case study.
Methods: One 21-year-old male with Duchenne muscular dystrophy participated in the experiment. We measured NIRS signals with16 channels in the prefrontal cortex during three cognitive tasks: mental arithmetic (MA), figure rotation imagery (FRI), and Japanese word chain (JWC). Using support vector machine, a supervised machine learning, we constructed a classification model that discriminate type of cognitive task from features in the NIRS signals. In addition, the state-trait anxiety inventory and visual analogue scale were conducted to assess subjective burden associated with performing cognitive tasks.
Results: The classification accuracy of the MA versus FRI tasks was 73.1% (p = .03). The subjective evaluation scores showed the JWC had the lowest burden, and the MA and FRI were also rated as low anxiety tasks.
Conclusion: In this participant, we could identify whether the MA or FRI was being performed with 73.1% accuracy. These results suggest that brain activation state may be applicable as a means of communicating intentions.

Keywords: duchenne muscular dystrophy, near-infrared spectroscopy, assistive technology, cognitive task, brain-computer interface

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Introduction

Duchenne muscular dystrophy (DMD) is a neuromuscular disease characterized by atrophy of skeletal muscle throughout the body due to a defect in the gene encoding the cytoskeletal protein dystrophin [1]. DMD causes limited communication owing to severe motor paralysis. For patients with severe motor dysfunction, occupational therapists give support to them to acquire means of communication through device control that utilizes their few remaining functions, such as eye movement. However, as the disease progresses, there are patients with locked-in syndrome (LIS) [2] who retain consciousness and mental function but have difficulty communicating due to loss of motor function. Therefore, the establishment of new means of communication support for people with severe motor dysfunction is eagerly awaited in clinical practice.

A brain-computer interface (BCI) is a technology for enabling the control of external devices using brain signals generated by cognitive activities [3]. A BCI system generally consists of a brain function measurement, preprocessing, feature selection and extraction, classification, and device control [4]. After filtering out unwanted components such as noise from the physiological signals acquired by the brain function measurement,

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feature selection and extraction are performed to extract information highly relevant to brain activity. Then, by pattern recognition of the information obtained using machine learning, it is possible to control equipment using physiological signals. The medical application of BCI has the potential to provide a new means of communication using physiological signals for people with severe motor dysfunction.

Previous studies on BCI have used P300, the event-related potential component of electroencephalography [5], and near-infrared spectroscopy (NIRS) [6–8]. However, P300 measurements are vulnerable to noise from body movements, making it difficult to apply to subjects with neurological disorders prone to involuntary movements by abnormal muscle tone or spasticity. In addition, BCI systems that require responses to externally presented visual stimuli are difficult to adapt to late-stage patients with LIS. In contrast, NIRS has a lower temporal resolution, but has the advantage of requiring low constraints during measurement and can be applied to patients who are prone to involuntary movements. Therefore, it is considered a useful method for measuring physiological signals in studies aimed at medical applications of BCI systems.

In related studies on NIRS-based BCI [6, 7], the classification performance and usability of the BCI system were evaluated by cross-validation using support vector machine (SVM) on healthy subjects for BCI construction. We also have conducted experiments using NIRS signals from healthy subjects to identify brain activation states and investigated the accuracy and the appropriate types of cognitive tasks [8]. However, to examine the possibility of constructing BCI, it is necessary to investigate the performance of brain activation state discrimination and usability in patients with intractable neurological diseases based on the findings of studies on healthy subjects, but there are few such case studies. Because improvement of lost motor function cannot be expected in the field of intractable neurological diseases, it is very valuable to explore occupational therapy approaches that utilize remaining brain function as a compensatory method.

Therefore, the purpose of this study was to examine (i) the accuracy of discriminating brain activation states using NIRS and (ii) the effects of cognitive tasks for measuring NIRS signals on subjective burden through a case study, as a basic study for constructing a BCI that can be applied to communication support for patients with intractable neurological diseases. This study was conducted following the ethical principles of the Helsinki Declaration and was reviewed and approved by the Ethics Committee of Nagoya Institute of Technology (Approval No. 2019–017), and consent of the participant was obtained.

Methods

Participant

The participant was one 21-year-old male with DMD, whose dominant hand was determined to be right-handed based on the Edinburgh handedness Test [9]. The participant was diagnosed with DMD at the age of 11 due to difficulty walking, began using an electric wheelchair, and currently lived in a welfare facility. Concerning DMD severity, the upper extremity function scale by Brooke [10], which rates patients on a scale from 1, indicating the ability to abduct both upper extremities and touch above the head, to 6, indicating no useful hand function, was 5, indicating that the patient could not raise both hands to the mouth but could hold a pen. The lower extremity function scale by Vignos [11], which rates patients on a scale of 1, indicating the ability to walk and climb stairs without assistance, to 9, indicating being confined to a wheelchair or bed, was 9. The functional independence measure (FIM) score was 26 points for motor FIM and 29 points for cognitive FIM. The participant required maximum physical assistance in all activities of daily living but was able to communicate through spontaneous speech and still had sufficient intellectual function for daily living. The participant could also communicate independently by writing.

Near-Infrared Spectroscopy Signals Recording

The OEG-SpO_2 (Spectratech Inc., Yokohama, Japan) system was used to measure the NIRS signals. Figure 1 shows the equipment used for NIRS signal measurement. Following the international 10–20 method, the headset was mounted so that the nine-channel part was located directly above the frontal pole, and 16-channel measurement was performed with the region of interest being the prefrontal cortex. The distance between adjacent optodes was 3 cm, and the changes in the concentration of oxygenated hemoglobin were measured at a sampling interval of 0.082 seconds.

Overview of Proposed BCI-Based Communication Method

Figure 2 shows an overview of the proposed BCI system and the evaluation procedure of system performance. BCI consists of the learning phase and performance evaluation phase. First, in the learning phase, two types of cognitive tasks are performed and NIRS signals are acquired. Before measuring the NIRS signal, occupational therapist instructs the participant on the correspondence between the type of cognitive task and the BCI output, e.g., performing MA means YES and

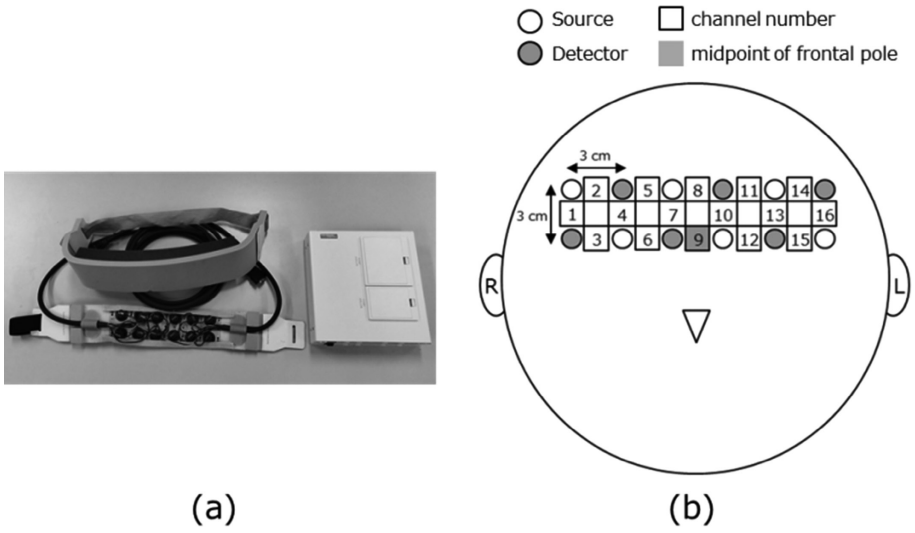

Fig. 1. Overview of the equipment used. (a) OEG-SpO_2 system. (b) The configuration of sources, detectors, and channels

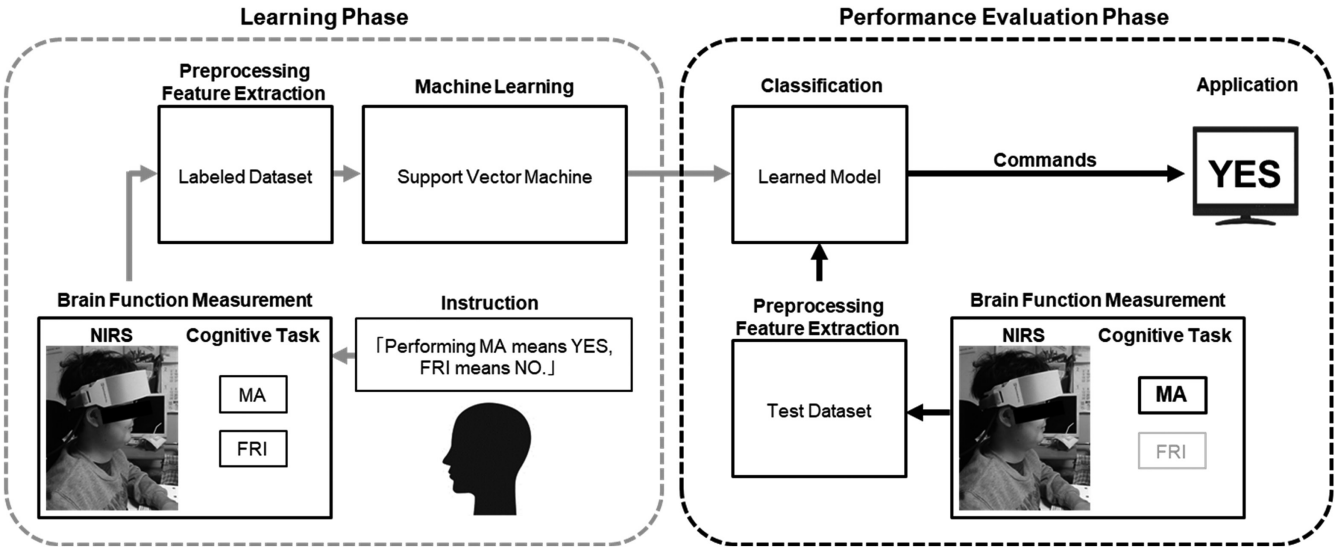

Fig. 2. Proposed BCI-based communication method (example using MA and FRI tasks).
MA: mental arithmetic, FRI: figure rotation imagery, NIRS: near-infrared spectroscopy.

FRI means NO, respectively. Then, labels indicating the type of cognitive task are assigned to the measured NIRS signals to construct a dataset with supervised data. Thus, we construct a learned model that recognizes the correspondence between the type of cognitive task and the pattern of variation in the NIRS signal using machine learning. Next, in the performance evaluation phase, based on the correspondence between cognitive tasks and BCI outputs, participant select and perform a cognitive task that corresponds to the intention. Note that in this experiment, participant is asked, e.g., "Please perform the MA to output YES", so that the true answer of the participant can be known. The measured NIRS signal is classified by the learned model and output as a prediction, i.e., YES or NO. Finally, the accuracy of the BCI output is evaluated by comparing the true answer to the BCI output.

Cognitive Tasks

Referring to previous studies [12, 13], we used three cognitive tasks that participants could perform: mental arithmetic (MA), figure rotation imagery (FRI), and Japanese word chain (JWC). Before the measurement, participant practiced cognitive tasks. We confirmed that the cognitive tasks were feasible for MA and JWC by having them perform the task aloud, and for FRI by interviewing. The following paragraphs provide the definitions of each cognitive task.

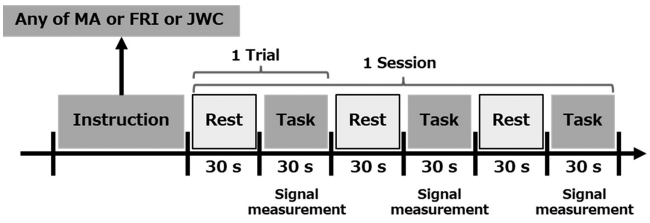

Fig. 3. Diagram of the block design used measuring physiological signals.

1. MA: A task in which participants are asked to add a series of small numbers (e.g., 3) by rote (e.g., 3, 6, 9, 12, ...). The numbers were selected randomly to avoid habituation.
2. FRI: A task of imagining the rotational motion of a 2-D figure. The direction and speed of rotation were arbitrarily set by the participant.
3. JWC: A word chaining task in which the participant had to name an arbitrary word and repeatedly name a new word starting from the last symbol (in Japanese) of that word. The participant was asked to refrain from using words whose last symbol was "n" so that the task would not be terminated. In addition, to avoid habituation, the same word was not repeated.

Experimental Protocol

Figure 3 shows the experimental protocol used to measure the NIRS signals. We used a block design with a 30-second rest and task repetition. One session consists of a total of three trials, with rest and task as one trial. Three sessions were conducted each day, one session for each cognitive task. Then, to avoid bias in the acquired NIRS signals, we measured NIRS signals in five days with a one-week interval between measurements. The experiment was conducted in the living room of the participant, in a resting seated position on an electric wheelchair. The participant performed the tasks by following an instruction screen on a display placed 70 cm in front of him. The experiment was controlled so that the participant performed the cognitive task while gazing at a fixed viewpoint on the display. The order of the cognitive tasks was randomized to minimize the effects of fatigue.

Subjective Evaluation

State-Trait Anxiety Inventory

We conducted the State-Trait Anxiety Inventory Form JYZ (STAI) [14] to measure the mental burden perceived from the performance of the cognitive task. State anxiety is defined as a transient situational response to an event that arouses anxiety regarding "exactly how you feel right now". The state anxiety test consists of a total of 20 questions with 10 anxiety-present items (P-item) and 10 anxiety-absent items (A-item). It is a self-rating scale; the participant chooses the most applicable of the four levels (1 to 4), and the higher the score, the higher the state anxiety. The sum of scores and the five-grade scale from very low (Stage 1) to very high (Stage 5) were evaluated for A-item, P-item, and all-item.

Visual Analogue Scale

Eight evaluation items related to the practicality of the cognitive task were set by referring to previous studies [4, 15, 16]: flexibility, ease of performance, practicality, ease of understanding, difficulty, discomfort, concentration, and sleepiness. The subjective evaluation of each cognitive task was conducted according to the visual analogue scale (VAS). Each item was scored numerically on a 100-point scale, with a high score indicating high practicality. The scores for each item and overall average were calculated.

Data Analysis

Preprocessing and Feature Extraction

For the preprocessing, we applied the hemodynamic separation method [17] to the NIRS signals to separate the skin blood flow components, and then the NIRS signals of each channel were standardized by z-score transformation. Z-score is the transformed NIRS data so that the mean of the 5-second pre-task resting data for each trial is 0 and the standard deviation is 1. The first 5 seconds of the task interval were excluded from the analysis to account for the inherent delay of the NIRS signal. For the data of the 25-second task interval, a 3-second time window with a step width of 0.5-second were used to divide the data into the 45 samples. Then, we calculated the temporal features using seven types of statistics (arithmetic mean, standard deviation, maximum, minimum, slope, kurtosis, and skewness). The NIRS signals were labeled according to the type of cognitive task. Thus, we constructed a dataset consisting of 675 samples and 112 features per cognitive task.

Classification

The SVM [18], a supervised machine learning, was used to construct the classification model. Considering the time-series characteristics of the acquired NIRS signals and the calibration procedure in actual operation, the classification model was constructed and evaluated using time-series cross-validation (TSCV) as shown in Fig. 4. TSCV is a method to evaluate the generalization performance of a classification model against unknown data by dividing the data along the time axis, with the last data being used as the test data (striped cell in Fig.

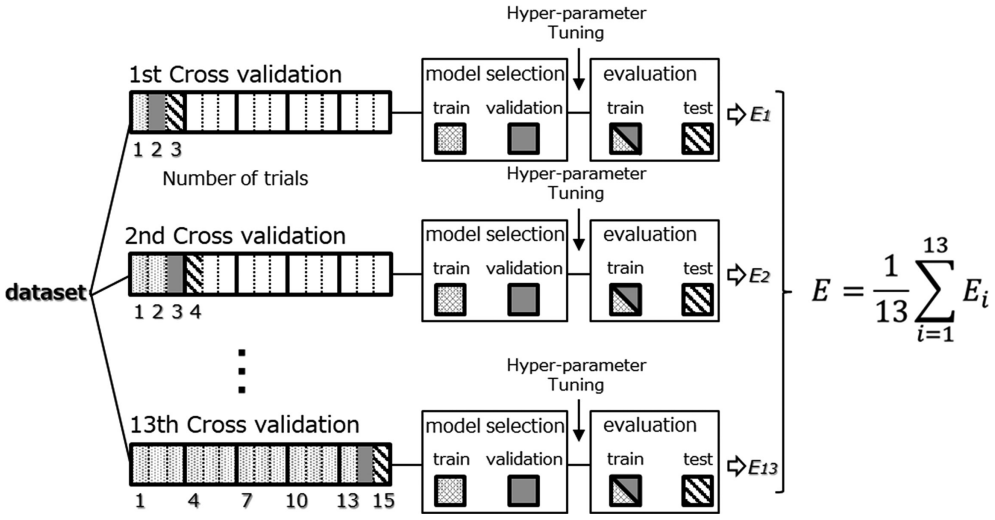

Fig. 4. Overview of performance evaluation by time-series cross-validation (TSCV)

4), the data most recent to the test data being used as the validation data (gray cell in Fig. 4), and all other data being used as the training data (shaded cell in Fig. 4). The dataset is divided into 15 parts while maintaining the time-series, and the first cross-validation is performed with the first trial as training data, the second trial as validation data, and the third trial as test data. Then, one trial of NIRS data is sequentially added to the training data for each cross-validation, and the classification performance is evaluated by 13-fold cross-validation. The evaluation index was the sum of decision function values in each class representing the confidence level of predictions in the model. The kernel parameters were linear and radial basis functions, and the hyper-parameters C and γ were tuned by grid search in the range of 10^{-2}, 10^{-1}, …, 10^{2}. Under these conditions, we evaluated the correct answer rate of the model's output for each combination of MA, FRI, and JWC. The data analysis was performed using python 3.7.4 and the python machine learning library. For the statistical analysis, the binomial test was used to compare the correct answer rate of the constructed classifiers and chance level, and a two-sided test was used with a significance level α of .05.

Results

NIRS Signals

Figure 5 shows the grand averaged waveforms of all channels and 15 trials of standardized NIRS data for each cognitive task. In Fig. 5, the NIRS data were pre-processed with bandpass filtering in frequency bands of 0.01–0.2 Hz for visualization. The MA and JWC showed fluctuations that peaked at the end of the task interval, whereas the FRI showed an increasing trend with a peak

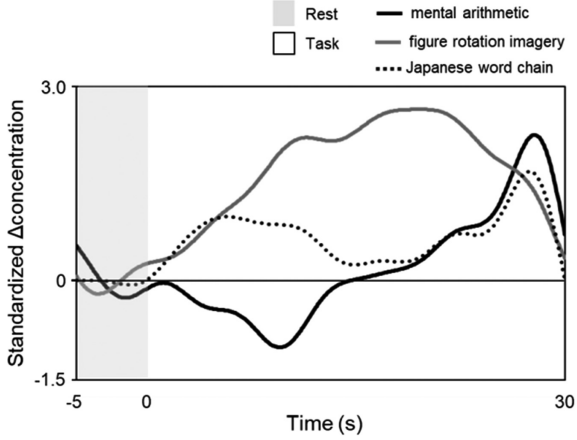

Fig. 5. Grand averaged NIRS waveforms measured during mental arithmetic (MA), figure rotation imagery (FRI), and Japanese word chain (JWC).

at about 20 seconds followed by a decreasing trend.

Classification Performance

Table 1 shows the classification performance of each classification model.

The highest rate of the correct answer was 73.1% for TSCV with MA versus FRI, which was significantly higher than the chance level (p = .03). In contrast, the classification models using MA versus JWC and FRI versus JWC showed no significant difference in classification performance at 61.5% (p = .33) and 53.8% (p = .85), respectively.

Subjective Evaluation

Figure 6 (a) and (b) show the results from the STAI and the VAS, respectively. In the STAI, the scores of all-item were 38 (Stage 2), 33 (Stage 2), and 25 (Stage 1)

Table 1 Performance evaluation of binary classification using each cognitive task combination

	MA versus FRI	MA versus JWC	FRI versus JWC
Correct answer rate, n (%)			
Total of A and B (n = 26)	19 (73.1)*	16 (61.5)	14 (53.8)
A (n = 13)	7 (53.8)	10 (76.9)	10 (76.9)
B (n = 13)	12 (92.3)	6 (46.2)	4 (30.8)

A and B represent type of task in the binary classification of task A versus task B.
*: binomial test, $p < .05$.
Data are presented as numbers (percent).
MA, mental arithmetic; FRI, figure rotation imagery; JWC, Japanese word chain.

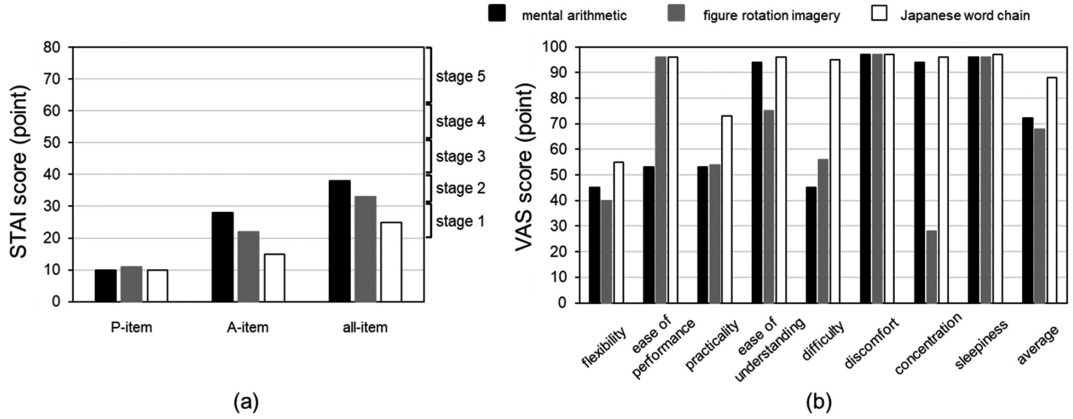

Fig. 6. Results of subjective evaluation by (a) State-Trait Anxiety Inventory (STAI) and (b) visual analogue scale (VAS)

for the MA, FRI, and JWC, respectively. The score of A-item and all-item showed that JWC was the task with the lowest mental load. Although MA was the highest mental load of the three types of tasks, it was a Stage 2 and low anxiety task. As a result of the VAS, the mean scores of the eight items were 72.1, 67.8, and 88.1 for the MA, FRI, and JWC, respectively, showing that JWC was the most preferred task. In addition, JWC had the highest rating in all items, whereas FRI was the least practical task in the overall average.

Discussion

Classification Performance

The results of the classification performance evaluation showed that TSCV with MA versus FRI could guess the type of cognitive task being performed from the NIRS data with a 73.1% accuracy. Shin et al. [6] reported the accuracy of an SVM based on 10 times 5-fold cross-validation was 77.0%, and Naseer et al. [7] reported the accuracy of an SVM based on 10-fold cross-validation was 82.1%. However, when cross-validation is applied to NIRS signals, it includes a condition, i.e., that data acquired later than the validation or test data is assigned to the training data. Such a method causes the possibility of estimating a higher accuracy than the actual accuracy owing to overfitting. Therefore, it is important to construct models considering the time-series characteristics of NIRS and evaluate the classification performance following actual operational procedures. TSCV, in contrast, divides the data along the time axis and evaluates the model performance. Considering the operation of the BCI system, the evaluation results obtained by the TSCV are considered more valid than those of the cross-validation, which does not consider the time-series characteristics of the data.

Psychological Burden

The STAI and VAS showed the JWC was the most practical task with the least psychological burden for the participants. Bos et al. [19] reported the importance of selecting tasks that are less burdensome for users to use the BCI stably. Considering the constraint of having to perform a cognitive task for every communication opportunity, the chosen cognitive task should have as low mental load as possible. In general, as JWC is a familiar task in daily life, it is easy to perform and is not likely to cause anxiety. Therefore, using a familiar cognitive task could lead to the construction of BCI with less mental burden for a user.

In contrast, the STAI showed MA was the task that increased the state of anxiety the most. The VAS also

showed FRI was the task with the lowest perceived practicality. Weyand et al. [20] reported the importance of evaluating usability and classification performance of BCI. For this participant, MA and FRI may not have been preferred because they have less of a leisure activity component and involve mental loads related to intellectual functions. However, STAI showed both MA and FRI were stage 2, thereby categorized as low-anxiety tasks. Additionally, if the sense of burden is reduced by practice performing the task, it may become a cognitive task with a sufficiently acceptable psychological burden for this participant. Although occupational therapy for intractable neurological diseases has mainly treated motor functions, the introduction of cognitive rehabilitation program that performs cognitive tasks might provide further stabilization of physiological signals and reduction of mental burden.

Possibility of Application to Brain-Computer Interface System

Müller-Putz [21] reported 70% is the criterion for practical performance in binary BCI. The present results, 73.1%, exceed that criterion, suggesting the utility of the TSCV models with MA and FRI in communication applications such as yes and no. Considering the BCI operating procedure, the discriminator should be adjustable to the daily non-stationarity of the NIRS signal. The TSCV model adopts a verification method that follows actual operational procedures, i.e., calibration using data acquired before the operation, followed by the use of BCI, which is considered a practical design. In addition, results of the subjective evaluation showed MA and FRI, although inferior to JWC, were considered to have an acceptable level of mental burden for the participant. Therefore, these findings could be applied as a BCI with less psychological burden if limited to applications where misjudgments are acceptable. Furthermore, it is necessary to consider the pathological characteristics of users in designing a BCI. In patients with DMD, brain functions are maintained but motor functions are lost gradually. Therefore, in this study, we proposed an independent BCI that utilizes residual brain functions such as mental tasks, rather than a presented stimulus-dependent BCI that requires motor functions such as the external eye muscles. Additionally, Schreuder et al. [22] reported the importance of validation with potential end-users, suggesting the importance of translational research of BCI with case studies. Because no effective treatment has been shown for DMD, ensuring alternative means of communication is a critical issue in occupational therapy. Nevertheless, few BCI studies have examined the possibility of acquiring means of communication for patients with neurological impairments in case study in occupational therapy. Therefore, these findings will contribute to the promotion of technical development of new communication methods using BCI for patients with neurological disabilities. NIRS equipment is expensive and has the disadvantage of low temporal resolution. For future work, we will investigate brain regions and NIRS signal lengths, which contribute to classifying brain activity states, and aim to construct a simple BCI system with fewer channels that can identify brain activity in shorter time.

Limitations

Because this study focused on means of communication for closed questions, we did not consider open questions. We also did not examine the effects of the non-stationarity of the NIRS signals that may occur with aging or disease severity. For the practical use of the BCI, the long-term robustness of the classification model should be investigated. In addition, this study is a single-case result and may show different trends among participants. We will increase the number of participants in the future and longitudinally evaluate the classification performance and subjective burden of the individual-specific model using the same algorithm to verify the generalizability.

Conclusions

We performed NIRS signal measurements and subjective evaluation during MA, FRI, and JWC tasks on a participant with DMD. As a result of evaluating the binary classification performance using the NIRS signals, the TSCV model for MA versus FRI achieved 73.1% accuracy. The STAI and VAS for subjective evaluation of the cognitive tasks showed that JWC had the lowest burden, and MA and FRI were rated as low anxiety tasks. These results indicate the possibility of applying NIRS signals as a means of communication for subjects with intractable neurological diseases.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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■CASE REPORTS

Difficulty in Counting Similar Juxtaposed Items after Subarachnoid Hemorrhage: A Case Report

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Abstract: Introduction: Focal brain damage can cause difficulties in counting similar items. It has been hypothesized that this visual counting disorder (VCD) is caused by an inability to recall places seen in the immediate past. However, this has not been directly tested. There also have been no studies on the impacts of VCD on patients' daily lives.
Methods: A 60-year-old, right-handed man visited our hospital complaining of difficulty counting multiple similar objects placed next to each other; for example, accounting errors caused by an inability to read multiple zeros in numbers in sales receipts. This patient had the problem for 25 years, since an infarction in the right temporoparietal region after a subarachnoid hemorrhage. To test the recall hypothesis, we performed a visual counting test on the patient and healthy control subjects. Circles were presented under two conditions: static (rows of circles presented vertically, centered on the screen) and dynamic (rows of circles presented by scrolling vertically). Subjects were asked to count and report numbers of circles as soon as each row appeared.
Results: Under the static condition, the patient showed a significantly longer reaction time and more frequent gaze retentions than did the control subjects; however, no differences were observed under the dynamic condition.
Conclusion: These findings directly support the hypothesis. Our patient's compensatory methods might be useful to other patients.

Keywords: visual counting, daily activities, static, dynamic, saccadic eye movement

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Introduction

Visual counting tasks that use geometric figures such as circles of the same color and size, have been used as a highly sensitive test for detecting simultanagnosia [1]. Three recent reports [2–4] have shown that visual counting disorders (VCDs) manifested in the absence of simultanagnosia, and there is a high prevalence of VCDs in patients with brain injury [4]. Dehaene and Laurent [5] hypothesized that the mechanism by which VCD occur is related to an inability to recall places seen in the immediate past. Nevertheless, the hypothesis has not tested in the VCD itself, regardless of the presence or absence of simultanagnosia. There are also no studies on the impact of a VCD on a patient's daily life.

Case report

A right-handed male aged 60 years, with 12 years of educational history and who operates a liquor shop visited our hospital complaining of difficulty counting multiple similar objects placed next to each other. The problem started 25 years prior, when the patient had suffered an infarction, caused by a vasospasm after a subarachnoid hemorrhage due to rupture of an aneurysm in the middle cerebral artery.

His computed tomography images showed low-density areas in the right temporoparietal region (Fig. 1a). Neurological examination showed no abnormal

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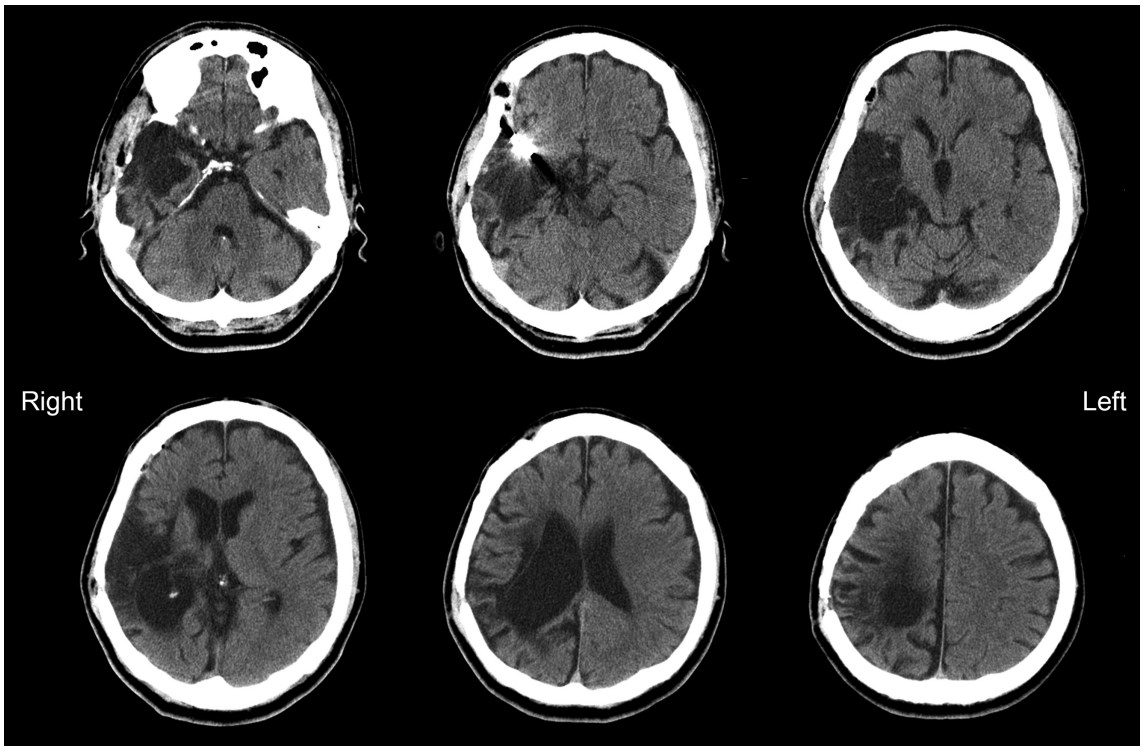

Fig. 1. CT image of the patient's head. Low-density areas shown in the right temporal pole, superior and middle temporal gyrus, insula, supramarginal gyrus, angular gyrus, and medial superior occipital gyrus and their subcortical white matter, as well as in the posterior thalamus.

findings other than left homonymous hemianopia without macular sparing, and mild left hemiplegia. Neuropsychological examinations revealed no abnormality (Table 1).

Regarding the difficulty in couting multiple objects, he said: "*If I transfer my gaze, I forget where I have been looking at immediately beforehand*," "*So, if similar things are placed next to each other, I get confused because there are no clues to tell me where I was looking before.*"

The patient had developed compensatory methods during the 25 years. As shown in Fig. 2a, the method differed depending on the condition of the objects to be counted. If they were within arm's reach and could be moved, he arranged them in groups of four or five, then counted groups. For example, when he counted hooks in a row, he put four hooks in a bundle and calculated how many bundles he has. When he counted beer bottles at his liquor shop, he would confirm the number by first lining up five bottles while counting them, then placing more bottles behind them sequentially in rows and cuiculated them. For immovable objects, such as symbols on paper, he located the end of the row, then moved over the objects in sequence, being careful not to skip any, checking the count when he reached the opposite end. While doing this, if the objects could be marked, he

Table 1 Results of neuropsychological examinations

Test	Performance
Handedness	
Edinburgh Handedness Inventory (max: 100)	100
General attention (short-term memory)	
Digit span	6
General cognition	
Mini-Mental State Examination (max: 30)	30
Wechsler Adult Intelligence Scale Revised (VIQ)	111
Episodic Memory	
Recall of three words (max: 3)	
Immediate	3
Post-interference	3
He could give accurate oral descriptions of the contents of his previous day's training	
Hemispatial neglect	
Catherine Bergego Scale (max: 30)	1
Behavioral inattention test	
Conventional subtest (max: 146)	135
Line crossing (max: 36)	36
Letter cancelation (max: 40)	37
Star cancellation (max: 54)	52
Figure and shape copying (max: 4)	3
Line bisection (max: 9)	**4**
	Both leftward and rightward shifts of midpoints were shown.
Representational drawing (max: 3)	3

max, maximum
Abnormal values are indicated in bold.

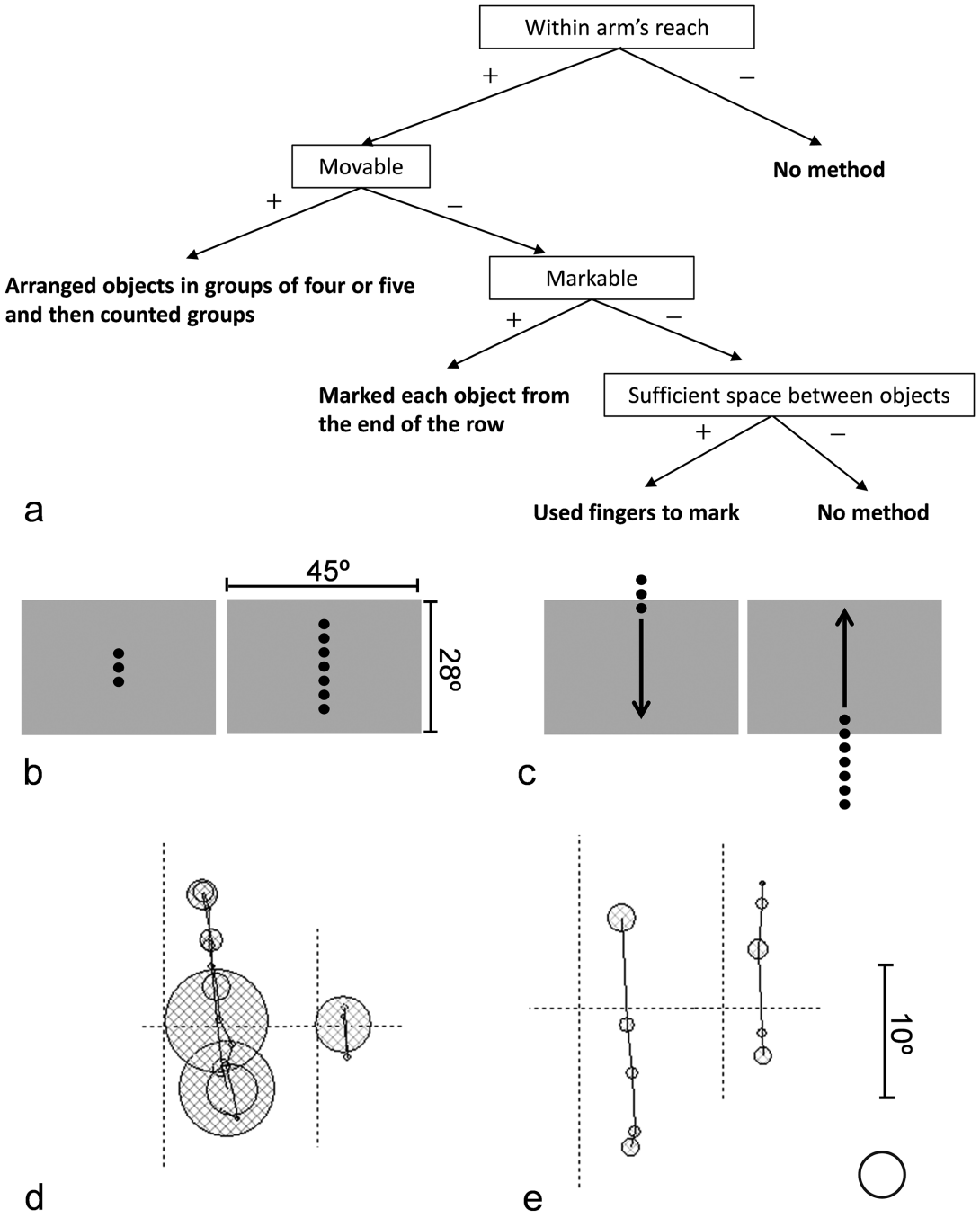

Fig. 2. (a) The conditions of objects and compensatory methods. Text inside boxes describes conditions of objects to be counted visually, and in bold text below are compensatory methods. + indicates a satisfied condition; − indicates a nonsatisfied condition. (b)(c) Examples of stimuli in the visual counting test. The gray rectangle represents the monitor screen. The diameter of all circles had a visual angle of 1.5°, and the distance between the centers of two adjoining circles was 2.5°. Under static conditions (b), the arrangement of the circles was vertically symmetrical, centered on the middle of the screen. The circles were presented without setting time limits. The reaction time corresponded to the time elapsed between the appearance of a stimulus to when the participants started providing the correct answers. Under dynamic conditions (c), rows of circles were presented as scrolling downwards from the upper edge of the screen and disappearing at the bottom or scrolling upwards from the lower edge of the screen and disappearing at the top. The moving speed was 5.5°/sec. It took three seconds for each circle to appear and disappear from the screen. The reaction time started when part of the stimulus appeared on the screen and finished when the participants started providing the correct answers.

We defined "gaze retention" according to Grüsser and Grüsser–Cornehs [6], as a gaze's moving speed within 50°/s continuous for ≥ 0.15 s and measured the number of retentions and the duration of each retention. (d)(e) Examples of retention points (center of each circle), retention time (circle size), and trajectory (straight line connecting the center of a circle) of the patient's (left) and healthy participants' (right) gazes analyzed using an eye tracker. (d) Response under static conditions, and (e) response under dynamic conditions. The white circle (below right) shows the size when the retention time is 1 second.

did so while counting. If they could not be marked, he counted them using fingers to mark his place, provided that there was sufficient space to do so.

However, when he could not use any of these compensatory methods, he had to count by moving his gaze, which took a long time and resulted in errors even when paying close attention. For example, when he made a sketch of hanging persimmons, he drew the wrong number of juxtaposed dried persimmons. He frequently made accounting mistakes by incorrectly reading the number of zeros on sales receipts. He failed to pass the tests because he erroneously counted the number of bubbles in the optical mark recognition sheet and as a result filled in the wrong bubbles.

We performed a visual counting test using this patient and 11 healthy controls (10 men, one woman; age 62 ± 5 years; educational history, 15 ± 3 years) as participants. We showed from one to seven black circles arranged vertically. The participants were told to count and report, as quickly and accurately as possible, the number of black circles as soon as a row appeared on the screen. The circles were presented under two types of conditions: static and dynamic (see the details in Figs. 2b, c). A total of 14 trials were conducted under both conditions. We also recorded the participants' voices and gaze movements, using an eye tracker (EMR-9; nac Image Technology, Tokyo, Japan).

Under static condition, the median (range) reaction time (RAT), number of gaze retentions (NGR), and retention time (RTT) were 9.3 (1.0–31.4) seconds, 13.0 (1.0–36.0) times, and 0.3 (0.2–3.6) seconds for the patients, respectively, and 1.0 (0.4–3.0) seconds, 1.0 (0.0–6.0) times, and 0.4 (0.2–3.6) seconds for the healthy controls, respectively. The median RAT and NGR of the patients were approximately 10 times greater than those of the healthy participants, and the patients showed a significantly longer RAT ($p < 0.001$, Mann-Whitney U test) and greater NGR ($p < 0.001$, Mann-Whitney U test) than the healthy participants. However, no difference in RTT was observed ($p = 0.12$, Mann-Whitney U test). Under the dynamic condition, the median (range) RAT, NGR, and RTT were 1.9 (0.8–4.5) seconds, 3.0 (1.0–6.0) times, 0.4 (0.2–2.7) seconds for the patients and 1.7 (0.5–2.6) seconds, 2.0 (0.0–6.0) times, and 0.4 (0.2–4.0) seconds for the healthy controls. No differences in the RAT ($p = 0.46$, Mann-Whitney U test), NGR ($p = 0.21$, Mann-Whitney U test), or RTT ($p = 0.66$, Mann-Whitney U test) were observed between the patients and healthy participants.

Figures 2d, e shows examples of the retention points and times as well as the trajectory of gaze movements of the patient and a healthy participant for seven circles under static and dynamic conditions. Under static conditions, with increasing circle numbers, we have to transfer their gaze—that is, perform saccadic eye movements. Therefore, the gaze trajectory shown in Fig. 2d is believed to reflect saccadic eye movements. On the other hand, under dynamic conditions with moving black circles, no saccadic eye movements are required. Even if they must visually track them, they simply need to perform smooth pursuit eye movements without removing their gaze from the circles. The gaze trajectory in Fig. 2e shows these smooth pursuit eye movements.

Discussion

Our test results showed that, under static conditions, the patient had a longer reaction time than healthy participants. Furthermore, the reaction time was long not because the patient spent more time fixating his gaze in one place than healthy participants, but because he stopped his gaze more often. This finding coincides with the patient's report that he looked at objects one after another, starting from the end, making sure not to skip any spaces in-between. Under dynamic conditions, on the other hand, the patient's reaction time was just as short as that in healthy participants, and there were no other differences from healthy participants. These findings directly support the hypothesis by Dehaene and Laurent [5] and the patient's self-reflection reports. The findings also suggest that his inability to remember the spatial position might occur only after performing saccadic movements, not after smooth pursuit eye movements.

Recommending a patient to use the compensatory strategies adopted by the patient in this study might be useful as rehabilitation for VCD. Although we could not let the current patient do, it might be useful if the patients with VCD could use a smartphone or other devices which are equipped with a function that can capture an image of objects and scrolls it automatically, in a similar way we did as a dynamic condition in this research.

Ethical statement

The participants provided written informed consent after receiving a detailed description of the study. This study was approved by the ethical committee of Yamagata Prefectural University of Health Science and conducted in accordance with the Declaration of Helsinki.

Conflict of interest

The authors declare no conflicts of interest.

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■ORIGINAL ARTICLE

Effect of Upper Limb Function Training Combined with Goal Setting Using the Aid for Decision-Making in Occupation Choice for Hand Application in Patients with Acute Stroke

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Abstract

Background and Purpose: We introduced an intervention that aimed to improve upper limb use in daily life using Aid for Decision-making in Occupation Choice for Hand (ADOC-H), a monitoring and problem-solving technique, in addition to conventional occupational therapy for hospitalized patients with acute stroke. This pilot study examined the effectiveness of this intervention to improve paralyzed upper limb use in daily life and their motor function.

Methods: This comparative study included 28 patients with acute stroke who underwent an intervention based on the ADOC-H process (ADOC-H group) and 155 participants from a previous study (control group). The paralytic arm participation measure (PPM; scores for eating and toileting items) was used to evaluate upper limb use in daily life, and the Stroke Impairment Assessment Set (SIAS; knee mouth [K-M] and finger flexion [F-F] tests) was used to evaluate upper limb motor function. The amount of change in these evaluations was compared between the two groups.

Results: Using propensity score matching, 21 participants were allocated to each group. Comparing the two groups, significant improvements were observed in the ADOC-H group for all items, as shown by the scores for PPM total (P = 0.005, r = 0.43), eating (P = 0.035, r = 0.32), toileting (P = 0.004, r = 0.44), upper limb motor function (P = 0.001, r = 0.52), K-M (P = 0.014, r = 0.38), and F-F (P = 0.002, r = 0.48).

Conclusion: This intervention process may be effective for improving the frequency of paralyzed upper limb use and upper limb motor function of the paralyzed upper limbs in patients with acute stroke.

Keywords: acute phase, stroke, use of paralyzed upper limb, Aid for Decision-making in Occupation Choice for Hand, pilot study

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1. Introduction

Motor paralysis is a sequela of stroke. Functional recovery from motor paralysis peaks at 1 month after onset [1], and delayed rehabilitation, which begins 1 month after the onset of cerebral infarction, does not sufficiently improve motor performance [2]. Moreover, the severity of motor paralysis in the acute phase is a predictor of activities of daily living (ADL) after the convalescence phase [3], and early intervention for functional recovery of paralyzed upper limbs is important. Paralyzed upper limb use in daily life is the most important factor for functional recovery of the paralyzed side after stroke [4]. Encouraging paralyzed upper limb use for ADL in the acute phase of stroke is important to prevent learned non-use. However, the amount and frequency of paralyzed upper limb use in patients with acute stroke are small [5]. A previous study noted that several patients with acute stroke can hardly use their paralyzed upper limb in daily life even if their paralysis is mild [6].

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Studies have reported the use of robot-assisted therapy [7], constraint-induced movement therapy (CIMT) [8], virtual reality [9], and accelerometers [10] in promoting paralyzed upper limb use in patients with stroke. CIMT can achieve this promotion by introducing a transfer package in addition to intensive task-oriented training [11]. The transfer package focuses on transferring the results obtained in clinical situations in real life and involves the following: the patient and therapist develop a behavioral contract for using the paralyzed upper limb in a specific life situation; oral or descriptive monitoring of upper limb use in the targeted behavior is promoted; and guidance on problem-solving methods for using the upper limb in daily life is provided [12].

However, despite recent reports on the effectiveness of CIMT in the acute phase of stroke, this effectiveness remains controversial [13, 14]. Administering a rigorous CIMT program in the acute phase is difficult because general care and stroke treatment are prioritized, and the time allocated to rehabilitation is limited. Moreover, although the transfer package is effective, a study reported that setting goals for patients with cognitive impairment and speech disorders is challenging [15]. Recently, an application called Aid for Decision-making in Occupation Choice for Hand (ADOC-H) that allows the visual setting of goals for using the paralyzed upper limbs in daily life has been developed. This application is easy to use and can facilitate goal setting, even in patients with cognitive dysfunction and speech disorders [15], and is clinically useful [16]. With ADOC-H, the goal of using the paralyzed upper limb in daily life can be shared with the patient, even in the acute phase, promoting paralyzed upper limb use.

This study aimed to examine the effectiveness of an intervention that included goal setting for upper limb use in daily life using ADOC-H and monitoring and guidance on problem-solving techniques for patients with acute stroke, in addition to conventional occupational therapy. We also explored the effectiveness of this intervention for patients with cognitive impairment and aphasia.

2. Patients and Methods

2.1 Study design and setting

This study used a comparative design and propensity score matching to compare current and previous patients with stroke. At our institution, rehabilitation starts on the day of hospitalization or on the day following hospitalization, with sufficient risk management. Further, patients undergo rehabilitation for 20–40 minutes/day, 7 days/week. Upper limb function training includes the following exercises performed alone or in combination: reach movement training, instrument manipulation training, neuromuscular facilitation training, and therapeutic electrical stimulation. Physical therapy included basic movement and walking training from early disease onset, and speech-language training was provided for swallowing dysfunction and speech disorders from early disease onset.

2.2 Participants

The participants were divided into an intervention (ADOC-H) or control group. The intervention group comprised inpatients aged ≥ 20 years who were admitted to the hospital from February 2021 to February 2022 and were diagnosed with stroke (cerebral infarction, cerebral hemorrhage, and subarachnoid hemorrhage). The exclusion criteria were as follows: patients (1) diagnosed with transient ischemic attacks, (2) with limited joint range of motion and muscle weakness in the paralyzed upper limb before the onset of stroke; this information was obtained through interviews and from patients' medical records at the time of admission, (3) with impaired consciousness, i.e., a Glasgow Coma Scale (GCS) less than E3V1M6, (4) with total aphasia, (5) who were unable to provide informed consent, (6) with recurrent stroke that occurred during hospitalization, (7) with ataxia, (8) with a perfect score (3 points) for eating and toileting items in the paralytic arm participation measure (PPM) at the time of admission, (9) with severe motor paralysis of < 1 point as assessed by the knee mouth (K-M) or finger flexion (F-F) tests of the Stroke Impairment Assessment Set (SIAS) at the time of admission, and (10) who had previously participated in this research [6]. The PPM and SIAS assessments were performed on admission and discharge. Additionally, details on age, sex, length of stay, disease type, paralyzed side, dominant hand, intervention days, duration of occupational therapy intervention in minutes, GCS score at the time of admission, National Institutes of Health Stroke Scale score, Functional Independent Measure (FIM) score, and Mini-Mental State Examination (MMSE) score were obtained from medical records.

The control group included 155 patients with stroke who were admitted to our hospital from October 2018 to October 2019 and had participated in a previous study [6]. The exclusion criteria for the control group were the same as those used for the intervention group. Additionally, the same patient characteristics retrieved from medical records of patients in the intervention group were obtained for patients in the control group.

2.3 Outcome measures

2.3.1. Stroke Impairment Assessment Set

The SIAS was used to assess stroke dysfunction.

It comprises 22 items classified into nine types of dysfunctions, and each item is evaluated on a scale of 3 or 5 points: the higher the score, the better the function [17]. Among the upper limb motor functions on the paralyzed side, the K-M: (0–5), F-F: (0–5), and total: (0–10) scores were assessed. The lower limb motor function on the paralyzed side (total of hip flexion test, knee extension test, and foot pad test: 0–15), upper limb sensation (total of upper limb tactile sensation and upper limb position sense: 0–6), and language function (0–3) were used. Evaluation was performed at the time of admission (within 2 days) and discharge (within 2 days).

2.3.2 Evaluation of paralyzed upper limb use in daily life

The Motor Activity Log [18] is generally used as an evaluation method for paralyzed upper limb use in daily life. However, as we included patients with cognitive and speech impairments in this study, we used the PPM [19, 20]. The PPM is a scale used by occupational therapists (OTs) to observe and evaluate patients' paralyzed upper limb use [19, 20]. The PPM consists of 15 items. Each item is assessed on a 4-point scale ranging from 0 to 3 points (3 points, the paralyzed upper limb can smoothly perform the desired movement; 2 points, movement can be performed until the end but is awkward and has a longer duration; 1 point, the limb is partially used; and 0 points, the limb is not used entirely). In this study, two items were investigated at the time of admission (within 2 days) and discharge (within 2 days): PPM eating (either holding a bowl or maneuvering chopsticks or a spoon) and toileting (two items: lowering the pants to the knees and pulling the pants up to the waist). Regarding the items selected for the ADOC-H, the OT in charge observed the daily life situation of patients at the time of discharge and performed a two-stage evaluation of whether or not the paralyzed upper limb was used in daily life. The paralyzed upper limb was judged as "used in daily life" if it could complete a movement, even if the movement was awkward, from the beginning to the end of the movement.

2.4 Goal-setting tool

ADOC-H was used to set goals for paralyzed upper limb use. ADOC-H is an application that includes 130 illustrated movements in 16 categories related to ADL and instrumental ADL [15]. The ADOC-H uses "words," "letters," and "illustrations" to communicate specific tasks to patients and therapists that require the use of the hands and to promote the use of paralyzed upper limbs in daily life situations [15].

We set the goals based on shared decision-making, which is an ideal decision-making model [21, 22]. We referred to the ADOC-H items presented on the iPad screen, and both the patient and occupational therapist selected items for the task of using the paralyzed upper limb in real life situations, according to upper limb function, at the time of the interview. Then, the goal was set based on mutual agreement.

3. Methods

3.1 Intervention protocol for the groups

In the ADOC-H group, goal setting using ADOC-H and monitoring and problem-solving techniques were added to the conventional upper limb function and ADL training. The control group received only conventional training.

3.2 Interventions

We referred to the transfer package [12] of the CIMT and modified the methods that could be implemented at our facility for behavioral contracting, monitoring, and problem-solving. The details of this process are presented below.

3.2.1 Goal setting and agreement

An OT interviewed the intervention group using the ADOC-H within 1 week after stroke onset, reached a consensus with the patient on their preferred tasks to enable paralyzed upper limb use in daily life, and set goals. The goals that are agreed upon are printed on paper and placed on the participant's bedside desk so that the patient could always check them. Once the goal-setting activities could be used with the paralyzed upper limb, the OT interviewed the patient again using the ADOC-H and added new goals as needed.

3.2.2 Monitoring

The transfer package recommends monitoring of the performance of targeted behaviors using the Motor Activity Log and a diary [12]. In this study, the OT encouraged patients' self-monitoring of difficulty in paralyzed upper limb use for the items provided by ADOC-H during each intervention. As this study included patients with cognitive impairment and aphasia, in addition to oral monitoring, we devised ways to enable patients to recall the activities by using manipulating tools when necessary.

3.2.3 Problem-solving

The OT discussed how to use the paralyzed upper limbs with the patient. The therapists then provided advice, introduced self-help tools, and adjusted the environment as needed, encouraging paralyzed upper limb use.

3.2.4 Upper limb function training

The training included reach movement training using tools such as pegs and manipulation training using daily items and simulated articles targeted toward paralyzed upper limb use for items set as targets in the ADOC-H application. Additionally, the above training was combined with neuromuscular facilitation and therapeutic electrical stimulation. The training method and time differed depending on the patient's level of tolerance, and almost the same method was performed for both the intervention and control groups.

3.2.5 ADL training

The patients practiced movements such as toileting, dressing, and bathing in a simulated or actual environment for ADL training based on their condition.

3.3 Statistical analysis

3.3.1 Propensity score matching

Based on the following items, the propensity score was calculated using binomial logistic regression analysis: age, sex, length of hospital stay, disease type, total FIM cognitive item score at admission, total GCS score at admission, paralysis of the dominant hand, SIAS subitems score at admission (including K-M and F-F), and PPM subitems score at admission (including eating and toileting). Factors for calculating the propensity score were obtained from previous studies [6, 23, 24] and clinical experience. The caliper was set to 0.25.

3.3.2 Comparison between the ADOC-H and control groups

The Shapiro–Wilk test was performed to test for normality. The Wilcoxon signed-rank test was used to compare the following items at admission and discharge in the ADOC-H and control groups: SIAS K-M and F-F and their total score and PPM eating and toileting and their total score. The effect size (r) was obtained from the Z-value.

3.3.3 Comparison of the ADOC-H and control groups

Patient characteristics at admission were compared between the ADOC-H and control groups using Fisher's exact test, t-test, and Mann–Whitney U test. Additionally, the Mann–Whitney U test was used to compare the scores of the following items at discharge and their changes (the score at discharge minus the score at admission) between the two groups: SIAS K-M and F-F and their total scores and PPM eating and toileting and their total scores. The effect size (r) was calculated using the Z-value.

For patients in the ADOC-H group with cognitive decline and an MMSE score of < 24 points or those with aphasia and an SIAS language function score of ≤ 2 points, the propensity score was calculated using the same factors, and propensity score matching with the control group was performed. The caliper was set to 0.25. Analyses was performed in the same manner as in Sections 3.3.2 and 3.3.3.

3.3.4 Calculation of the achievement rate for items selected using ADOC-H

In the ADOC-H group and ADOC-H group with cognitive impairment or aphasia, the number of people who achieved paralyzed upper limb use with the items selected by the ADOC-H process at the time of discharge and the achievement rate were calculated.

Regarding the sample size, at least 12 participants were required for a larger sample size pilot follow-up study [25], and 28 people were recruited for this study.

Statistical significance was set at $P < 0.05$. All statistical analyses were performed using Easy R ver. 1.55 (Saitama, Japan) [26].

3.4 Ethics

This study was conducted in accordance with the ethical standards of the Declaration of Helsinki [27]. This study was approved by the Ethics Review Committee of our hospital (approval number: 20–27; approval date: 2021/1/20). All the patients provided written informed consent.

4. Results

Figure 1 shows the study flowchart. The ADOC-H group included 28 patients who selected both eating (chopsticks, spoon/fork, and bowl) and toileting (hike up/taking-off trouser) among the 31 patients who provided consent, and none dropped out. In the control group, of the 161 patients who provided consent, 6 dropped out due to death and stroke recurrence after providing consent; therefore, the study included 155 patients. The final analysis included 21 propensity matched patients in each group. Table 1 presents a comparison of the basic characteristics of all patients between the two groups.

There were no significant differences in any basic characteristics between the two groups. Table 2 shows a comparison of the SIAS and PPM in all patients between the two groups. In each group, upper limb motor function, K-M, F-F, PPM total, eating, and toileting scores were significantly different after the intervention. Compared with that noted in the control group, upper limb motor function, K-M, F-F, PPM total, eating, and toileting scores were significantly improved in the ADOC-H group. Regarding the items selected by 28 people during the ADOC-H process, the number of

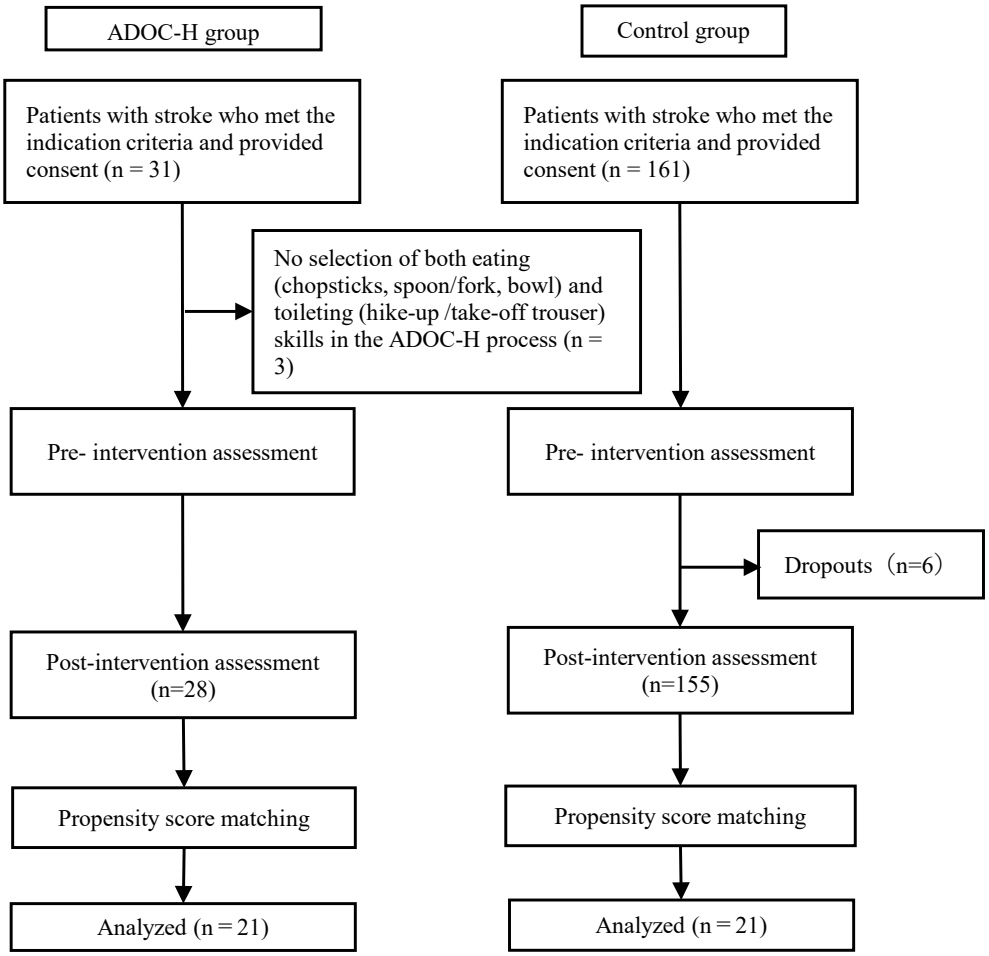

Fig. 1. Flowchart of this study

Table 1 Comparison of the characteristics of all patients at admission between the ADOC-H and control groups

Characteristics		ADOC-H (n = 21)	Control (n = 21)	*P*
Age, years	Median year (IQR)	76.00 (68.00, 82.00)	78.00 (67.00, 83.00)	0.724
Sex	Male/female (%)	18 (85.7)/3 (14.3)	16 (76.2)/5 (23.8)	0.697
Length of hospital stay, days	Mean ± SD	25.0 ± 10.02	22.9 ± 10.78	0.508
OT intervention days	Mean ± SD	23.86 ± 9.67	21.00 ± 10.34	0.361
Number of minutes of OT intervention per day	Mean ± SD	36.07 ± 6.85	35.16 ± 10.16	0.735
Disease type	Lacunar infarction/other (%)	2 (9.5)/19 (90.5)	3 (14.3)/18 (85.7)	1
Affected hand	Right/left (%)	6 (28.6)/15 (71.4)	6 (28.6)/15 (71.4)	1
Dominant hand	Right/left (%)	21 (100)/0 (0)	21 (100)/0 (0)	–
Paralysis of the dominant hand	Yes/no (%)	6 (28.6)/15 (71.4)	6 (28.6)/15 (71.4)	1
GCS score	Median (IQR)	15.00 (14.00, 15.00)	15.00 (14.0, 15.0)	0.673
NIHSS score	Median (IQR)	4.00 (3.00, 6.00)	4.00 (3.00, 7.00)	0.732
FIM score	Median (IQR)			
Motor		22.00 (18.00, 31.00)	18.00 (14.00, 25.00)	0.283
Cognitive		27.00 (21.00, 29.00)	25.00 (20.00, 33.00)	0.99
Eating		4.00 (1.00, 5.00)	2.00 (1.00, 4.00)	0.417
Toileting		1.00 (1.00, 3.00)	1.00 (1.00, 1.00)	0.858
SIAS score				
Lower limb motor function		11.00 (6.00, 12.00)	12.00 (6.00, 14.00)	0.317
Upper limb sensory function		5.00 (4.00, 6.00)	6.00 (3.00, 6.00)	0.798
Language function		3.00 (3.00, 3.00)	3.00 (3.00, 3.00)	0.655

IQR, interquartile range; SD, standard deviation; GCS, Glasgow coma scale; NIHSS, National Institutes of Health Stroke Scale; FIM, functional independent measure; SIAS, stroke impairment assessment set; PPM, paralytic arm participation measure; ADOC-H, Aid for Decision-making in Occupation Choice for Hand; OT, occupational therapist.

Table 2 Comparison of the PPM and SIAS scores in all patients between the ADOC-H and control groups

	ADOC-H group (n = 21)			Control group (n = 21)			ADOC-H group versus control group (pre-intervention)	ADOC-H group versus control group (post-intervention)		ADOC-H group versus control group (change in scores)		ADOC-H group (pre- versus post-intervention)		Control group (pre- versus post-intervention)	
	Pre-intervention	Post-intervention	Change in score	Pre-intervention	Post-intervention	Change in score	*P*	*P*	r	*P*	r	*P*	r	*P*	r
PPM Total (Eating + Toileting)	0.00 (0.00, 3.00)	8.00 (5.00, 9.00)	6.00 (5.00, 8.00)	0.00 (0.00, 0.00)	3.00 (0.00, 9.00)	1.00 (0.00, 6.00)	0.308	0.018	0.36	0.005	0.43	< 0.001	0.88	0.003	0.64
PPM Eating	0.00 (0.00, 0.00)	3.00 (2.00, 3.00)	2.00 (1.00, 3.00)	0.00 (0.00, 0.00)	0.00 (0.00, 3.00)	0.00 (0.00, 3.00)	0.408	0.023	0.35	0.035	0.32	< 0.001	0.83	0.006	0.61
PPM Toileting	0.00 (0.00, 3.00)	6.00 (4.00, 6.00)	3.00 (3.00, 6.00)	0.00 (0.00, 0.00)	2.00 (0.00, 6.00)	0.00 (0.00, 4.00)	0.613	0.017	0.37	0.004	0.44	< 0.001	0.88	0.013	0.55
SIAS Upper limb motor function	5.00 (3.00, 7.00)	9.00 (7.00, 9.00)	3.00 (2.00, 4.00)	4.00 (2.00, 9.00)	7.00 (4.00, 10.00)	1.00 (0.00, 2.00)	0.63	0.195	0.20	0.001	0.52	< 0.001	0.88	< 0.001	0.73
SIAS K-M	3.00 (2.00, 3.00)	4.00 (4.00, 5.00)	1.00 (1.00, 2.00)	3.00 (1.00, 4.00)	4.00 (2.00, 5.00)	1.00 (0.00, 1.00)	0.928	0.311	0.15	0.014	0.38	< 0.001	0.88	0.003	0.64
SIAS F-F	2.00 (1.00, 4.00)	4.00 (4.00, 5.00)	2.00 (1.00, 3.00)	1.00 (1.00, 4.00)	3.00 (1.00, 5.00)	0.00 (0.00, 1.00)	0.461	0.071	0.28	0.002	0.48	< 0.001	0.85	0.004	0.63

PPM, paralytic arm participation measure; SIAS, stroke impairment assessment set; K-M, knee mouth; F-F, finger flexion.

people who achieved the use of the paralyzed hand at the time of discharge and their proportions are summarized in Supplementary Table 1. Twenty-one items were selected, and the total number of people who selected each item was 111. The number of people who achieved paralyzed upper limb use was 94, and the average achievement rate was 85%.

The MMSE score was evaluated in 27 of the 28 patients. Eleven patients scored < 24 points; three patients with aphasia had an SIAS language function score of ≤ 2; and one patient was common to both. The above 13 participants were classified as the ADOC-H group with cognitive impairment or aphasia, and propensity score matching was performed with 155 patients in the control group. Analysis was conducted on 12 participants in both groups. Table 3 presents a comparison of the basic attributes of the two groups. There were no significant differences in any of the basic attributes between the two groups. Table 4 shows a comparison of the SIAS and PPM scores between the two groups. In the ADOC-H group, upper-limb motor function, K-M, F-F, PPM total, eating, and toileting scores were significantly different after the intervention. In the control group, upper limb motor function, PPM total, and eating scores were significantly different after the intervention, but K-M, F-F, and toileting scores showed no significant differences. Compared to the control group, upper limb motor function, K-M, F-F, PPM total, and toileting scores were significantly improved in the ADOC-H group with cognitive impairment or aphasia. The items selected during the ADOC-H process in the 13 participants with cognitive impairment or aphasia, number of people who achieved those movements at the time of discharge, and their ratios are summarized in Supplementary Table 1. Eleven items were selected, and the total number of people who selected each item was 44. The number of people who achieved use was 33, and the average achievement rate was 75%.

5. Discussion

We introduced an intervention of setting goals for upper limb use in daily life using ADOC-H, monitoring, and problem-solving techniques in addition to conventional occupational therapy for hospitalized patients with acute stroke. This intervention resulted in significant improvement in upper limb use. Moreover, similar significant improvement was observed in participants with cognitive impairment or aphasia. In this intervention, the average achievement rate for the items selected was high.

Table 3 Comparison of patient characteristics at admission between the ADOC-H group and control groups in patients with cognitive impairment or aphasia

Characteristics		ADOC-H (n = 12)	Control (n = 12)	P
Age, years	Median year (IQR)	78.00 (69.75, 83.50)	76.50 (70.00, 81.25)	0.686
Sex	Male/female (%)	11 (91.7)/1 (8.3)	12 (100)/0	1
Length of hospital stay, days	Mean ± SD	25.33 ± 8.26	21.92 ± 14.78	0.118
OT intervention days	Mean ± SD	23.92 ± 6.96	20.08 ± 12.22	0.355
Number of minutes of OT intervention per day	Mean ± SD	33.66 ± 6.59	32.46 ± 10.03	0.732
Disease type	Lacunar infarction/other (%)	1 (8.3)/11 (91.7)	1 (8.3)/11 (91.7)	1
Affected hand	Right/left (%)	5 (41.7)/7 (58.3)	5 (41.7)/7 (58.3)	1
Dominant hand	Right/left (%)	12 (100)/0	11 (91.7)/1 (8.3)	1
Paralysis of the dominant hand	Yes/no (%)	5 (41.7)/7 (58.3)	6 (50)/6 (50)	1
GCS score	Median (IQR)	14.50 (14.00, 15.00)	15.00 (14.75, 15.00)	0.348
NIHSS score	Median (IQR)	4.00 (2.75, 6.25)	3.50 (2.75, 7.00)	0.977
FIM score	Median (IQR)			
Motor		21.50 (17.75, 30.50)	20.50 (13.75, 46.75)	0.931
Cognitive		21.50 (15.75, 27.75)	25.00 (19.00, 29.00)	0.664
Eating		4.50 (1.00, 5.00)	4.00 (1.75, 5.00)	0.761
Toileting		1.00 (1.00, 1.50)	1.00 (1.00, 4.25)	0.334
SIAS score				
Lower limb motor function		11.00 (5.75, 12.00)	13.50 (5.00, 14.00)	0.281
Upper limb sensory function		5.50 (3.75, 6.00)	5.00 (3.00, 6.00)	0.805
Language function		3.00 (2.75, 3.00)	3.00 (3.00, 3.00)	0.654

IQR, interquartile range; SD, standard deviation; GCS, Glasgow coma scale; NIHSS, National Institutes of Health Stroke Scale; FIM, functional independent measure; SIAS, stroke impairment assessment set; PPM, paralytic arm participation measure; ADOC-H, Aid for Decision-making in Occupation Choice for Hand; OT, occupational therapist.

5.1 Increase in upper limb usage on the paralyzed side

The time for upper limb function training was shorter in this study than that reported for CIMT, and interventions to promote upper limb use in daily life were not conducted by written contracts or monitored using a diary. However, the ADOC-H group showed a significant increase in paralyzed upper limb usage, suggesting that our intervention is effective for upper limb use in the daily life of patients with acute stroke.

Further, as shown in the study using the transfer package in CIMT, we identified that it was important for OTs to not only intervene during training but also to intervene to change the behavior regarding upper limb use in daily life.

We also found a significant increase in the number of upper limbs used on the paralyzed side in the ADOC-H group compared with the control group in patients with cognitive impairment or aphasia. A feature of ADOC-H is that it allows patients and therapists to share specific tasks involving the use of the hands by using "words," "letters," and "illustrations." Studies on ADOC have reported that patients can easily express their wishes and desires because of the simple process of selecting from the illustrations displayed on the iPad, and most patients and OTs felt encouraged to participate in the goal-setting process using ADOC [22]. Based on the above, even in patients with impaired cognitive and language functions, by setting goals from illustrations provided during the ADOC-H process, patients can be actively involved in goal setting, and the effect of goal setting is clearer. Therefore, this intervention method using the ADOC-H, which can help patients and therapists to visually share goals, can increase the number of upper limbs on the paralyzed side used in daily life, even in cases where the transfer package cannot be adapted. Therefore, this intervention may be applicable to a wider range of participants.

5.2 Improvement of the function of the paralyzed upper limb

Upper limb motor paralysis showed significant improvement in the ADOC-H group. In this study, propensity score matching was performed using factors related to motor paralysis improvement. There was no difference in the duration and quality of occupational therapy interventions between the two groups. Therefore, the improvement in motor paralysis by natural recovery was considered similar in both groups. Paralyzed upper limb use in daily life is important for the functional recovery of the paralyzed upper limb [4]. It is possible that the recovery of upper limb function was further promoted by the increase in the frequency of paralyzed upper limb use in daily life owing to the combined intervention in this study.

Table 4 Comparison of the PPM and SIAS scores between the ADOC-H and control groups in patients with cognitive impairment or aphasia

	ADOC-H group (n = 12)			Control group (n = 12)			ADOC-H group versus control group (pre-intervention)	ADOC-H group versus control group (post-intervention)		ADOC-H group versus control group (change in scores)		ADOC-H group (pre- versus post-intervention)		Control group (pre- versus post-intervention)	
	Pre-intervention	Post-intervention	Change in score	Pre-intervention	Post-intervention	Change in score	*P*	*P*	r	*P*	r	*P*	r	*P*	r
PPM Total (Eating + Toileting)	0.00 (0.00, 2.25)	8.50 (4.75, 9.00)	6.00 (4.75, 8.25)	0.00 (0.00, 2.25)	3.00 (0.00, 9.00)	0.50 (0.00, 3.75)	0.783	0.159	0.28	0.011	0.51	0.002	0.89	0.049	0.59
PPM Eating	0.00 (0.00, 0.00)	3.00 (1.75, 3.00)	2.50 (1.00, 3.00)	0.00 (0.00, 0.25)	1.00 (0.00, 3.00)	0.50 (0.00, 2.25)	0.306	0.219	0.25	0.08	0.35	0.004	0.83	0.048	0.59
PPM Toileting	0.00 (0.00, 0.75)	6.00 (4.50, 6.00)	4.00 (2.75, 6.00)	0.00 (0.00, 1.50)	2.00 (0.00, 6.00)	0.00 (0.00, 1.00)	0.732	0.099	0.33	0.005	0.57	0.002	0.89	0.174	0.47
SIAS Upper limb motor function	5.00 (3.75, 6.25)	9.00 (7.75, 9.25)	3.00 (2.75, 3.25)	4.50 (2.50, 9.00)	7.00 (2.50, 10.00)	1.00 (0.00, 1.00)	1.0	0.391	0.17	< 0.001	0.74	0.002	0.90	0.04	0.61
SIAS K-M	3.00 (2.00, 3.00)	4.00 (4.00, 5.00)	1.00 (1.00, 2.00)	3.00 (1.75, 4.00)	3.50 (1.75, 5.00)	0.00 (0.00, 1.00)	0.789	0.224	0.24	0.001	0.69	0.001	0.91	0.129	0.47
SIAS F-F	2.00 (1.75, 3.25)	4.50 (3.75, 5.00)	1.50 (1.00, 2.00)	2.00 (0.75, 5.00)	3.50 (0.75, 5.00)	0.00 (0.00, 1.00)	0.86	0.247	0.23	0.003	0.61	0.003	0.86	0.089	0.55

PPM, paralytic arm participation measure; SIAS, stroke impairment assessment set; K-M, knee mouth; F-F, finger flexion

5.3 Limitations

This study included patients who had undergone occupational therapy in the past as controls and performed pseudo-randomization using existing patient characteristics and evaluation results that could be collected from medical records. However, since it was not a randomized control, unmeasured confounding factors and exposure suspicion bias cannot be excluded. In the future, it will be necessary to increase the number of patients and conduct randomized controlled studies to eliminate confounding factors and biases.

We evaluated the frequency of paralyzed upper limb use, as assessed by the PPM eating and toileting; however, we did not evaluate basic ADL such as dressing and bathing. Moreover, paralyzed upper limb use for other items selected during the ADOC-H process was investigated only for achievement or non-achievement of the task. In the future, to evaluate changes in usage conditions, evaluating the amount and frequency of use in stages and patients' degree of satisfaction and achievement is necessary.

In conclusion, this pilot study demonstrated that compared with the conventional occupational therapy, the combination of techniques improved the frequency of usage of the upper limbs on the paralyzed side in daily life as assessed by the PPM and the motor function scores of the SIAS. This result was the same, even in patients with cognitive impairment or aphasia. The ADOC-H intervention method used in this study is applicable to a wider range of patients compared to that of the conventional transfer package and may be effective in improving the frequency of paralytic upper limb use and motor function of the paralyzed side in patients with acute stroke. In the future, it will be necessary to verify these effects with randomized controlled trials.

Conflict of Interest

No potential conflict of interest was reported by the authors.

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■ORIGINAL ARTICLE

Reminiscence Content and Quality Among Community-Dwelling Older Adults in Japan

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Abstract: Objective: It is well known that reminiscence therapy improves mental health by encouraging the elderly to recall past life events; however, the content and how it can contribute to the intervention is still not fully understood. This study examined the relationship between reminiscence content and the quality of reminiscence and determined whether the latter was associated with depression, life satisfaction, and self-esteem.
Methods: A total of seventy-one community-dwelling older adults participated in this study. We chose 15 topics to determine whether they could recall the reminiscence contents. Data were collected on mental health using the Japanese versions of the Geriatric Depression Scale-5, Life Satisfaction Index-Koyano Scale, and Rosenberg Self-esteem Scale. Multiple imputations were performed to compensate for missing values.
Results: A single regression showed that 10 reminiscence content items were associated with positive reminiscence, while three predicted lower negative reminiscences. Positive reminiscence was significantly correlated with negative reminiscence ($r = -0.456$, $p < 0.001$), depression ($r = -0.299$, $p = 0.012$), life satisfaction ($r = 0.315$, $p < 0.010$), and self-esteem ($r = 0.400$, $p < 0.001$). Negative reminiscence significantly correlated with depression ($r = 0.435$, $p < 0.001$), life satisfaction ($r = -0.423$, $p < 0.001$), and self-esteem ($r = -0{,}345$, $p = 0.003$).
Conclusion: Reminiscence content was associated with positive and negative recalling experiences, which are possible factors affecting mental health. Understanding the influence of reminiscence content and quality on mental health can inform strategies to improve mental health.

Keywords: reminiscence contents, quality of reminiscence, depression, life satisfaction, self-esteem

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Introduction

In recent years, reminiscence therapy has been recognized as a type of psychotherapy that is especially recommended for older adults because it has few adverse effects, is inexpensive, and effective [1]. It can be broadly defined as a method to encourage older adults to recall past events and experiences [2]. Unlike simply remembering the past, reminiscence can evoke the feelings and thoughts of past events to facilitate adaptation to the present, resolve past conflicts, establish self-identity, and improve quality of life [3, 4]. During this kind of intervention, older adults are asked to share past memories according to the topics selected by the therapist with the help of old objects or photographs.

Studies conducted over the past decade have examined the effects of reminiscence therapy on reducing the symptoms of depression [5], improving life satisfaction [6], and increasing self-esteem [7] among older adults. With regard to how reminiscence therapy can alleviate mental health problems, a few researchers have focused on the quality of reminiscence. When people recall the past, the mood can be happy and satisfied, also can be sad or painful or other. According to the characteristics of emotions can be basically divided into positive or negative [8]. It has been reported that older adults are better able to adapt to life satisfaction and self-esteem when recalling the past with positive emotions [9, 10].

However, findings from some published studies on the effect of reminiscence are inconsistent [7, 11, 12]. A systematic review of research on reminiscence effects

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among older adults has suggested that the conflicting outcomes may be attributed to various reminiscence processes [13]. It is difficult to compare the results of these adoptions of reminiscence therapy because the processes are not standardized and the shared contents and factors are not clear [13]. Elias et al. [14]also concluded that differing processes of reminiscence therapy remain a problem, and reminiscence content for sessions needs to be investigated. Until now, however, little attention has been paid to the reminiscence content. An understanding of the content that can contribute to the effect of reminiscence is still lacking. It is thus necessary to clarify the criteria based on which the therapist can establish the reminiscence content for future interventions on mental health.

To this end, this study aimed to explore the relationship between reminiscence content and the quality of reminiscence to extend the knowledge of the process of reminiscence therapy and to examine whether the quality of reminiscence is associated with depression, life satisfaction, and self-esteem.

Materials and Methods

Participants

This cross-sectional study was conducted in Hiroshima City, Japan, between October, 2020 and November, 2020. Participants were community-dwelling older adults who participated in preventive care programs run by a regional comprehensive support center. A total of 71 individuals were recruited for this study.

The inclusion criteria were as follows: individuals who were over 65 years of age; those who could answer the questionnaire and who did not have hearing or visual impairment; and individuals who agreed to participate in this investigation.

The researcher explained the purpose and significance of the study to the person in charge of the preventive care program and obtained consent to conduct the questionnaire survey.

Measurements

The questionnaire contained the following six aspects:

Participant Characteristics

At the beginning of the questionnaire, demographic characteristics including age, gender, marital status, living arrangement, economic status, health status, and outpatient treatment were obtained. For this study, we created a checklist for older adults and asked them to choose the option that best matched their current situations. To the question "Are you satisfied with your current economic status?" participants replied by choosing one of the following options: "very satisfied" "somewhat satisfied" "somewhat dissatisfied" or "very dissatisfied" For ease of reviewing the results, "very satisfied" and "somewhat satisfied" were grouped as "good", while "somewhat dissatisfied" and "very dissatisfied" were grouped as "bad". The question "How is your current physical health?" was answered by the participants by choosing any one of the following options: "very good" "fair" "not very good" or "very bad". For ease of reviewing the results, "very good" and "fair" were grouped as "good", while "not very good" and "very bad" as "bad".

Reminiscence Content

To explore what older adults may recall in their daily lives, we referred to the examples of contents for reminiscence sessions proposed by Nomura [15], additionally, we referred to the common topics in Japanese intervention studies [16]. Since the participants were Japanese, we selected 15 themes that would be most appropriate to them: "new year," "Obon dance" (a dancing style in Japan), "hometown," "regional festival," "the song one used to listen to in one's youth," "doing housework as a child," "playing with friends," "memories about primary school," "Japanese snack," "sports one used to play," "family," "summer," "marriage," "raising children," and "jobs." The contents were carefully reviewed by the primary, second, and last authors. In case of disagreements on the choices of the themes, the primary and second author reviewed the previous research and held discussions, while the last author decided whether to reach a consensus. The participants were asked to answer "Yes" or "No" to questions, such as "Have you remembered anything about the new year in your daily life?"

Quality of Reminiscences

After asking about reminiscence content, we used a self-report checklist which developed by Nomura and Hashimoto [17] to evaluate the quality of emotions generated by reminiscence. They reported Cronbach's α coefficient of 0.918 and 0.845 for positive and negative reminiscence, respectively. We used the short form of the checklist proposed by Nomura and Hashimoto [10]. It contains six positive and six negative items, positive items are: 1. When I think of the past, I feel happy; 2. When I think of the past, my heart is peaceful; 3. When I think of the past, I feel at ease; 4. When I think of the past, I feel satisfied; 5. I think my memory of the past is irreplaceable; and, 6. I feel nostalgic when thinking about the past. The negative items are: 1. It is painful to think about the past; 2. I have a past I do not want to remember; 3. When I looked back at the past, my mood becomes low; 4. I have many bad memories; 5. Until now, there have been unforgettable unhappy memories; 6. To date, there have been regretful and

reluctant memories. Participants rated each item on a five-point scale ranging from "Yes, I think so" (5 points) to "No, I do not think so" (1 point), with a total possible score of 30 points, with higher scores indicating higher levels of positive or negative emotions. In this study, the Cronbach's α coefficients for positive and negative reminiscence were 0.94 and 0.93, respectively.

Depression

The Geriatric Depression Scale-5 was used as a screening tool for depression symptoms, and the Cronbach's α coefficient was 0.80 [18]. However, we used the Japanese version designed by Toba [19]. This scale comprises five questions, such as "Are you basically satisfied with life?" According to the questions, the participants were asked to describe their feelings over the past week, responding with "Yes" or "No," The total possible scores ranged from 0 to 5, with a cutoff point equal to or higher than 2 indicating depressive symptoms. The Cronbach's α coefficient in this study was 0.637, which is acceptable [20].

Life Satisfaction

Koyano et al.'s [21] Japanese version of the Life Satisfaction Index (LSI-K) was used to assess the level of life satisfaction. The original study reported a Cronbach's α coefficient of 0.849, indicating high reliability. In this study, the coefficient was 0.746. This scale comprises three subscales, including "Satisfaction with life as a whole," "Psychological stability," and "Evaluation of one's own aging," composed of nine items. Among them, seven items comprised a two-point response format of "Yes" and "No." One item had a three-point response format of "almost nothing," "not much," and "a lot." The remaining item also followed a three-point response format of "Satisfied," "Generally satisfied," and "Dissatisfied." The scores range from 0 to 9, with higher total scores indicating greater life satisfaction.

Self-Esteem

The Rosenberg Self-Esteem Scale (RSE) is the most commonly used and highly reliable instrument for measuring self-esteem [22]. We used a translated Japanese version with a Cronbach's α coefficient of 0.80, signifying high reliability, to determine participants' feelings of self-worth [23]. In this study, the coefficient was 0.767. The RSE is composed of 10 items rated on a five-point scale. The scores on the RSE ranged from 10 to 50, with higher scores indicating higher self-esteem.

Statistical Analyses

Among the responses (n = 71), 14 (24.6%) had missing values for one or more items. Therefore, we first compared each item between complete and incomplete data to check for data bias and determine whether participants with missing data were excluded from the analysis (Table 1). Fisher's exact test and Mann-Whitney U test were used for the comparisons. Thereafter, we identified the differences in each item between the participants with complete data and those with missing data, which we decided to address by data completion to avoid selection bias. Therefore, we performed multiple imputations, which we consider the most advanced method for improving the accuracy and statistical power of missing data. We created 20 multiple imputed datasets with missing values to complement incomplete data containing all variables. Missing at random was assumed for the data (missing completely at random was rejected by Little's test statistic ($p < 0.001$)) [24], and multiple imputation was performed, including the item scores of each scale, and total scores as well as each survey item. The parameters were estimated individually for each multiple imputed dataset and combined using Rubin's [25] rules [26].

To analyze the results, first, a single regression analysis was performed for each explanatory variable, which comprised the content of the reminiscence and the scores of positive and negative reminiscence, which were the response variables. Second, the correlation between the scores for positive reminiscence, negative reminiscence, GDS-5, LSI-K, and RSE were evaluated using Spearman's rank correlation coefficient. Third, multiple linear regression analysis was performed, and social factors were used as explanatory variables, and the scores of positive reminiscence, negative reminiscence, GDS-5, LSI-K, and RSE were used as response variables.

The statistical software "R" (version 4.0.5; R Foundation for Statistical Computing, Vienna, Austria), naniar (version 0.6.1) package, "mice" (version 3.13.0) package, "miceadds" (version 3.11-6) package, and "mitml" (version 0.4-1) package were used for statistical analysis. Statistical significance was set at $p < 0.05$. The "ltm" (version 1.1-1) package was used for calculating Cronbach's α.

Ethical Statement

This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ethical Committee for Epidemiology of Hiroshima University (E-2207).

Results

Characteristics of Participants

In total, 71 older adults participated in this study. Table 1 presents the complete and missing data regarding participants' characteristics. Most of the participants

Table 1 Participants' Characteristics and Comparison Between Participants with Complete and Incomplete Data

	Total (n = 71)			Participants who had complete data (n = 57)			Participants who had missing data (n = 14)			*p*-value
	Number of valid responses	Mean/n	SD/%	Number of valid responses	Mean/n	SD/%	Number of valid responses	Mean/n	SD/%	
Characteristics										
Age, year	71	77.7	6.1	57	76.4	6.2	14	78.4	6.5	< 0.001
Female, n (%)	71	62	87.3%	57	50	87.7%	14	13	92.9%	1.000
Marital status, married, n (%)	71	38	53.5%	57	32	56.1%	14	6	42.9%	0.390
Living arrangement, alone, n (%)	71	23	32.4%	57	17	29.8%	14	7	50.0%	0.209
Economic status, good, n (%)	71	51	71.8%	57	40	70.2%	14	12	85.7%	0.324
Community activities, yes, n (%)	71	66	93.0%	57	53	93.0%	14	13	92.9%	1.000
Health status, good, n (%)	70	54	77.1%	57	42	73.7%	13	12	92.3%	0.272
Outpatient treatment, yes, n (%)	68	61	89.7%	57	50	87.7%	10	10	100.0%	0.588
Reminiscence contents										
New Year's Day, yes, n (%)	71	56	78.9%	57	44	77.2%	14	12	85.7%	0.719
Obon dance, yes, n (%)	71	42	59.2%	57	34	59.6%	14	7	50.0%	0.557
Hometown, yes, n (%)	71	59	83.1%	57	49	86.0%	14	11	78.6%	0.444
Regional festival, yes, n (%)	71	55	77.5%	57	44	77.2%	14	11	78.6%	1.000
Song, yes, n (%)	71	61	85.9%	57	50	87.7%	14	11	78.6%	0.402
Housework, yes, n (%)	71	55	77.5%	57	42	73.7%	14	13	92.9%	0.166
Playing, yes, n (%)	71	59	83.1%	57	48	84.2%	14	10	71.4%	0.270
Primary school, yes, n (%)	71	55	77.5%	57	44	77.2%	14	11	78.6%	1.000
Traditional food, yes, n (%)	70	45	64.3%	57	35	61.4%	13	10	76.9%	0.353
Sport, yes, n (%)	71	43	60.6%	57	35	61.4%	14	8	57.1%	0.770
Family, yes, n (%)	71	65	91.5%	57	52	91.2%	14	13	92.9%	1.000
Summer, yes, n (%)	71	62	87.3%	57	50	87.7%	14	12	85.7%	1.000
Marriage, yes, n (%)	71	58	81.7%	57	46	80.7%	14	12	85.7%	1.000
Raising children, yes, n (%)	71	61	85.9%	57	48	84.2%	14	13	92.9%	0.674
Jobs, yes, n (%)	71	60	84.5%	57	49	86.0%	14	10	71.4%	0.442
Psychological assessments										
Positive reminiscence, score	69	22.6	5.6	57	22.2	5.6	12	24.2	5.6	< 0.001
Negative reminiscence, score	70	16.3	7.4	57	16.7	7.7	13	14.5	5.6	< 0.001
GDS-5, score	66	1.3	1.4	57	2.4	1.4	9	0.4	0.7	< 0.001
LSI-K, score	67	4.5	2.5	57	4.4	2.4	10	5.6	2.5	< 0.001
RSE, score	69	34.7	6.1	57	34.6	6.3	12	35.2	5.0	< 0.001

Note. GDS-5: Geriatric Depression Scale-5 Japan version; LSI-K: Life Satisfaction Index-K Japanese version; RSE: Rosenberg Self-Esteem Survey Japanese version.
The Fisher's exact test and Mann-Whitney U test were used for complete data and incomplete data comparisons.

were women (n = 62, 87.3%). The mean age of the participants was 77.7 ± 6.1 years. There was a significant difference between the age groups, with participants who had missing data more likely to be older. No significant difference was found between the groups for the reminiscence content.

The data also revealed that there were significant differences between the groups in terms of positive reminiscence, negative reminiscence, and GDS, LSI-K, and RSE. The mean score of positive reminiscence for participants with missing data tended to be higher, while that of negative reminiscence tended to be lower. Meanwhile, the GDS-5 score was reported to be relatively lower, whereas the LSI-K and RSE scores were higher.

Relationships Between Reminiscence Contents and Quality of Reminiscence

The results of the single linear regression using multiple imputed datasets are shown in Table 2. The results revealed that New Year's Day (β = 0.384, p = 0.001), Obon dance (β = 0.271, p = 0.026), hometown (β = 0.251, p = 0.035), regional festival (β = 0.456, p < 0.001), housework (β = 0.250, p = 0.042), playing (β = 0.274, p = 0.021), primary school (β = 0.377, p = 0.002), traditional food (β = 0.373, p = 0.002), sports (β = 0.283, p = 0.020), and summer (β = 0.285, p = 0.023) were significant predictors of positive reminiscence. Furthermore, sports (β = −0.233, p = 0.047), family (β = −0.275, p = 0.020), and summer (β = −0.234, p = 0.047) were found to be significant predic-

Table 2 Single Linear Regression Analysis of The Relationship Between Reminiscence Content and Quality by Analyzing Multiply Imputed Data Sets (n = 71)

	Positive reminiscence						Negative reminiscence					
	Estimate	95% CI		β	*t*	*p*-value	Estimate	95% CI		β	*t*	*p*-value
New Year's Day	5.269	2.270	8.268	0.384	2.341	***0.001***	−2.437	−6.631	1.757	−0.133	4.579	0.285
Obon dance	3.072	0.429	5.715	0.271	1.818	***0.026***	−1.335	−4.841	2.172	−0.097	3.200	0.458
Hometown	3.885	0.345	7.424	0.251	3.261	***0.035***	−4.052	−8.873	0.770	−0.214	6.051	0.105
Regional festival	6.123	3.298	8.948	0.456	2.078	***< 0.001***	−2.254	−6.431	1.922	−0.140	4.540	0.294
Song	3.853	−0.274	7.981	0.239	4.436	0.074	0.750	−4.212	5.712	0.038	6.409	0.768
Housework	3.275	0.177	6.372	0.250	2.497	***0.042***	0.525	−3.610	4.660	0.033	4.450	0.804
Playing	3.976	0.683	7.268	0.274	2.822	***0.021***	−1.975	−6.525	2.575	−0.117	5.389	0.398
Primary school	4.969	2.000	7.938	0.377	2.295	***0.002***	−0.040	−4.176	4.097	0.001	4.454	0.985
Traditional food	4.324	1.733	6.916	0.373	1.748	***0.002***	−1.852	−5.480	1.775	−0.115	3.425	0.321
Sport	3.250	0.579	5.921	0.283	1.857	***0.020***	−3.559	−7.002	−0.116	−0.233	3.085	***0.047***
Family	3.338	−1.344	8.020	0.166	5.706	0.163	−7.270	−13.235	−1.305	−0.275	9.262	***0.020***
Summer	4.670	0.737	8.602	0.285	4.025	***0.023***	−5.204	−10.247	−0.161	−0.234	6.621	***0.047***
Marriage	2.940	−0.412	6.293	0.202	2.926	0.090	−1.933	−6.377	2.511	−0.099	5.141	0.397
Raising children	−0.517	−4.317	3.283	−0.032	3.758	0.790	0.168	−4.797	5.133	0.010	6.416	0.947
Jobs	3.438	−0.181	7.058	0.215	3.410	0.071	−2.605	−7.339	2.129	−0.126	5.834	0.294

Table 3 Correlations Between Positive Reminiscence, Negative Reminiscence, and GDS-5, LSI-K, and RSE

	r	*p*-value	*r*	*p*-value	*r*	*p*-value	*r*	*p*-value	*r*	*p*-value
Positive reminiscence	—									
Negative reminiscence	−0.456	***< 0.001***	—							
GDS-5	−0.299	***0.012***	0.435	***< 0.001***	—					
LSI-K	0.315	***0.010***	−0.423	***< 0.001***	−0.477	***< 0.001***	—			
RSE	0.400	***< 0.001***	−0.345	***0.003***	−0.392	***< 0.001***	0.433	***< 0.001***	—	

Note. GDS-5: Geriatric Depression Scale-5 Japan version; LSI-K: Life Satisfaction Index-K Japanese version; RSE: Rosenberg Self-Esteem Survey Japanese version.
The spearman's rank correlation coefficient was used for the correlation between the scores for positive reminiscence, negative reminiscence, GDS-5, LSI-K, and RSE.

tors of negative reminiscence.

Correlations Between Quality of Reminiscence, Depression, Life-Satisfaction, and Self-Esteem

Table 3 reports weak to moderate significant correlations of positive reminiscence with negative reminiscence (r = −0.456, $p < 0.001$), depression (r = −0.299, $p = 0.012$), life-satisfaction (r = 0.315, $p < 0.010$), and self-esteem (r = 0.400, $p < 0.001$). Negative reminiscence was significantly correlated with depression (r = 0.435, $p < 0.001$), life-satisfaction (r = −0.423, $p < 0.001$), and self-esteem (r = −0,345, $p = 0.003$). With regard to mental health, there was a significant correlation between depression and life-satisfaction (r = −0.477, $p < 0.001$) and self-esteem (r = −0.392, $p < 0.001$). Life-satisfaction and self-esteem were also significantly correlated (r = 0.433, $p < 0.001$).

Relationships Between Sociodemographic Factors and Quality of Reminiscence, Depression, Life-Satisfaction, and Self-Esteem

The results of the multiple regression shown in Table 4, Table 5, and Fig. 1 reveal that predictors explained significant proportions of the variance in positive reminiscence ($R^2 = 0.267$, F (8,76471.620) = 2.654, $p = 0.007$), negative reminiscence ($R^2 = 0.138$, F (8, 1945000) = 1.221, $p = 0.281$), depression ($R^2 = 0.304$, F (8, 670400) = 3.321, $p = 0.001$), life satisfaction ($R^2 = 0.428$, F (8, 13034.467) = 5.103, $p < 0.001$), and self-esteem ($R^2 = 0,235$, F (8, 122300, $p = 0.020$). Economic status was found to significantly predict positive reminiscence (β = 0.356, $p = 0.008$), whereas marital status (β = 0.360, $p = 0.019$) and economic status (β = 0.471, $p < 0.001$) were significant predictors of depression. Living arrangements (β = 0.276, $p = 0.043$), economic status (β = 0.285, $p < 0.011$), and health status (β = 0.449, $p < 0.001$) were significant predictors of life satisfaction.

Table 4 Multiple Regression of Analysis of the Relationship Between Sociodemographic Variables and Quality of Reminiscence

	Positive reminiscence						Negative reminiscence					
	Estimate	95% CI		β	*t*	*p*	Estimate	95% CI		β	*t*	*p*
Age	0.224	−0.001	0.449	0.241	0.013	0.055	−0.120	−0.433	0.193	−0.106	0.026	0.455
Gender	1.513	−2.873	5.900	0.083	5.008	0.501	−2.012	−8.235	4.211	−0.088	10.081	0.529
Marital status	−0.706	−4.019	2.607	−0.061	2.857	0.678	2.915	−1.762	7.592	0.199	5.695	0.227
Living arrangement	0.154	−3.079	3.386	0.009	2.720	0.926	1.976	−2.604	6.555	0.127	5.459	0.401
Economic status	4.522	1.618	7.426	0.356	2.195	***0.003***	−3.706	−7.816	0.403	−0.224	4.395	0.082
Community activities	3.815	−1.328	8.958	0.178	6.885	0.152	−4.126	−10.981	2.730	−0.144	12.234	0.243
Health status	1.147	−2.039	4.332	0.078	2.641	0.483	−1.891	−6.372	2.590	−0.107	5.227	0.411
Outpatient treatment	−1.553	−5.627	2.520	−0.093	4.319	0.458	−0.269	−5.950	5.411	−0.004	8.400	0.926

Note. CI: Confidence Interval.

Table 5 Multiple Regression Analysis of the Relationship Between Sociodemographic Variables and GDS-5, LSI-K, and RSE

	GDS-5						LSI-K					
	Estimate	95% CI		β	*t*	*p*	Estimate	95% CI		β	*t*	*p*
Age	0.045	−0.009	0.099	0.206	0.001	0.104	−0.071	−0.165	0.023	−0.181	0.002	0.144
Gender	0.608	−0.470	1.687	0.142	0.303	0.273	−1.521	−3.301	0.260	−0.188	0.825	0.100
Marital status	0.998	0.189	1.807	0.360	0.170	***0.019***	−0.124	−1.548	1.301	−0.025	0.528	0.866
Living arrangement	0.349	−0.440	1.139	0.121	0.162	0.389	1.458	0.084	2.831	0.276	0.491	***0.043***
Economic status	−1.483	−2.194	−0.772	−0.471	0.132	***< 0.001***	1.551	0.393	2.708	0.285	0.349	***0.011***
Community activities	0.512	−0.672	1.696	0.097	0.365	0.400	−0.942	−2.848	0.964	−0.098	0.946	0.337
Health status	−0.460	−1.237	0.317	−0.136	0.157	0.250	2.602	1.259	3.944	0.449	0.469	***< 0.001***
Outpatient treatment	0.135	−0.862	1.133	0.044	0.259	0.791	1.084	−0.587	2.756	0.134	0.727	0.209

	RSE					
	Estimate	95% CI		β	*t*	*p*
Age	−0.134	−0.380	0.112	−0.124	0.016	0.291
Gender	3.367	−1.483	8.217	0.176	6.123	0.179
Marital status	−1.884	−5.575	1.807	−0.151	3.546	0.321
Living arrangement	−2.861	−6.484	0.761	−0.216	3.416	0.127
Economic status	3.030	−0.159	6.219	0.224	2.647	0.067
Community activities	1.494	−3.830	6.818	0.065	7.378	0.584
Health status	1.938	−1.541	5.418	0.135	3.152	0.279
Outpatient treatment	−2.245	−6.979	2.489	−0.139	5.833	0.357

Note. GDS-5: Geriatric Depression Scale-5 Japan version; LSI-K: Life Satisfaction Index-K Japanese version; RSE: Rosenberg Self-Esteem Survey Japanese version; CI: Confidence Interval.

Discussion

Reminiscence Contents and Quality of Reminiscence

Reminiscence Contents and Positive Reminiscence

Our findings revealed that older adults, who tend to generate positive emotions, are more likely to be triggered by "New Year's Day," "Obon dance," "hometown," "regional festival," "housework," "playing with friends," "primary school," "traditional food," "sports one used to play," and "summer" in their daily life. In previous studies, Chang and Chien [27] suggested that incorporating culturally related topics into the reminiscence intervention is associated with improved psychological outcomes and has been proved to be effective. In agreement with these authors, our study found that positive reminiscence was easily generated from culturally relevant topics, such as "New Year's Day," "Obon dance," "regional festivals," and "traditional food" among Japanese older adults. "New Year's Day," "Obon dance," and "regional festivals" are special events for them. These holidays represent the local culture and heritage, people usually spend with family groups or with friends and neighbors. They also share food and do housework together, which may promote interpersonal relationships and create meaningful memories of these festivals. Thus, reminiscence about culturally relevant content may help stimulate positive emotions among older adults.

Chao et al. [7] suggested that selected topics should focus on past events from early life stages to encourage older adults to look back on their lives and gain a sense of achievement and satisfaction. One's hometown is

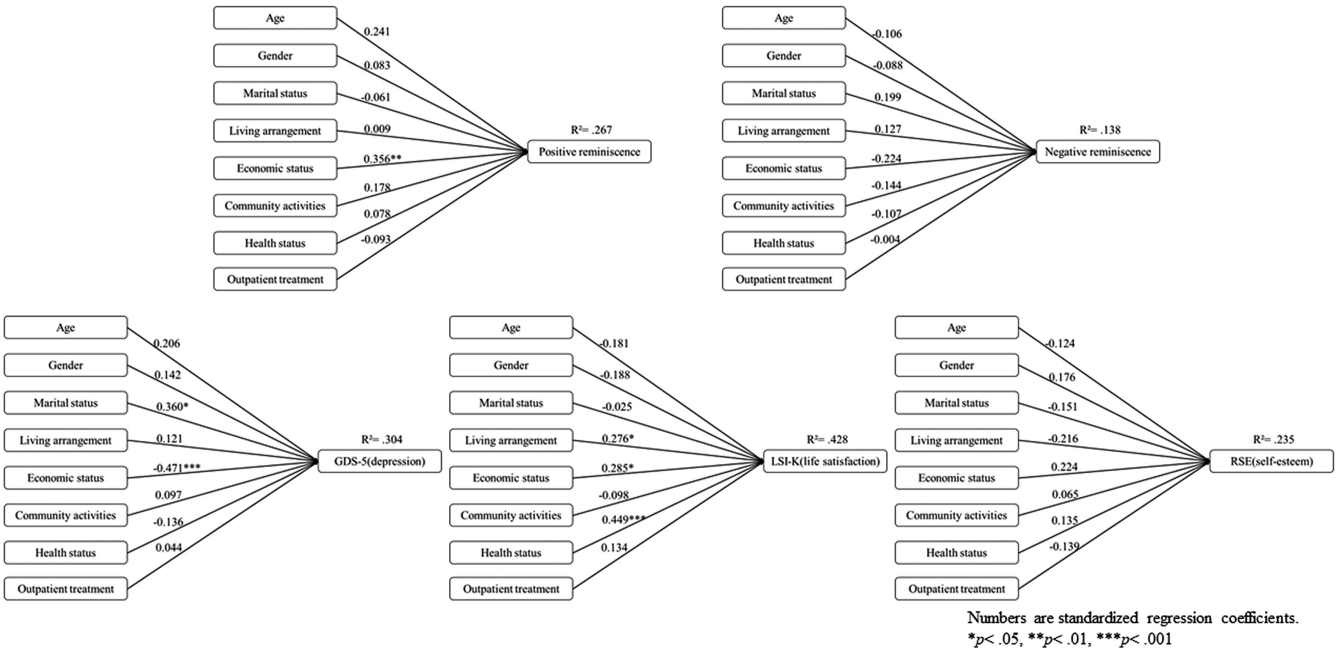

Fig. 1. Multiple Regression of Analysis of the Relationship Between Sociodemographic Variables and Positive Reminiscence.

usually a place where people live when they are young. Thus, memories of activities and people from one's hometown can stir emotions. Going to primary school is a significant event that occurs at an early stage in one's life. Playing with friends could bring back memories of when one started to integrate into school life and learn to develop human relationships. Sports may bring back memories of accomplishment and transcendence. Summer involves various activities and events, such as firework festivals, catching fireflies, and eating ice cream, which are easy and happy memories to stimulate older adults. Therefore, our results indicate that positive emotions are more likely to be generated by the reminiscence of the above-mentioned 10 contents.

Reminiscence Contents and Negative Reminiscence

Results of negative reminiscence indicated that older adults, who generate less negative emotions, are more likely to recall "sports one used to play," "family," and "summer." Families nurture the most intimate relationships among people. Older adults feel lonely, especially when they enter old age, as they long for the company of and communication with their families. Reflecting on past times and experiences with family can help eliminate some bad memories. It is noteworthy that both "sports one used to play" and "summer" not only generate positive emotions but also reduce negative emotions from negative reminiscence. This may be because most participants practiced gymnastics exercises, and there may also be regional differences. It is noteworthy that although the results reveal that the recall of these three contents represents positive meanings, they could potentially generate negative memories, considering the actual situation in the process of reminiscence. Meanwhile, it may be interesting to classify reminiscence contents according to their functions or characteristics and integrate them into a model that may help develop a better understanding of the process of reminiscence. More broadly, further research and discussion are required to clarify the order in which these themes are used.

Relationship Between Quality of Reminiscence and Depression, Life-Satisfaction, and Self-Esteem

Our data analysis revealed that an increase in positive reminiscence was associated with a decrease in negative reminiscence, decrease in depression, high self-esteem, and high life-satisfaction. In contrast, when recalling the past along with negative emotions, depressive symptoms may worsen, and life satisfaction and self-esteem may reduce. These findings are consistent with those of previous studies on this topic. When recalling the past with positive emotions, self-esteem and life satisfaction may increase [9, 10, 28]. Negative emotions in everyday life are associated with depression, life satisfaction, and self-esteem, and the production of negative reminiscence worsen these psychological effects [10, 28]. Memories of daily life can be both pleasant and sad for older adults, positive memories can help them learn from past memories to solve problems, become aware of the positive aspects of their lives, have better

satisfaction, and gain personal values and self-identity, which can improve or increase their self-esteem [29]. Negative memories focusing on past regrets, unachieved goals, and the loss of loved ones are more likely to produce depressive symptoms [30].

Relationships Between Socio-Demographic Characteristics and Quality of Reminiscence, Depression, Life-Satisfaction, and Self-Esteem

In terms of sociodemographic characteristics, economic status was a significant factor for positive reminiscence, depression, and life satisfaction. Meanwhile, living arrangements and health status were also significant factors for life satisfaction. This suggests that older adults with better financial status tend to have fewer depressive symptoms and produce positive reminiscence. However, lower income, poor health status, and lack of a partner may increase the risk of mental health problems and result in less positive reminiscence. Notably, older adults who tend to generate negative reminiscence may need to consider their health, economic status, and living arrangements even before the reminiscence intervention.

Limitations

The data obtained from the study participants were subjective data extracted through questions. The results for economic and health statuses may differ from those obtained using objective data. Thus, future studies using objective data are needed to address these gaps.

Regarding the contents on "marriage" and "raising children," those who were widowed or divorced at the time of their responses may have had negative reminiscences; however, this survey did not distinguish between them. Therefore, it seems that the number of respondents who had a spouse at the time of the response ("married" in "Marital status") was smaller than those who answered "yes" to "marriage" or "raising children." Thus, it is possible that there was a mixture of those who had positive reminiscences about "marriage" and "raising children" and those who had negative reminiscences, which may have affected the analysis results. In the future, it is necessary to consider characteristics such as bereavement and divorce. Furthermore, with regard to marital status and children, the analysis in this study included participants who had not experienced marriage or childrearing. Thus, in the future, we may need to consider an analysis by strata after securing a larger number of participants. As for "job," in this study, we were only investigating the presence or absence of experience, so we were unable to examine each type of job. In the current study, more than 80% of the respondents were women, and many answered that they had jobs. Thus, there is a possibility of a bias in the target group, and thus, it is possible that women may have responded that they considered helping with the family business as a job. In the future, therefore, we need to include older adults who do not actively participate in community activities, and collect more data on men to obtain a detailed and a more inclusive set of data for a comprehensive analysis. In addition, the survey items in this study were structured so that participants responded to the reminiscence content and then to the quality of reminiscence. However, the fact that participants responded first to the reminiscence content may have influenced their subsequent responses to the quality of reminiscence. Therefore, it is necessary to consider the structure of the survey in future surveys, taking into account the influence of the questions before and after.

With regard to the sample size of this study, because the participants included people involved in local care prevention programs, the number was limited; moreover, the proportion of men was much lower than that of women. Thus, the results may not be generalizable to a large population of community-dwelling elderly individuals. Since the subjects of the study were selected non-randomly from a specific region, there may have been a risk of bias. Additionally, since this was a cross-sectional study, a causal relationship could not be determined. Therefore, in the future, it would be necessary to examine whether the content and social factors that affect the quality of reminiscences shown in this study actually induce positive (negative) reminiscences and to seek clinical usefulness. Therefore, based on this study, it is necessary to verify whether taking reminiscence contents and social factors into consideration affects reminiscence, using a longitudinal design in future studies.

Conclusion

Despite the limitations, we can conclude that older adults, who tend to recall 10 reminiscence contents ("New Year's Day," "Obon dance," "hometown," "regional festivals," "housework," "playing with friends," "primary school," "traditional foods," "sports one used to play," and "summer") in their daily lives, are more likely to generate positive emotions, which are associated with not only a decrease in depression but also an increase in satisfaction and self-esteem. Generally, this study provided insight into the possibility of monitoring and preventing mental health problems through the recall of positive reminiscence contents. Furthermore, it would be feasible to consider adding cultural factors in the process of reminiscence for the Japanese community-dwelling older adults.

Conflict of Interest

The authors declare that they have no competing interests.

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■ORIGINAL ARTICLE

The Effects of Sensory Integration Therapy on Children with Neurodevelopmental Disorders

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Abstract: The purpose of this study was to determine the effects of SIT on developmentally disabled children with sensory integration disorder.

The subjects were children with developmental disabilities diagnosed as autism spectrum disorder, attention deficit hyperactivity disorder, and motor retardation. There were eight children in a SIT group, and seven children in a non-SIT group. The SIT group received individualized SIT at a hospital, and the non-SIT group received social skills training at a welfare facility. The training period for both groups was about 10 months. In a non-randomized controlled trial, the effectiveness of SIT was examined by comparing the differences in SSP, DAM, and S-JPAN scores before and after therapy. No significant differences in changes of these scores were found between the non-SIT and SIT groups before and after the intervention. However, the SIT group showed a significant difference in the subdomains of hyporesponsiveness and sensory seeking ($p < .05$). A marginal difference was also observed in visual and auditory hypersensitivity ($p < .1$). The DAM showed a marginal difference in pre- and post-intervention differences between the two groups ($p < .1$). The S-JPAN showed a significant difference between the two groups ($p < .05$). In the present study, SIT was found to improve the sensory processing function, body schemas, and some praxes of children with sensory integration disorder. In the future, we would like to consider homogenizing the target children's disorders, expanding the sample size, and conducting a randomized controlled trial.

Keywords: neurodevelopmental disorders, sensory integration therapy, non-randomized controlled trial

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Introduction

Ayres was an American occupational therapist in the 1960s who systematized sensory integration theory for children with learning disabilities. Ayres defined sensory integration as "the neurological process by which humans regulate sensory information from their bodies and environment. It enables humans to use their bodies effectively in the environment" [1]. Occupational therapists apply sensory integration therapy (SIT) to children with autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), learning disabilities (LD), motor developmental delay, cerebral palsy, and other sensory integration problems.

In Japan, sensory integration therapy (SIT) for children with developmental disabilities has been conducted in hospitals and educational institutions. However, effectiveness studies in Japan tend to be case studies. Arikawa et al. (2006) [2] published a review of research papers on the effects of SIT. They found no studies at Levels I, II, or III of evidence, and one case-control study at Level IV. Level V included seven case-control studies and five case-report studies. In addition, the American Academy of Pediatrics (2012) [3] recommended that the number of studies on the effectiveness of SIT is limited. Therefore, they recommended that parents need to be informed that its effectiveness is not sufficient. In response to such recommendations, some papers have been published that clearly demonstrate the effectiveness of SIT.

Pfeiffer et al. (2011) [4] conducted a randomized

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controlled trial (RCT) in their study of the effects of SIT in children with autism spectrum disorder (ASD). The SI intervention group showed more significant positive changes than the fine motor group in Goal Attainment Scaling (hereafter referred to as GAS) scores for both groups, but the SI group showed more significant changes. Schaaf et al. (2014) [5] also conducted an RCT for children with ASD. They noted that the SI intervention group had better GAS results as a primary outcome compared to the usual care group. Thus, in the U.S., studies have shown the effectiveness of SIT. In Japan, Iwanaga et al. (2014) [6] conducted a study of non-randomized controlled trials, but the number of such studies is still very small.

The purpose of this study was to determine the effectiveness of SIT for developmentally disabled children with sensory integration disorder. The effectiveness of SIT for developmentally disabled children with sensory integration disorder was compared by examining differences in SSP, DAM, and S-JPAN scores before and after therapy in a non-randomized controlled trial.

Method

Subjects

The subject children were children with diagnosed developmental disorders. The disorders were defined as children with diagnoses of autism spectrum disorder (ASD), pervasive developmental disorder (PDD), attention deficit hyperactivity disorder (ADHD), motor development delay, and language development delay. The intervention group (SIT group) consisted of children who received SIT at the hospital. The control group (non-SIT group) consisted of children who attended a medical institution.

The number of eligible children in the study was 9 in the SIT group and 9 in the non-SIT group. The SIT group ranged from 5 years 2 months to 8 years 8 months, with a mean age of 6.7 years. Gender was seven boys and two girls. The SIT group had more diagnoses of motor developmental delay, language developmental delay, dysarthria, and ASD. The non-SIT group ranged from 5 years 5 months to 8 years 10 months, with a mean age of 6.9 years. All were boys. The non-SIT group had more diagnoses of ASD, PDD, and ASD with intellectual disability (Tables 1, 2).

IQ and DQ

The IQ of the SIT group ranged from 56 to 103, with a mean of 73.5 ± 17.5. In the non-SIT group, four of the seven patients had seen a health care provider and had their intelligence quotient (IQ) measured. Two of the four were 90 and 95, and the other two were 55 and 56. The mean IQ of the four children with known IQ was 74.0. Three of the seven had known developmental quotients (DQ) of 80, 54, and 78. We did not set cutoffs for IQ or DQ because of the small number of children in our study.

Training duration and frequency for SIT group

The frequency of training for the SIT group was twice a month for 40 minutes per session. The training period was 10 months, and the total duration was 13 hours. The training period was extended when the subject missed the training due to reasons. The total training time was to be fulfilled within 12 months at most. The average number of times training was conducted was 20.1. The training period was 10.6 months.

Training content, duration, and frequency for the non-SIT group

The children received social skills training and other therapies. In some facilities, physical activity was observed, but SIT was not implemented. The training period was 10 months, and the frequency of training was once or twice a week. The children received 2 to 3.5 hours of training per session. The average number of sessions was 5.1 days/month, and the average duration of instruction was 10.0 months.

Explanation and consent

The researcher explained the study orally and in writing to the parents of the subject children and obtained their consent. We gave informed assent to the target children. This study was approved by the Ethics Committee of our hospital (Approval No. 2755-1).

SIT Providers

The SIT providers were one SI therapist (principal investigator) certified by the Japanese Society for Sensory Integration, and three occupational therapists with knowledge of SIT. The certified therapist had 18 years of experience. The other three therapists had 8, 12, and 18 years of experience. Two of them had completed the ‘A’ course of the Japanese Society for Sensory Integration certification training. The remaining one had not attended any course, but had knowledge of sensory integration. The principal investigator was present during the initial therapy of the three OTs to confirm the validity of the SIT. The certified therapist checked the content of each OT’s therapy using the Ayres Sensory Integration Intervention Fidelity Measure Summary (ASIFM) proposed by Parham et al. (2011) [7].

This ASIFM is designed to help OTs follow Ayres’ principles of sensory integration when using SIT, according to the following 10 items.

Table 1 Attributes of the SIT group.

No.	Gender	Initial age	Disorder			IQ	Test Name	DQ	Test Name
1	female	5	motor retardation	speech and language delay		56	Tanaka-Binet test V		
2	female	5	motor retardation	developmental dysarthria		68	WPPSI		
3	male	6	motor retardation	speech and language delay	ASD	103	WISC-IV		
4	male	6	motor retardation			56	Tanaka-Binet test V	49	Kyodaishiki developmental schedule
5	male	6	motor retardation	ASD		61	Tanaka-Binet test V		
6	male	6	ADHD	lisping disorder	speech and language delay	70	WPPSI		
7	male	8	motor retardation			94	WISC-IV		
8	male	8	mental retardation	speech and language delay		80	WISC-IV		

Table 1 shows the attributes (gender, age, disorder, IQ, DQ, and the name of each test) of the target children in the SIT group.

Table 2 Attributes of non-SIT group.

No.	Gender	Initial age	Disorder		IQ	DQ	Test Name
1	male	5	ASD			80	Kyodaishiki developmental schedule
2	male	5	ASD			54	Kyodaishiki developmental schedule
3	male	5	ASD	Mental development in the borderlands		78	Kyodaishiki developmental schedule
4	male	6	ASD with intellectual disability		55		Tanaka-Binet test V
5	male	7	PDD		95		WISC-IV
6	male	8	ASD	ADHD	90		WISC-IV
7	male	8	ASD with mild intellectual disability		56		Tanaka-Binet test V

Table 2 shows the attributes of the target children in the non-SIT group (gender, age, disorder, IQ, DQ, and name of each test).

Provide documentation of the child's characteristics and home program

The principal investigator took videos to review the training, and provided advice to the three OTs after the training. The principal investigator provided the parents of the SIT group with a document describing the children's characteristics and a home program, and asked them to work on it at home. Since the SIT group trained less frequently than the non-SIT group, the home program was implemented to supplement the frequency of training. The home program was designed based on the results of the evaluation conducted in this study. The therapist introduced gross play, manual play, and helping. The principal investigator similarly provided the parents of the non-SIT group with a written description of their child's characteristics.

Training environments

The SI provider provided therapy to the children in the SIT group in the sensory integration therapy room of our hospital. The room was equipped with various types of swings, trampolines, ball pools, rope ladders, toddler slides, balance boards, balance balls, and barrel rolls. The children were able to use the equipment and play independently. Therapists conducted SIT on a one-on-one basis. The therapist, the child, and the child's guardian were present in the training room. No other children were in the same room.

Training providers for non-SIT group

In the non-SIT group, training was conducted by instructors from child development support offices. The three instructors had 5, 6, and 7 years of experience. Three of them possessed a license as a child development support manager. Their work included communi-

Table 3 S-JPAN evaluation items.

No	Test item	Sensory processing processes and action functions in four areas	Key related capabilities	Evaluation method
1	Airplane part 2	posture and balance function	anti-gravity posture movement	The child assumes a supine extension position on the floor.
2	Crane games		posture background movement	The child sits upright on a special seat, rotates the trunk, and moves the marbles.
3	Treasure hunting	somatic sensation	active tactile pressure sensation	The child finds the projections arranged on the sheet from the invisible box by fingering them.
4	Let's do a good imitation	praxis	body schema	The examiner shows the child pictures of the various poses and the child imitates them.
5	Ottotto		bilateral coordinated movement eye-hand coordination	The child holds the special tube on either side, and rolls the ball from side to side so as not to drop it.
6	Moving in close together (cross)		bilateral coordinated movement	The examiner places special towers in front of the child. The child simultaneously lifts the towers, crosses his/her upper extremities, and stacks the towers.
7	Serious injury		bilateral coordinated movement	The child attaches the rope to his non-dominant hand, and wraps it around his dominant hand.
8	Pig's face (wrong number of dominant hand)	visual perception, eye-hand coordination	visual exercise planning	The child uses a special inspection form. The child draws lines with a sign pen so that they do not extend beyond the parallel lines.

Table 3 shows the S-JPAN assessment items, sensory processing processes in the four domains, main related abilities, and assessment methods.

cation and social skills practice, parental consultation and interviews, preparation of individual support plans, and training and guidance of child guidance staff.

Training content for non-SIT group

The instructors belonging to the treatment and education institutions provided individual and group training. These institutions used small-group training. In individual training, desk-based tasks were performed, and in group training, social training and other social skills training were performed.

Instruments

The children were assessed before and after the intervention using the S-JPAN, the Short Sensory Profile (SSP), and the Good Enough Picture Intelligence Test (DAM). The S-JPAN is a short version of the JPAN sensory processing and praxis test. It was developed as a method to screen children with developmental disabilities for sensory integration disorders. The test consists of eight items: two items for equilibrium function and posture, one item for somatosensory perception, four items for praxis, and one item for visual perception and eye-hand coordination [8]. The table shows the description of each item (Table 3). The explanations were taken from the JPAN manual for Japanese Playful Assessment for Neuropsychological Abilities [9].

The SSP is a shortened version of the sensory profile developed by Dunn [10]. This sensory profile is supposed to be a standardized scale for professionals to assess children's sensory processing abilities, and to profile the impact of sensory processing in daily life. It consists of a 38-item questionnaire to which parents respond on a 5-point scale of "never," "rarely," "sometimes," "often," and "always." The examiners score on a scale of 1 to 5, and classify the total section score and the total SSP as "average," "high," or "very high.

The DAM [11] is a standardized, portrait-based test of intelligence, indicated for ages 3-9. This assessment is essentially a nonverbal test that attempts to capture the developmental stages of the visual-motor system.

In this study, it was used to look at the development of the child's body schema. Scores are converted to mental age (MA) using the MA conversion table. The intelligence quotient (IQ) is calculated by dividing the converted MA by the living age (CA), and multiplying by 100. Goodenough [12] stated that children represent their concept of the person (body schema) as a drawing. Tanaka et al. [13] conducted a study to characterize body schema in children with ASD using the DAM.

Procedure

In both the SIT and non-SIT groups, the simplified JPAN sensory processing and praxis test (hereafter referred to as S-JPAN) was administered to identify

whether the subject children had sensory integration disorders. Children with S-JPAN scores of 0.55 or higher were selected for inclusion; those with scores below 0.55 were excluded because they were unlikely to have sensory integration disorder. The Japanese version of the Sensory Profile Shortened (SSP) and the Good Enough Picture Intelligence Test (DAM) were also used as evaluation indicators.

Data Analysis

In this study, nonparametric statistics were used because of the small number of eligible children in the two groups. Before and after the intervention in each group, each value of the evaluation index was statistically processed by Wilcoxon's signed rank sum test. Differences in changes of each value between the non-SIT and SIT groups before and after the intervention were statistically treated with the Mann-Whitney U test.

Results

Selection of eligible children

In the SIT group, one child had an S-JPAN value of 0.55 or higher, which met the criteria. However, due to the child's family circumstances, the OT was unable to provide regular training. Therefore, the child was excluded from the study due to the prolonged training period. In the non-SIT group, two children had S-JPAN values of less than 0.55 and did not meet the criteria, so they were excluded from the study. The final number of eligible children was eight in the SIT group and seven in the non-SIT group. The SIT group ranged in age from 5 years and 2 months to 8 years and 8 months, with a mean age of 6.7 years. The gender of the children was six boys and two girls. The non-SIT group ranged in age from 5 years and 5 months to 8 years and 10 months, with a mean age of 7.0 years. All were boys. The authors compared age with the Mann-Whitney U test. The results showed no significant difference in age. Thus, the two groups were homogeneous in age. The authors compared the presence or absence of ASD with a chi-square test. The results showed a significant difference between the two groups ($p < .01$). Thus, the two groups were not homogeneous in the diagnosis of ASD. The non-SIT group had more children diagnosed with ASD than the SIT group.

There was no predominant difference in the pre-intervention scores of the two groups: S-JPAN (p-value = 0.78), DAM (p-value = 1), and SSP (p-value = 0.38).

Results for each indicator

SSP

In terms of total SSP, the non-SIT group had a median of 61.0 (interquartile range 45.0–68.0) before the intervention. After the intervention, the median was 58.0 (interquartile range 43.0–63.0). There was no significant difference before and after the intervention. Before the intervention, the SIT group had a median of 67.5 (interquartile range 60.5–74.0). After the intervention, the median was 55.5 (interquartile range 51.0–58.5). There was a significant difference before and after the intervention ($p < .05$). No significant difference was found between the non-SIT and SIT groups before and after the intervention. In the non-SIT group, the median was −3.0 (interquartile range −7.5–2.0). In the SIT group, the median was −12.0 (interquartile range −15.3–(−0.8)). However, the non-SIT group showed significant differences in visual and auditory hypersensitivity ($p < .05$). Before intervention, the median was 7.0 (interquartile range 6.5–7.5). After intervention, the median was 5.0 (interquartile range 5.0–6.5). The SIT group showed significant differences in hyporesponsiveness and sensory exploration ($p < .05$). Before intervention, the median was 13.0 (interquartile range 11.8–15.3). After intervention, the median was 10.0 (interquartile range 7.0–10.8). Marginal differences were also observed in visual and auditory hypersensitivity ($p < .1$). Before intervention, the median was 7.5 (interquartile range 6.0–11.8). After intervention, the median was 6.5 (interquartile range 5.0–7.3) (Table 4).

DAM

In terms of total DAM, the non-SIT group had a median of 73.4 (interquartile range 58.1–86.2) before the intervention. After the intervention, the median was 64.4 (interquartile range 52.7–74.4). There was no significant difference in changes of those tests' scores before and after the intervention. Before the intervention, the SIT group had a median of 69.7 (interquartile range 61.4–75.4). After the intervention, the median was 79.7 (interquartile range 71.2–88.6). There was a significant difference before and after the intervention ($p < .05$). The difference between the non-SIT and SIT groups before and after the intervention showed marginal differences ($p < .1$). In the non-SIT group, the median was 9.0 (interquartile range −12.7–2.8). In the SIT group, the median was −10.0 (interquartile range 6.6–11.5).

S-JPAN

In the non-SIT group of S-JPAN, only the test of eye-hand coordination (Butasan's face, dominant hand error) was significantly decreased ($p < .05$). Marginal differences were observed in limb position imitation (let's imitate coolly) ($p < .1$). However, the remaining items did not differ significantly. In the SIT group, there was a significant improvement in the posture test (crane

Table 4 Comparison of median and interquartile range for each subitem of SSP.

Test item	non-SIT group			SIT group			non-SIT group	SIT group	
	Pre-intervention	Post-intervention	*p*-value	Pre-intervention	Post-intervention	*p*-value	Difference pre and post intervention	Difference pre and post intervention	*p*-value
Tactile hypersensitivity	8.0 7.0–8.5	7.0 7.0–8.5	0.35	10.0 9.8–10.5	8.0 7.8–9.0	0.34	0 −0.5–0	−2 −2.5–0	0.28
Taste and smell sensitivity	4.0 4.0–5.5	5.0 4.0–5.5	0.77	5.0 4.0–5.0	4.0 4.0–4.3	0.12	0 −1.0–0.5	−1.0 −1.0–0	0.35
Sensitivity to movement	3.0 3.0–3.0	3.0 3.0–3.0	NA	4.0 3.0–4.0	3.5 3.0–4.3	1.0	0 0–0	0 0–0.5	1.00
Hyporesponsiveness and sensory exploration	11.0 9.0–12.5	8.0 7.5–11.0	0.44	13.0 11.8–15.3	10.0 7.0–10.8	0.02**	−1.0 −2.0–0	−2.0 −5.0–(−1.5)	0.17
Auditory Filtering	15.0 11.5–17.0	12.0 10.5–15.5	0.80	13.0 10.8–15.0	11.0 9.8–15.0	0.48	1.0 −3.5–1.5	−1.0 −4.0–2.5	0.77
Low activity and weakness	11.0 8.0–15.5	10.0 7.5–12.0	0.86	13.5 10.5–16.3	12.5 9.8–15.0	0.68	0 −2.0–0	0 −1.5–0.5	0.86
Visual and auditory hypersensitivity	7.0 6.5–7.5	5.0 5.0–6.5	0.05*	7.5 6.0–11.8	6.5 5.0–7.3	0.06†	−1.0 −1.5–(−0.5)	−3.0 −4.0–(−1.5)	0.35

† 10% level, * 5% level, ** 1% level

Table 4 represents a comparison of the median and interquartile range for each subitem of the SSP for the non-SIT and SIT groups.

game) ($p < .01$). There were also marginal differences ($p < .1$) in the flying machine part 2. There were also significant improvements ($p < .05$) in discriminative tactile perception (treasure hunt), limb imitation (let's imitate coolly), and two-handed coordination tests (moving in a friendly manner cross). No significant differences were found in the other three test items (Table 5). The difference between the non-SIT and SIT groups before and after the intervention was significant in both groups ($p < .05$). The non-SIT group had a median of −0.2 (interquartile range −0.8–1.2). In the SIT group, the median was −2.5 (interquartile range −5.2–(−0.9)). There were also marginal differences for Airplane part 2 ($p < .1$). The non-SIT group had a median of 0 (interquartile range 0–0.5). The SIT group had a median of 23.0 (interquartile range 2.0–34.5) (Table 5).

Discussion

The purpose of this study was to determine the effectiveness of SIT for developmentally disabled children with sensory integration disorder. The effectiveness of SIT for developmentally disabled children with sensory integration disorder was compared by examining differences in SSP, DAM, and S-JPAN scores before and after therapy in a non-randomized controlled trial. The authors also compared and examined pre- and post-intervention differences between the non-SIT and SIT groups.

SSP

The authors compared the pre- and post-intervention differences between the non-SIT and SIT groups in each sub-domain of the SSP. The results showed no significant differences between the two groups.

The same was true for the total score of the SSP in both groups. However, there were significant differences in the subdomains of hyporesponsiveness and sensory seeking in the SIT group before and after the intervention. This was thought to be due to the SIT group's understanding of the children's sensory needs before conducting therapy. In terms of visual and auditory sensitivity, the SIT group showed marginal differences before and after the intervention. This was thought to be due to the fact that the SIT group gave visual and auditory information to the children while taking their condition into consideration. Miller's study reported improved scores in the OT-SI group over the no-treatment and active groups, although there was no significant difference in total SSP scores. In our study, there were no significant differences between the two groups before and after the intervention. However, the SIT group showed significant differences in pre- and post-intervention comparisons, and total scores also improved, suggesting the effectiveness of SIT for sensory processing function.

Table 5 Comparison of median and interquartile range for each test item of S-JPAN.

Test item	non-SIT group			SIT group			non-SIT group	SIT group	
	Pre-intervention	Post-intervention	*p*-value	Pre-intervention	Post-intervention	*p*-value	Difference pre and post intervention	Difference pre and post intervention	*p*-value
Airplane part 2	1.0 0–22.0	2.0 0–38.0	1.00	8.5 1.5–21.0	33.0 17.0–60.0	0.08†	0 0–0.5	23.0 2.0–34.5	0.09†
Crane games	4.0 0–7.0	4.0 1.0–7.0	0.56	2.5 1.5–5.0	6.5 4.5–10.0	0.01**	0 −1.5–3.0	2.5 1.8–4.8	0.12
Treasure hunting	11.0 6.0–18.0	12.0 3.0–20.0	0.80	13.5 5.5–16.0	15.5 12.5–21.0	0.05*	2.0 −2.5–4.5	3.0 0.8–6.0	0.35
Let's do a good imitation	16.0 13.0–33.0	23.0 18.0–36.0	0.06†	12.5 7.5–22.5	22.0 12.0–28.5	0.03*	3.0 1.5–3.0	5.5 2.5–7.5	0.32
Ottotto	40.0 4.0–45.0	27.0 5.0–54.0	0.94	38.5 15.0–49.0	38.0 27.0–50.0	0.34	1.0 −18.5–14.0	2.0 −2.5–15.3	0.60
Moving in close together (cross)	14.0 10.0–17.0	11.0 8.0–14.0	0.13	18.5 10.5–25.5	9.5 8.5–11.0	0.02*	−2.0 −5.0–0	−9.0 −15.0–(−5.0)	0.13
Serious injury	18.0 15.0–23.0	17.0 11.0–43.0	0.63	13.0 9.0–23.0	10.5 9.0–16.5	0.19	0 −3.0–9.0	−3.0 −7.5–1.0	0.28
Pig's face (Wrong number of dominant hand)	62.0 33.0–101	51.0 32.0–76.0	0.02*	74.5 55.5–86.0	72.0 47.0–90.0	0.31	−11.0 −13.0–(−6.0)	−8.0 −13.8–1.0	0.52

† 10% level, * 5% level, ** 1% level

Table 5 shows the comparison of the median and interquartile range for each test item of S-JPAN between the non-SIT and SIT groups.

DAM

The non-SIT group showed no significant difference in DAM before and after the intervention. The SIT group showed significant differences in pre- and post-intervention comparisons. The authors compared pre- and post-intervention differences between the non-SIT and SIT groups. The results showed marginal differences in both groups. This was thought to suggest that the SIT group may improve the body diagram. In Ayres' study (1966) [14], she reported that when a perceptual-motor test battery including figure drawing was administered to 100 children aged 6 or 7 years suspected of perceptual disturbances and to 50 children selected independently of perceptual ability, the mean scores between the two groups on figure drawing were better in the latter group and the difference was statistically significant. Again, the SIT group had better scores than the non-SIT group. Ayres stated that the basic idea is to enhance the flow of sensory impulses, develop conscious knowledge of the body's structure and basic movements, and then combine that sensory and conscious knowledge through simple, gross motor tasks. In the SIT group, the children played independently, and appropriate sensory processing took place, leading to improvement of the body schema.

S-JPAN

In the non-SIT group, there were significant differences or trends in two test items in the pre- and post-intervention comparisons. However, no significant differences were found in six items. In the non-SIT group, there may have been little positive impact on the abilities assessed by the assessment instruments. In the SIT group, significant differences were found in four test items in the pre- and post-intervention comparisons. One of the tests showed marginal differences. Overall, there was a significant difference between the non-SIT group and the SIT group in the pre- and post-intervention comparisons for both groups. This was thought to indicate that some sensory processing and praxis might be improved. In particular, we will discuss posture and action function, where significant differences were observed.

Postural Problems

In the non-SIT group, there was no significant difference in the posture-related test items (Airplane part 2 and crane game) before and after the intervention, but there was an advantage in the SIT group. Postural problems are observed in children with sensory integration disorder. SIT states that "the development of postural flexion and extension is facilitated by activities that re-

quire symmetrical movements, whereas the development of lateral bending, weight shifting, and rotation requires movements in asymmetrical patterns [1]. The SIT group was able to promote extension and flexion postures, as well as lateral bending and rotation movements with weight shifting during activities such as swing and barrel roll. In the non-SIT group, desk tasks and SST activities were the main activities, and postural problems may not have been approached as much. Therefore, this may account for the difference between the SIT group and the non-SIT group.

Praxis Problems

Ayres classified conduct dysfunction into two types: bilateral integration and sequencing (BIS), and somatic conduct dysfunction. It was not possible to determine which type of child the subject was because of the small number of test items. In the present study, the non-SIT group showed no significant difference in the test items related to praxis (imitate coolly, move in peace) before and after the intervention, but the SIT group showed a significant difference. This was because the SIT group was programmed to perform activities such as moving both sides of the body in a coordinated manner and crossing the midline. In addition, activities that required timing were provided. In the SIT group, the therapist determined the level of difficulty according to the child's condition, whether the child or the target was moving, and this was thought to be because the therapist allowed the child to process temporal and spatial information [1].

The Home Program

The home program was incorporated to supplement the training frequency of the SIT group. The therapists made suggestions to the parents regarding the exercises and help they would like them to perform at home. However, the therapists did not confirm with the parents whether they had implemented the home program or not, suggesting that there were differences in the implementation of the home program among the parents. This difference in implementation was thought to affect the results of the SIT group.

Therapy is often prescribed and performed once or twice a month at our clinic. Schaaf et al. (2014) [5] intervened three times a week for one-hour sessions in 10 weeks. From these results, it was considered that a frequency of about three times a week was necessary to achieve the intervention effect in the SIT group.

Diagnoses in both groups

The non-SI group tended to have more cases of ASD and the SI group more cases of motor developmental delay. Differences in diagnosis were thought to affect the results. However, both groups met the criteria for S-JPAN and may have sensory integration problems. Since there were no significant differences in the pre-intervention values of the S-JPAN in both groups, it was considered that there were no differences in sensory integration problems. Since no significant differences were found in the pre-intervention values of DAM and SSP in both groups, no sensory bias was considered to be present. Therefore, in the results of the S-JPAN, DAM, and SSP, there were no differences in the pre-intervention scores of the two groups, which was considered valid in determining the effectiveness of SIT.

Limitations of the study

In the present study, there was a variation in the target disorders in the SIT group. Both groups did not have cut-off values for IQ and developmental indices. In the non-SIT group, DQ and IQ were mixed. In the SIT group, IQ values varied widely, with a minimum of 56 and a maximum of 103. It was thought that a decline in intellectual functioning may have affected the results. It was thought necessary to test the effect of SIT by making the group homogeneous, for example, with an IQ of 70 or higher. It is necessary to homogenize the attributes of the target children in the future. We would like to consider increasing the sample size and conducting a randomized controlled trial.

Conclusion

In the present study, the SIT group showed improvement in sensory processing functions, body schemas, and some praxis in children with sensory integration disorder when compared to the non-SIT group. This suggests that SIT is effective for these children.

Conflict of interest

There are no companies, etc., with COI relationships that should be disclosed in relation to the publication of the paper.

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The Use of Applied Behavioural Analysis for Autism Spectrum Disorders- Experiences from Working with Children in Sri Lanka

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Abstract: In Sri Lanka, the prevalence and detection of Autism Spectrum Disorders (ASDs) has increased in recent times. Applied Behaviour Analysis (ABA) is an evidence based intervention in ASDs. In Sri Lanka the principals and methods of ABA are used as part of generalized intervention rather than a stand-alone intervention. This paper discusses how an evidence based intervention such as ABA can be adapted, so that it is effective and accepted in a different culture. This is important as concepts that come in ABA such as reinforcement is influenced by culture. Cultural awareness allows the therapist to utilise aspects of culture such as appropriate reframes to increase the acceptability of an intervention. ABA can be a very useful intervention in less resourced and culturally different situations when adapted in an appropriate way.

Keywords: culture, autism, Sri Lanka, ABA, reinforcement

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Introduction

In Sri Lanka, the prevalence and detection of Autism Spectrum Disorders (ASDs) has increased in recent times. With ABA being an evidence base therapeutic intervention [1], especially for children with Autism Spectrum Disorders (ASDs) [2], there has been more interest in ABA in Sri Lanka.

ABA is broadly described as the process of applying behavioral principles to change specific behaviors. Attention is given to the social and physical environment, including the antecedent conditions and consequences that elicit and maintain behaviour. In ABA complex behaviors are broken down into smaller, "discrete" skills and taught in a systematic fashion over time using substantial repetition and reinforcement [3].

ABA is one of the most established forms of treatment for ASDs, with most evidence being for individual comprehensive ABA, with there being lesser levels of evidence for other forms of ABA. Many therapeutic modalities use the principals of ABA, but not the full structure of ABA. Some examples being differential reinforcement of alternatives behaviours, discrete trial training, prompting and reinforcement. These modalities have also gained an evidence base for effectiveness in ASDs [4]. However, many current interventions based on applied behavioural approaches have shifted from the traditional repetitive training model to more natural, child-initiated, developmentally appropriate strategies and tasks [5].

Virtually all interventions that have been categorised as established treatments for ASDs are based on knowledge and applications of the scientific discipline of behaviour analysis [6]. The evidence for ABA-based interventions spans all valid and recognised research methodologies, including Single-System Design (SSD), Randomised Controlled Trials (RCT), Meta-analysis and Sequential Meta-analysis, Systematic Reviews, Social Validity studies, Neuroscience studies, and Cost-benefit analysis [7]. A recent scoping review in 2022 also concluded that the majority of studies showed positive outcomes for ASDs when ABA is used as an intervention [8].

Although the results of Randomised Controlled Trials (RCTs) are considered the gold standard of evi-

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dence based, there are many difficulties in conducting such trials in autism interventions, the main issue being difficulties in providing a uniform intervention for all participants. However, several RCTs have shown the effectiveness of ABA based interventions in ASDs. A good example is Howard et al. [9], who evaluated 29 pre-school children who received intensive behaviour analytic intervention (treatment group) and two matched control groups of 16 children each, receiving either intensive or non-intensive ‘‘eclectic’’ interventions. While the scores for cognitive, language, and adaptive skills were similar at intake, at follow-up the treatment group had statistically significant higher mean standard scores in all areas. These data were confirmed at the 2 year follow-up [10].

Whilst these forms of therapy are well established elsewhere in the world, there are only a handful of qualified ABA therapists in Sri Lanka. What is practiced more frequently, is a form of therapy that utilises different aspects of ABA incorporated into more general ways of working with children with behavioural issues. For example, a therapist may discuss not reinforcing disruptive behaviour by providing attention to it, or priming children to communicate, without explicitly using the terms of ABA. This kind of instruction would usually not receive emphasis on continued practice as in use of ABA in other countries, and would be couched in other more generalised instructions related to psychoeducation and other supportive measures.

There is currently a lack of research on the cultural adaptability of ABA based interventions or its effectiveness in Sri Lanka. However, Sri Lankan culture has many similarities to other South Asian cultures. In nearby India there have been many discussions on how to intervene in ASDs in a more culturally acceptable way [11]. More generally there has been much debate on how ABA in particular, can be made more culturally acceptable worldwide [12]. Culture is sometimes defined as a set of variables arranged by other people [13]. From a behavioural perspective this means a set of contingencies of reinforcement and punishment that affect the learned behaviour of a person or a group of people. Culture can also be predictive of how individuals within the group act in specific setting and conditions [14]. These behaviours can include selecting culturally appropriate treatments by parents for their children [15]. In the Sri Lankan context, having a language that is acceptable to communicate the concepts of ABA, understanding cultural factors that maintain some behaviours as well as the understanding the economic factors that may make attending regular sessions, are all factor that can affect the outcomes of ABA.

Thus, this paper attempts to describe how ABA is currently used and accepted in Sri Lanka, and to discuss how ABA can be utilised with more benefit and acceptability in culturally diverse situations.

The structure of service delivery in relation to ABA in Sri Lanka

In Sri Lanka, most clients who need help with both mental and physical health issues seek services from public sector facilities. Health services including mental health services are provided free of charge in the public sector. Within the structure of the public sector health service, there are currently no designated behaviour therapists even at specialised tertiary level centres [16]. As such the knowledge of behavioural principals are utilised in therapy mainly by Occupational therapists, who are also not available at all centres. However, when available, they would be working as part of a small multi-disciplinary team in the management of issues such as ASDs. In Sri Lanka available team members sometimes share their knowledge and skills across disciplines, with occupation therapist, nursing officers, social workers and even psychiatrists taking on the role that would otherwise require a psychologist or a behaviour therapist. This is out of necessity as a full complement of members (e.g. psychologists, behaviour analysts) are not available to most teams [17]. As such, if some knowledge and training is available other professionals will also contribute to behavioural interventions together with the occupational therapist.

Socio economic factors that influence service delivery

The families of many children with ASDs in Sri Lanka find it difficult to attend regular intensive therapy sessions due to socio-economic reasons. In our experience, although treatment in the public sector is free of charge, travelling costs and the loss of wages when daily wage-earning parents attend sessions are major considerations. As such, home based interventions are widely used in Sri Lanka. Such interventions carried out early, with parents acting as full-time therapists have been found to be beneficial in ASDs in Sri Lanka [17]. These kinds of interventions have been perceived to be useful in other parts of the world as well [18]. When considering the aspects of ABA used in home-based interventions in Sri Lanka, discrete trail training is initiated at therapy sessions and parents are trained to carry out and reinforce these behaviours at home. The progress of such home based interventions are then re-evaluated and discussed during visits to the centres.

Interventions utilising parents trained in the basics of ABA have been found to be effective for children with ASD in other South Asian settings as well [19]. Evaluation of the outcomes of such culturally attuned therapeutic interventions may also require a non-traditional framework. Different ways of evaluating behavioural interventions have been discussed in previous studies [20]. Recent studies have discussed the importance of evaluating the cultural validity of such interventions, as well as its efficacy [21].

Cultural differences in the use of reinforcement

The need to use culturally appropriate reinforcement, has been previously described [22]. The concept of reinforcement, and how it is likely to work in changing behaviours is generally well understood by parents of children attending services in Sri Lanka. In our experience, parents in Sri Lanka view the use of edibles and tangible items as reinforcers less favourably. Instead, praise given verbally, and physical touch were preferred reinforcers However, many parents are reluctant to accept the idea of changing their child's behaviour solely through overt reinforcement. Instead, there appears to be a preference for less overt ways of communicating and changing behaviour. This maybe through subtle nonverbal signals of displeasure. Collectivistic Asian cultures are also known to use greater verbal indirectness in their communications with each other [22]. While in normal circumstances children would over time learn to read these signals, difficulties arise when children have disorders such as ASDs that make social communication difficult. As such, a part of the work involved parents in more direct verbal communication and reinforcement.

Although it is generally assumed that praise is a conditioned reinforcer that has acquired its effects through previous association with other reinforcing events, how these social reinforcer work may be more complicated [23]. It was again seen that parents in Sri Lanka were in general more comfortable giving praise in indirect ways, acknowledging desired behaviours in the same manner and using nonverbal gestures at times. It has been previously described that using overt verbal praise in typical behaviourist lines in Asian cultures may cause difficulties and may be inappropriate as the children receiving this praise may be ostracization by their peers [24].

However, this indirectness in communication may sometimes lead to unwanted behaviours being inadvertently reinforced. It was seen that especially families living with grandparents had difficulties in managing meltdowns, as there is a belief that parents should not allow their children to cry [25]. This may have been culturally relevant in times when crying was an indication of physical pain, and ignoring it would not be approved in collectivist cultures. However, it can also act to reinforce undesired forms of behaviour in children. In these situations, understanding the function of such behaviours is vital. These undesirable behaviours can be understood as a manifestation of the child's need to communicate their needs better, failure to gain more desired way of getting attention, not have acceptable activities to engage in when they are alone or in social groups, and not having the coping skills to deal with tasks [26]. Function based behavioural strategies in which an individual is taught an alternative response that results in the same source of reinforcement previously identified as maintaining the problem behaviour may also be useful in these situations [27].

Some cultural factors may also impede the development of desired behaviours in children as well. For example, Asian parents have been found to have greater expectations for the academic achievement of their children [28]. Much less emphasis is placed on the development of social skills, and as such these skills are not reinforced as much. From our experience this also appear to be true in the Sri Lankan situation.

Physical punishment as a way of controlling behaviour in children is still widely used in Sri Lanka [29]. Physical punishment here denotes the use of physical means as a positive punishment in order to reduce undesired behaviours. In our experience, where this was practiced by parents it was mostly in the absence of reinforcing wanted behaviour, or providing alternatives. Currently behavioural forms of treatment do not advocate physical punishment, and argue that it is ineffective in producing significant and lasting behavioural changes in children [30]. Although non-physical forms of both positive and negative punishment can be used to reduce unwanted behaviour, most behavioural forms of treatment now espouse that children's behaviour be directed partly by rewards for their positive actions.

Communication and education variables

Communication is one of the most relevant cultural variables related to making therapeutic interventions more acceptable to clients and stakeholders [31]. Understanding how families comprehend and come to terms with a diagnosis of a mental health condition such as an ASD, is important in understanding how the treatment of such conditions might be made more acceptable to them. A study in India suggests that parents may not initially understand the importance of early intervention in ASDs and may consider the behaviours as "tempo-

rary", until both the parents and assessments of others lead to an understanding of persisting problems [32]. As a result, some parents may not recognise the need for consistent therapeutic interventions early on. In our experience as well, some parents with children who had marked behavioural issues that were amenable to ABA based interventions, come for treatment only after these were identified by health professionals. These health professionals had awareness of how problems would be identified culturally and were able to use culturally appropriate language to help the parents understand these behaviours as problematic. This cultural awareness is important as behavioural patterns that are viewed as problematic in one cultural context may be normalised in another [33]. Practitioners of ABA, tend to share an idiosyncratic technical language by virtue of their shared vocation [34]. Being able to digress from this common vocational language and engage culturally diverse clients in a language that they understand is vital in engaging those in different cultures [35].

However, in the Sri Lankan context, the use of descriptive terms for words such as "priming" is useful, as the local words for such terms are rarely used and not understood by many. The local words for these terms may also sound abrasive and maybe automatically unpleasant for clients, even for English language speaking clients [35]. On the other hand, Sinhala translations of some technical terms used in ABA may also have several meanings. For example, the local Sinhala term for extinction is also used to describe infertility and may not be acceptable to many clients. In our experience, simply describing to them how we worked with clients with similar issues in the past, is a good way of making a behavioural model more understandable.

Clients in Sri Lanka tend to express emotional states such as depression and frustration in indirect ways, such as using cultural idioms rather than using direct language [36]. Thus, being able to decipher these idioms as well as indirect language is important to understand the presentation. Similarly cultural idioms can be also used to explain the behaviour in a more understandable way. For example one could use the local idiom "Hisaradheta kotte maaru kala wagei" (Like changing pillows to get rid of a headache) to describe a course of action already taken by the parents with no possibility of having real benefit of changing behaviour. The final goal of those engaged in behaviour analytical practices should be to ensure that language and culture does not become a barrier to accessing and engaging in therapy for those who most need it [37].

Integrating Non-ABA practices into ABA

Traditional rituals and healing practices are still commonly practiced in Sri Lanka. In traditional Sri Lankan theatre culture called *Kolam* and *Tovil*, exorcists wear masks and dance to the rhythm of music. The *Sanni Yakuma* is a well-known exorcism ritual, in which numerous *Sanni* (disease) demons are portrayed by wearing elaborate masks [38]. Behavioural interpretations of some of these traditional rituals have also been attempted [39]. Traditional ritual and healing practices have been an important part of Sri Lankan culture and remains a part of the menu of options available to people, especially from villages, in times distress and trouble. The help of these traditional healers are also sought by parents in situations where children have behavioural problems and developmental delays, as seen in ASDs. This leads to delays in help seeking in parts of the country where such practices are common. Although this is problematic, it also points to the possible utility of incorporating a more ritualistic manner of ABA where this is acceptable. In our experience using a ritualistic reframe when incorporating activities into home-based practices has helped to ensure that these are actually carried out in an almost ritualistic manner.

Conclusion

In conclusion, currently in Sri Lanka ABA is used in the treatment of children with ASDs, mostly as part of a more general therapeutic intervention. Currently there are very few opportunities for clients to access formal behaviour analytic services in Sri Lanka. As such, there is a great need for training and awareness. Inputs of those trained in other countries in the region will be vital in expanding the local knowledge base and skill levels in ABA. One way of doing this is to use the experience of those already engaged in behaviour analytical practices elsewhere in Asia to help train those in Sri Lanka. It would also provide Applied Behaviour Analysts diversity in fieldwork experience and benefit the practice of ABA in general [40].

Statement Regarding Informed Consent- Not applicable
Statement Regarding Ethical Approval- Not applicable

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■ORIGINAL ARTICLE

Predicting Falls and Ability to Perform Activities of Daily Living using the Dual-Task Stepping Test in Older Patients Hospitalized for Acute Disease: A Prospective Study

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Abstract: Background: We prospectively investigated the capability of the dual-task stepping test in predicting falls and the ability to perform activities of daily living in older patients receiving acute care.
Methods: We recruited 92 participants aged ≥ 65 years who were admitted to our hospital for treatment of an acute disease from January to December 2021. They performed the dual-task stepping test, wherein they recalled their previous meal while stepping in place in the seated position for 30 s. Data regarding their falls and ability to use the toilet, change underwear, bathe, walk, and use stairs while in the hospital were recorded. We assessed the accuracy with which we could predict these measures at discharge using the dual-task stepping test results.
Results: A significant association was noted between the dual-task stepping test results and falls ($p = 0.014$). The area under the curve was 0.70, sensitivity was 100%, and specificity was 38.8%. The dual-task stepping test results were associated with all activities of daily living items examined ($p < 0.001$), with areas under the curve of 0.92, 0.83, 0.84, 0.87, and 0.87 for the ability to use the toilet, change underwear, bathe, walk, and use stairs, respectively. Sensitivity was the highest for the ability to use the toilet at 96.2%, and specificity exceeded 90% for changing underwear, bathing, walking, and using the stairs.
Conclusions: The dual-task stepping test is highly sensitive for predicting falls in the hospital and accurately predicts the need for assistance with activities of daily living in older patients.

Keywords: accidental falls, activities of daily living, aged, hospitalization

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Introduction

Dual-task performance (performing motor and cognitive tasks simultaneously) has been used to predict falls in older adults and assess their ability to perform daily activities independently. Dual-task ability decreases with age [1–5] and is essential for understanding motor performance in daily life for older adults. The most common dual-task assessment method for predicting falls is the Stop Walking When Talking Test developed by Olsson et al. [6] If subjects stop walking when asked "How old are you?" they are likely to fall within 6 months. The timed up-and-go test with a cognitive task [7] and the trail walking test, wherein subjects walk toward 15 flags placed in random order [8], also effectively predict falls in older adults. Furthermore, gait is affected in older adults when a cognitive task is added to a normal walking task [9–12]. These findings have been used to clinically assess walking independence. In activities of daily living (ADL), even patients with severe motor impairments can function independently when proper attention is provided. However, without proper precautions to increase the safety of their surroundings and actions, some patients with mild motor impairments cannot function independently. Multiple activities that

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require simultaneous attention are essential for the execution of ADLs [12]. However, while several studies have examined how dual-task performance relates to falls and walking, fewer studies have examined its relationship to ADLs [13, 14].

In acute care hospitals, predicting and managing falls is important for medical safety. In addition, falls can lead to disability, which can delay reintegration into society. Furthermore, patients with an episode of falling are treated more carefully by the medical personnel, making it difficult to perform more ADLs, which hinders achievement of ADL goals. Thus, proactive measures are needed to predict and prevent falls in the acute phase. However, fall prediction has not been properly studied in the older population receiving acute care [15]. Patients requiring treatment for acute diseases often remain stationary owing to their deteriorating condition. After surgery, given intravenous routes and other factors, completing detailed assessments can be difficult. Therefore, it would be useful to have a clinical tool capable of making early-stage predictions of falls and the ability to perform ADLs, including walking, at discharge in older patients in acute care hospitals.

Herein, we report that the dual-task stepping test, in which the patients performed a cognitive task while stepping in the seated position, can accurately predict whether patients are likely to need assistance with ADLs [16]. This test has been previously evaluated for criterion-related validity and inter-/intra-rater reliability [17]. As it can be easily performed in 30 s in the seated position, this task is feasible for use in acute-phase hospitals with patients who have limited movement. Suppose this test could predict falls and the ability to perform ADL, indicating whether assistance is required for older patients in acute care hospitals. In this case, fall prevention measures and discharge planning could be improved early following hospitalization. We prospectively examined the dual-task stepping test for predicting falls and performing ADLs at discharge in older patients hospitalized for acute diseases.

Patients and Methods

Patients and procedures

Patients were selected from the 2,674 individuals admitted to our acute care hospital from January to December 2021 who were referred to a rehabilitation therapist. The inclusion criteria were as follows: age ≥ 65 years, ability to independently perform ADLs before disease onset, ability to step in place while sitting on the edge of the bed, oral feeding capability, ability to follow simple verbal instructions, and no pain that could affect the assessment. All patients required assistance for toileting, changing underwear, bathing, walking, and using the stairs but had no movement restrictions while sitting, as indicated by the attending physician. Of the 769 patients who met these inclusion criteria, 92 were excluded because they did not require assistance with ADLs at admission, had short hospital stays of ≤ 7 days, or did not consent to participate (age 79.5 ± 7.7 years; 44 men, 48 women). Table 1 presents the patient characteristics. Written informed consent was obtained from the patients.

Table 1 Patients' characteristics and performance during the dual-task stepping test (n = 92).

Age (years)	–	79.5 ± 7.7
Sex (n)	Male/Female	44/48
Diagnoses (n)	Cerebrovascular disease	39
	Orthopedic disease	21
	Neuromuscular disease	11
	Other	21
Surgery (n)	Y/N	28/64
Dual-task stepping test (n)	Severe dual-task disability	40
	Mild dual-task disability	21
	Normal dual-task ability	31

One of the six experienced occupational therapists (mean years of clinical experience: 9.0 ± 4.8) administered the dual-task stepping test to the patients on days 3–7 of their hospital stay or on the day of surgery. The patients were prospectively monitored until discharge. Patients whose ADL status worsened markedly or who died within 7 days of discharge were excluded from the analysis. We measured the number of falls that occurred while the patients were hospitalized and determined each patient's functional independence measure (FIM) at the time of discharge for toileting, changing underwear, bathing, walking, and using the stairs. This study was approved by the Ethics Committee of A university (approval no. 366). The study was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Dual-task stepping test

In this test, patients recalled what they ate during their previous meal while stepping in place in the seated position for 30 s. Their stepping performance was evaluated during this task. The assessment procedure starts with the patient sitting on the edge of the bed. Then, the following steps are performed: (1) The investigator gives the patient the first instruction: "When I give the signal, step in place by alternating your feet for 30 s. Go at any speed that is comfortable for you, but do not stop the task or lower the height you raise each foot; step at a constant pace." (2) Stepping practice: The investigator

demonstrates stepping in place and gives the patient approximately 10 s to practice. (3) The investigator provides the second instruction: "I will ask you a question while you are walking. Please continue to step while answering." (4) The investigator prepares the stopwatch, and the patient starts stepping on the signal, "OK, start." (5) After 5 s, the investigator asks, "Here is the question: What did you eat for breakfast today?" (If the task is performed in the afternoon, the investigator replaces "breakfast" with "lunch.") Stepping performance is then evaluated until 30 s after the start point. The investigator observes the patient for the following three signs: (1) stepping stops for ≥ 1.0 s, (2) the feet are not raised high enough, or (3) the pace of stepping is disturbed. Similar to a previous study [16], sign one, signs two or three, and none of the signs indicated "severe dual-task disability," "mild dual-task disability," and "normal dual-task ability," respectively. This test has been evaluated for criterion-related validity and inter-/intra-rater reliability [17].

Fall incidence and ADL assessment

According to Gibson [18], a fall is defined as when any part of the body, other than the soles of the feet, hits the ground without intention. We surveyed whether any falls occurred during the patients' hospital stay after completing the dual-task stepping test and when they were discharged. The ADL assessment excluded items that did not involve standing, such as eating and grooming. The tasks included toileting, changing underwear, bathing, walking, and using stairs. The FIM at discharge was evaluated for these items, with a score ≤ 5 indicating that the patient needed assistance with the ADL and a score of ≥ 6 indicating that the patient was independent.

Statistical analysis

Fisher's exact test was used to compare the three dual-task stepping test groups (severe dual-task disability, mild dual-task disability, and normal dual-task ability). The occurrence of a fall was the dependent variable. The result of the dual-task stepping test was the independent variable for creating a receiver operating characteristic curve and calculating a cut-off value. Next, sensitivity, specificity, positive and negative predictive values, false positive and negative rates, and positive and negative likelihood ratios were calculated using a correspondence table. The area under the curve (AUC) was also calculated to examine the ability of the dual-task stepping test to predict falls. The same process was followed to predict ADL performance at discharge. Using independence or assistance for each ADL item as the dependent variable, cut-off values for the dual-task stepping test were calculated. The data needed to predict ADL assistance were recorded. Statistical analysis was conducted using the JMP Pro Version 16 software, and the significance level was set to $p < 0.05$.

Table 2 Status of patients at discharge, including the number of falls and ability to perform activities of daily living.

Duration of hospital stay (days)	–	37.4 ± 45.5
Discharge destination	Home/Other	49/43
Fall	Y/N	12/80
Ability to use the toilet	Assistance/ Independence	53/39
Ability to change underwear		67/25
Ability to bathe		82/10
Ability to walk		57/35
Ability to use stairs		77/15

Results

In the dual-task stepping test performed on hospital days 3–7, 40 patients exhibited severe dual-task disability (43.5%), 21 exhibited mild dual-task disability (22.8%), and 31 exhibited normal dual-task ability (33.7%).

The mean hospital stay was 37.4 ± 45.5 days, and 49 patients were discharged home. Overall, 12 patients experienced a fall while hospitalized. Fifty-three (57.6%) patients required assistance with ADLs at discharge for toileting, 67 (72.8%) for changing underwear, 82 (89.1%) for bathing, 57 (62.0%) for walking, and 77 (83.7%) for using stairs (Table 2).

Patients were classified as having severe, mild, or no impairment (normal) based on their dual-task performance abilities. Among classified patients, eight (20.0%) falls were noted among those with a severe dual-task disability, and four (19.0%) falls in those with a mild dual-task disability. No patients classified as demonstrating normal dual-task ability fell. This difference was statistically significant ($p = 0.014$). Significant differences were also observed among these three groups for all ADL items—toileting, changing underwear, bathing, walking, and using stairs ($p < 0.001$) (Table 3).

The AUC of the dual-task stepping test for predicting falls in the hospital was 0.70; the sensitivity was extremely high at 100%; however, the specificity was 38.8%. The negative predictive value was 100%, and the negative likelihood ratio was 0.0. The AUC for predicting assistance with ADLs at discharge using the dual-task stepping test was high for all the activities measured (Table 4): 0.92 for toileting, 0.83 for changing underwear, 0.84 for bathing, 0.87 for walking, and 0.87 for using stairs. Sensitivity was highest for toileting, and the specificity exceeded 90% for changing underwear, bathing, walking, and using stairs. The positive likeli-

Table 3 Relationship between dual-task stepping test and prediction of falls and ability to perform activities of daily living at discharge.

		Dual-task stepping test			p-value	Effect size
		Severe dual-task disability N = 40	Mild dual-task disability N = 21	Normal dual-task ability N = 31		
Fall	Y/N	8/32	4/17	0/31	0.014*	0.15
Ability to use the toilet	Assistance/ Independence	38/2	13/8	2/29	< 0.001*	0.53
Ability to change underwear		39/1	15/6	13/18	< 0.001*	0.29
Ability to bathe		40/0	20/1	22/9	< 0.001*	0.28
Ability to walk		38/2	13/8	6/25	< 0.001*	0.39
Ability to use stairs		40/0	20/1	17/14	< 0.001*	0.38

* Fisher's exact test Patients were classified based on their dual-task performance abilities. Among classified patients, eight falls were noted among those with a severe dual-task disability, and four falls in those with a mild dual-task disability. No patient classified as demonstrating normal dual-task ability fell. This difference was statistically significant. Significant differences were also observed among these three groups for all activities of daily living items—toileting, changing underwear, bathing, walking, and using stairs.

Table 4 Accuracy of predictions of falls and need for assistance with activities of daily living at discharge with the dual-task stepping test.

	Cut-off	AUC	Sensitivity %(N)	Specificity %(N)	Positive predictive value %(N)	Negative predictive value %(N)	False positive rate %(N)	False negative rate %(N)	Positive likelihood ratio	Negative likelihood ratio
Fall	Mild dual-task disability	0.70	100.0 (12/12)	38.8 (31/80)	19.6 (12/61)	100.0 (31/31)	81.4 (49/61)	0 (0/31)	1.63	0.00
Ability to use the toilet	Mild dual-task disability	0.92	96.2 (51/53)	74.4 (29/39)	83.6 (51/61)	93.5 (29/31)	16.4 (10/61)	6.5 (2/31)	3.77	0.05
Ability to change underwear	Severe dual-task disability	0.83	58.2 (39/67)	96.0 (24/25)	97.5 (39/40)	46.2 (24/52)	2.5 (1/40)	53.8 (28/52)	14.55	0.44
Ability to bathe	Mild dual-task disability	0.84	73.2 (60/82)	90.0 (9/10)	98.4 (60/61)	29.0 (9/31)	1.6 (1/61)	71.0 (22/31)	7.32	0.30
Ability to walk	Severe dual-task disability	0.87	66.7 (38/57)	94.3 (33/35)	95.0 (38/40)	63.5 (33/52)	5.0 (2/40)	36.5 (19/52)	11.70	0.35
Ability to use stairs	Mild dual-task disability	0.87	77.9 (60/77)	93.3 (14/15)	98.4 (60/61)	43.1 (14/31)	1.6 (1/61)	56.9 (17/31)	11.62	0.24

AUC; Area under the curve.

The area under the curve (AUC) of the dual-task stepping test for predicting falls in the hospital was 0.70; the sensitivity was extremely high at 100%; however, the specificity was 38.8%. The negative predictive value was 100%, and the negative likelihood ratio was 0.0. The AUC for predicting assistance with activities of daily living at discharge using the dual-task stepping test was high for all the activities measured, 0.92 for toileting, 0.83 for changing underwear, 0.84 for bathing, 0.87 for walking, and 0.87 for using stairs. Sensitivity was highest for toileting, and the specificity exceeded 90% for changing underwear, bathing, walking, and using stairs. The positive likelihood ratio was ≥ 10 for changing underwear, walking, and using stairs, and the negative likelihood ratio was 0.05 for toileting.

hood ratio was ≥ 10 for changing underwear, walking, and using stairs, and the negative likelihood ratio was 0.05 for toileting (Table 4).

Discussion

This study evaluated the dual-task stepping test performance in older, hospitalized patients with acute conditions from hospital days 3–7. The dual-task stepping test had high sensitivity for predicting falls in the hospital and could accurately predict the need for assistance with ADLs.

If a patient stops stepping with the addition of cognitive load during the dual-task stepping test, attention is temporarily completely directed away from stepping due to interference; this indicates a marked impairment in dual-task ability. Suppose the step height is reduced or the pace is disturbed with the addition of cognitive load. In that case, we infer that the attention directed toward stepping decreases, suggesting a slight decline in the ability to perform dual tasks. Patients able to properly allot attention to both tasks simultaneously demonstrate normal dual-task ability. Woollacott et al. [19] reported that dual-task conditions affect motor tasks more than cognitive tasks. The assessment in our study also focused on motor performance rather than cognitive performance and is thought to accurately reflect the motor abilities used in daily life.

The quality of the motion used in our study differed from commonly used walking and standing tasks. It showed that stepping in place in the seated position was feasible for evaluating dual-task ability. There are two possible reasons for this. First, recalling the last meal was a relatively difficult cognitive task that created a high degree of interference. A previous study [20] reported that difficulty in performing the cognitive task during dual-task affected motor performance. In this study, the cognitive task difficulty was appropriate for predicting falls and the need for assistance with ADLs in older patients hospitalized for acute disease. Second, brain activity differs between walking, a commonly used motor task, and stepping while seated. Apart from starting to walk, changing directions, and other such actions, walking is performed unconsciously by the central pattern generator of the spinal cord [21]. It involves little activation of the prefrontal cortex that consciously allocates attention [22]. In contrast, stepping in the seated position has a strong conscious element; therefore, the performance of this task would be affected by the interference of a recall task demanding activation of the prefrontal cortex. Therefore, dual-task ability can be feasibly assessed using a seated motor task. The test in our study can be widely used in acute care hospital settings wherein patients have restricted or limited movement.

In our study, the AUC of dual-task stepping tests for predicting falls in the hospital was 0.70, which was based on criteria from previous research [23] and was considered low to moderate [23]; the sensitivity was extremely high at 100%; however, specificity was low (38.8%). All patients who fell had severe or mild impairment in the dual-task stepping test, and no patients with normal dual-task stepping ability fell. Patients with normal dual-task stepping ability demonstrated appropriate motor performance, even with additional cognitive loading, and can be considered to have low risk of falling. In a previous study predicting falls in older adults in the acute phase, Milisen et al. [24] reported that the St. Thomas's Risk Assessment Tool in Falling Elderly Inpatients had 57.0% sensitivity and 72.0% specificity. Caldevilla et al. [25] reported that the Hendrich Fall Risk Model had 93.0% sensitivity and 35.0% specificity for predicting falls in older patients in the acute phase. The accuracy of the dual-task stepping test was high compared with these previously used assessment tools.

The AUC of the dual-task stepping test results for needing ADL assistance at discharge was 0.92 for toileting, 0.83 for changing underwear, 0.84 for bathing, 0.87 for walking, and 0.87 for using stairs. The sensitivity was the highest for the ability to use the toilet (96.2%), and specificity exceeded 90% for changing underwear, bathing, walking, and using stairs. The positive likelihood ratio was ≥10 for changing underwear, walking, and using stairs, and the negative likelihood ratio was 0.05 for toileting; these are effective values. To the best of our knowledge, no other studies have used a dual-task to predict ADL at discharge.

All ADLs examined in the present study required stability while maintaining dynamic standing. Mihara et al. [26] reported that dynamic standing requires conscious postural control by further activation of the prefrontal cortex as the swaying of the body increases. Older adults require a certain amount of attention to maintain dynamic standing when performing ADLs, while conscious attention must also be paid to other events [12]. Thus, a dual task that requires conscious attention for performing two tasks could be used to accurately predict whether a patient requires assistance with ADLs.

Patient information on the risk of falls in acute care hospitals and the need for assistance with ADLs at discharge is essential for early consideration of the need for transfer to a rehabilitation hospital. In addition, if the patient returns home, the family should start preparing for life after discharge, including family preparedness, consideration of caregivers, and environmental adjustments to prevent falls.

This study has some limitations: (1) We could not control the underlying diseases for which the patients were hospitalized; these diseases may have affected our outcomes. (2) We did not consider potential confounding factors, such as each patient's waist length, body mass index, and rehabilitation program. (3) This was a single-center study; therefore, it lacks external validity. Lastly (4), we did not examine repeated assessment reliability because only one measurement was performed. Future studies are needed to address these limitations. However, the strengths of this assessment include that it did not require any special equipment or environment and could be performed quickly while the patient was seated. This test could be used by nurses and other staff, not just by rehabilitation therapists, to screen older patients in acute care hospitals for fall risk and the ability to perform ADLs.

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Disclosure Statement

The authors declare no conflict of interest.

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■ORIGINAL ARTICLE

Difficulty and Change of Sub-items of the Dementia Behavior Disturbance Scale in Patients with Alzheimer-type Dementia

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Abstract: Objectives: It is difficult to predict behavioral disturbances in patients with Alzheimer's dementia because the order of appearance of behaviors is not clear. This study aimed to clarify the difficulty of the Dementia Behavior Disturbance Scale (DBDS) sub-items in patients with Alzheimer's disease and to compare changes in behavioral disorders after 6 months.

Methods: The participants were inpatients with Alzheimer-type dementia hospitalized in participating hospitals for more than a year. They were assessed with the DBDS, the Mini-Mental State Examination (MMSE), and the Functional Independence Measure (FIM) twice: at the initial assessment and after 6 months. Rasch analysis for the sub-items of the DBDS determined the difficulty of behavioral disturbances.

Results: The participants were 44 inpatients. There was no significant difference in the DBDS, MMSE, and FIM between the initial assessment and that after 6 months. Even though many participants increased or decreased for each assessment scale, there was no major change in the order of item difficulty of DBDS between the initial assessment and after 6 months.

Conclusions: The systematic indication of the difficulty of behavioral disturbances in the DBDS is a new finding. It is possible to rank the difficulty of sub-items of the DBDS and infer behavioral disturbances that are likely to appear in the future. This is useful for clinical decision-making in dementia rehabilitation and care because it indicates the predictability of signs of dementia and behavioral disturbances that suggest the need for dementia intervention.

Keywords: Alzheimer-type dementia, Dementia Behavior Disturbance Scale, difficulty, Rasch analysis

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Introduction

Predicting behavioral disturbances is an important topic in the rehabilitation of patients with dementia because behavioral disturbances in dementia make it difficult to approach these patients and cause distress and burden to caregivers. Conversion to dementia is characterized by increasing impairment in social and occupational functioning [1], and typical Alzheimer's disease is defined in the ICD-10 [2] as the presence of memory loss and cognitive impairment for more than 6 months. Behavioral disturbances tend to increase slowly with the slow progression of Alzheimer's disease symptoms and are involved in difficulties in activities of daily living and participation in social activities. Cognitive dysfunction is also reported to be related to behavioral disturbances and increased caregiver burden in Alzheimer's disease [3–6]. In addition, symptoms such as apathy, nocturnal wakefulness, unwarranted accusations,

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dressing inappropriately, and behavioral disturbances were reported to be more likely to occur [7]. However, because the symptoms of Alzheimer's disease are multidimensional and complex, strategies for predicting and coping with behavioral disturbances have yet to be established.

The Dementia Behavior Disturbance Scale (DBDS), which was verified by Baumgarten et al. for its reliability and validity [8], is one behavioral disability scale for dementia, and various and representative behavioral disorders in dementia are set as sub-items. The DBDS score is also known to correlate highly with the severity of dementia [8–9]. We reported that the DBDS score of a patient with dementia can be predicted from the first time to after 9 months using a mathematical approach with a logarithmic model [10]. Furthermore, a study on the rate of appearance of DBDS sub-items reported that items associated with memory loss, decreased interest, and decreased activity appeared with high frequency [11]. However, the order of appearance of behavioral disturbances according to their difficulty has not been clarified, and qualitative prediction of behavioral disturbances remains a task. Therefore, we decided to address this task by Rasch analysis using cross-sectional data of DBDS collected from Alzheimer's disease inpatients, in accordance with previous studies [12–13]. In other words, to clarify the order of appearance of behavioral disturbances, we interpreted the difficulty of DBDS sub-items by logit, an index of item difficulty in Rasch analysis. With this approach, if the types of behavioral disturbances that are likely to emerge next can be identified, it is thus possible to plan specific support that is appropriate for each patient's behavioral disturbance and to support the patient's life so that inappropriate behaviors do not emerge. In addition, it is possible to provide appropriate family coaching as caregiver education, which is important in preventing behavioral disturbances, by knowing which behavioral disturbances are more frequent [11].

The purpose of this study was to clarify the difficulty of the DBDS sub-items in patients with Alzheimer's disease as the index of the frequency of appearance of behavioral disturbances and to compare the changes in behavioral disturbances after 6 months.

Methods

Participants

The participants were 97 patients with Alzheimer-type dementia who were hospitalized in A Hoken Hospital for more than a year between February 2013 and November 2014. This hospital can accept patients with severe dementia whose symptoms are at a level of the Functional Assessment Stages (FAST) [14] 6 or 7, which makes it difficult for them to live in the community and take care of themselves, and is characterized by providing specialized dementia rehabilitation services. Although the patients present with severe dementia, they are not physically restrained, and nurses, care workers, and rehabilitation staff collaborate to assist them with activities of daily living. Eligibility criteria included hospital inpatients diagnosed as having Alzheimer-type dementia and absence of delirium, palsy, or any complications of note during the study. Alzheimer-type dementia was diagnosed on admission according to the criteria of the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) [15]. The assessments of behavioral disturbances, cognitive function and independences were immediately stopped if the patient showed a rejective attitude. The patients who could not complete all the assessment scales at the two evaluations (initial and after 6 months) were excluded. The aims of this study and the testing procedure were briefly explained to all participants and/or their families prior to participation. Written informed consent was obtained from each participant and/or their family. This study was approved by the Institution Review Board at Niigata University of Health and Welfare (17132-090805) and performed in accordance with the principles of the Declaration of Helsinki.

Assessment of Behavioral Disturbances, Cognitive Function and Independences

To assess the behavioral disturbances of inpatients with Alzheimer-type dementia, we used the DBDS, which is widely used for the assessment of behavioral disturbances associated with dementia. The DBDS consists of questions about wandering, agitation, eating disorders, aggression, and sexual abnormalities. The DBDS scores were rated on a 5-point Likert scale The DBDS scores were rated on a 5-point Likert scale of 0 (not at all), 1 (almost never), 2 (sometimes), 3 (often), and 4 (always) for the 28-item scale. Total scores ranged from 0 to 112, with scores of more than one point indicating a behavioral disturbance.

We used the Mini-Mental State Examination (MMSE) [16] for the assessment of the cognitive function. MMSE scores range from 0 to 30, with lower scores indicating greater cognitive impairment. Assessment items include patient attention, orientation, language, immediate and short-term recall, and the ability to follow simple oral and written instructions [17].

The Functional Independence Measure (FIM) [18] was used to assess each patient's behavioral independence and amount of care in daily life. FIM scores can range from 0 to 126, and the FIM is comprised of 13

motor items and 5 cognitive items. Each of these items consists of seven levels scored from one point (total dependence) to seven points (total independence), with higher scores indicating greater independence.

These assessments were carried out by the physical and occupational therapist and nurse who had regular contact with the participant.

Procedure

The participants were assessed with the DBDS, MMSE, and FIM on two occasions, at the initial assessment and after 6 months, because the symptoms of dementia have large variations and to clarify changes in behavioral disturbances over time. The reason for having two-time points, at the initial assessment and after 6 months, was to see if the difficulty level of the DBDS was stable although there were changes in cognitive function and behavioral disturbances after 6 months in our study [10]. For each assessment score, the change in scores for all participants and the divided three groups (increasing, maintaining, and decreasing) after 6 months compared to the initial assessment were identified. The two assessments were performed by the same rehabilitation staff, a total of 11 staff members. All patients received conventional physical and cognitive rehabilitation training and activities of daily living training for 3–4 days per week by an occupational therapist, physical therapist, and speech-language-hearing therapist.

Data Analysis

We used the Wilcoxon signed-rank test to assess the changes in the DBDS, MMSE, and FIM and Spearman's rank correlation coefficient to assess the relationship between behavioral disturbances and cognitive functioning. Rasch analysis of the sub-items of the DBDS determined the difficulty of the behavioral disturbances. Rasch analysis is a method of transforming ordinal counts into distance measured on an interval scale by using a distribution of the patient's ability and task difficulty [19–22], and it has been used in several behavioral studies [23–25]. In accordance with previous research [12–13], in the present study, we indicated that the logit, i.e., the level of difficulty indicated by the Rasch analysis, would be an indicator of the frequency of occurrence of behavioral disturbances, and if their frequency was low, the behavioral disturbances may be considered to be of high severity. Rasch analysis yields a mean square fit statistic (MnSq) accompanied by a standardized mean square (Zstd), which indicates significance for each individual sub-item and participant. The ideal value of infit MnSq is 1.0, and items that exceed the acceptable range are considered to be misfits and are removed. The ideal value of Zstd is 0.0, and if it exceeds ± 2.0, the item is judged to be misfit [26]. In this study, infit MnSq values above 1.4 and those associated with a Zstd greater than 2.0 were deleted to misfit [26–28]. The number of participants in this study was assumed to be more than 30 because previous reports using Rasch analysis have shown that the sample size range needs to be greater than 27 [29] to have 99% confidence that no item calibration is more than 1 logit away from its stable value. In addition, Krippendorff's alpha coefficient was calculated to examine the agreement between the difficulty rankings at the initial assessment and after 6 months. Statistical analyses were conducted using SPSS Statistical 27.0 software for the Wilcoxon signed-rank test, Spearman's rank correlation coefficients, Krippendorff's alpha coefficient using R version 4.1.1, and WINSTEPS 3.91.0 for Rasch analysis. A p-value < 0.05 was considered statistically significant.

Results

Among the 97 participants who met the eligibility criteria, we enrolled 44 patients (45.4%; 15 men, 29 women; age 82.02 ± 8.51 years [mean ± standard deviation]) in whom all data was present. Most of the reasons for exclusion were because there was a deficiency in one of the items of the assessment. The average time from admission until the initial assessment was 786.2 days (386–40,855 days). The participants were hospitalized in long-term care or medical care ward. The reason for hospitalization was difficulty in giving care at home or deterioration of the participant's condition. Medications were mainly for Alzheimer's disease drugs, antipsychotics, and Anti-Parkinson's disease drugs, with no major changes in medication use during the study period.

The DBDS scores at the initial assessment and after 6 months were 12.6 ± 8.8 and 12.0 ± 9.4, and the MMSE scores were 17.7 ± 7.0 and 18.1 ± 6.5, respectively, and they were not significantly different (Table 1). The respective FIM scores were 81.8 ± 25.3 and 80.3 ± 25.6, motor scores were 56.6 ± 21.2 and 55.4 ± 21.5, and cognitive scores were 25.2 ± 6.9 and 24.9 ± 6.6, respectively. The changes in the scores of the three groups (increasing, maintaining, and decreasing) in each assessment scale after 6 months were significant changes for the increasing and decreasing groups, respectively (Table 1). All participants were able to ambulate. The correlations of each variable at the initial assessment and after 6 months were significant for all of them (Table 2).

Rasch analysis was conducted at the initial assessment and after 6 months to clarify the difficulty level of each item of the DBDS (Fig. 1, Table 3). Higher logits indicate higher difficulty, that is, they indicate that the behavioral disturbance is more severe. After each of

Table 1 Characteristics of participants.

Characteristics		initial assessment	after 6 months	p value
Age (years)		82.2 ± 8.51		
Male/Female		15/29		
Duration of hospitalization days (days)		786.2 (386–40855)		
DBDS				
total	(n = 44)	12.6 ± 8.8	12.0 ± 9.4	0.283
improving	(n = 20)	12.6 ± 8.8	16.9 ± 7.9	0.000**
maintaining	(n = 8)	5.8 ± 7.1	5.8 ± 7.1	1.000
decreasing	(n = 16)	10.6 ± 8.1	14.6 ± 10.4	0.000**
MMSE				
total	(n = 44)	17.7 ± 7.0	18.1 ± 6.5	0.409
improving	(n = 18)	15.3 ± 8.3	20.1 ± 6.9	0.000**
maintaining	(n = 9)	19.9 ± 5.3	19.9 ± 5.3	1.000
decreasing	(n = 17)	19.0 ± 5.6	14.9 ± 5.6	0.000**
FIM				
total	(n = 44)	81.8 ± 25.3	80.3 ± 25.6	0.344
improving	(n = 21)	83.5 ± 26.1	87.8 ± 25.5	0.001**
maintaining	(n = 7)	81.9 ± 26.0	81.9 ± 26.0	1.000
decreasing	(n = 14)	79.5 ± 25.4	69.1 ± 23.0	0.001**
FIM motor score		56.6 ± 21.2	55.4 ± 21.5	0.358
FIM cognitive score		25.2 ± 6.9	24.9 ± 6.6	0.381

Scores are mean ± SD. P values were calculated by Wilcoxon signed-rank test.
DBDS: Dementia Behavior Disturbance Scale, MMSE: Mini-Mental State Examination, FIM: Functional Independence Measure.
** $p < 0.01$.

Table 2 Correlations between variables.

Variables	MMSE initial	FIM initial	MMSE 6months	FIM 6months
DBDS initial	−.512** (< .001)	−.502** (< .001)	—	—
MMSE initial	—	.301** (.047)	—	—
DBDS 6months	—	—	−.532** (< .001)	−.526** (< .001)
MMSE 6months	—	—	—	.578** (< .001)

Values are Spearman's correlation coefficients (p-value). The total score for each assessment scale was used in the analysis.
DBDS: Dementia Behavior Disturbance Scale, MMSE: Mini-Mental State Examination, FIM: Functional Independence Measure.
* $p < 0.05$, ** $p < 0.01$.

the misfit items was deleted, the Rasch analysis was conducted to fit the values of items of infit MnSq or Zstd. Firstly, the fit of the Rasch model was confirmed. Although items with Infit Mnsq ≥ 1.4 and Zstd ≥ 2.0 should be deleted, there were no such items at the two-time points, and all items fit the Rasch model. Next, the difficulty level of the items was confirmed. Five items were deleted at the initial assessment (item Nos. 25, 26, 28) and also after 6 months (item Nos. 17, 24, 25, 28) because infit MnSq was "maximum measure". There were no participants with these five behavioral disturbances at the two-time points. The distribution of item difficulty ranged from −1.25 to 1.91 logits for the initial assessment and from −1.35 to 1.61 logits at 6 months, both of which were sufficient. In the initial assessment, the logits of the highest sub-items were 1.91 logits (item No. 24: Makes inappropriate sexual advances), 0.99 logits (item No. 11: Cries or laughs inappropriately), and 0.76 logits (item No. 21: Wanders aimlessly during the day and No. 22: Makes physical attacks). Those of the lowest sub-items were −1.25 logits (item No. 1: Asks the same question repeatedly and No. 20: Is incontinent of urine) and −1.08 logits (item No. 3: Lack of interest in daily activities). In the assessment after 6 months, the logits of the highest sub-items were 1.61 logits (item No. 11: Cries or laughs inappropriately), 1.10 logits (item No. 23: Screams for no reason), 0.83 logits (item No. 22: Makes physical attacks, and No. 26: Destroys property

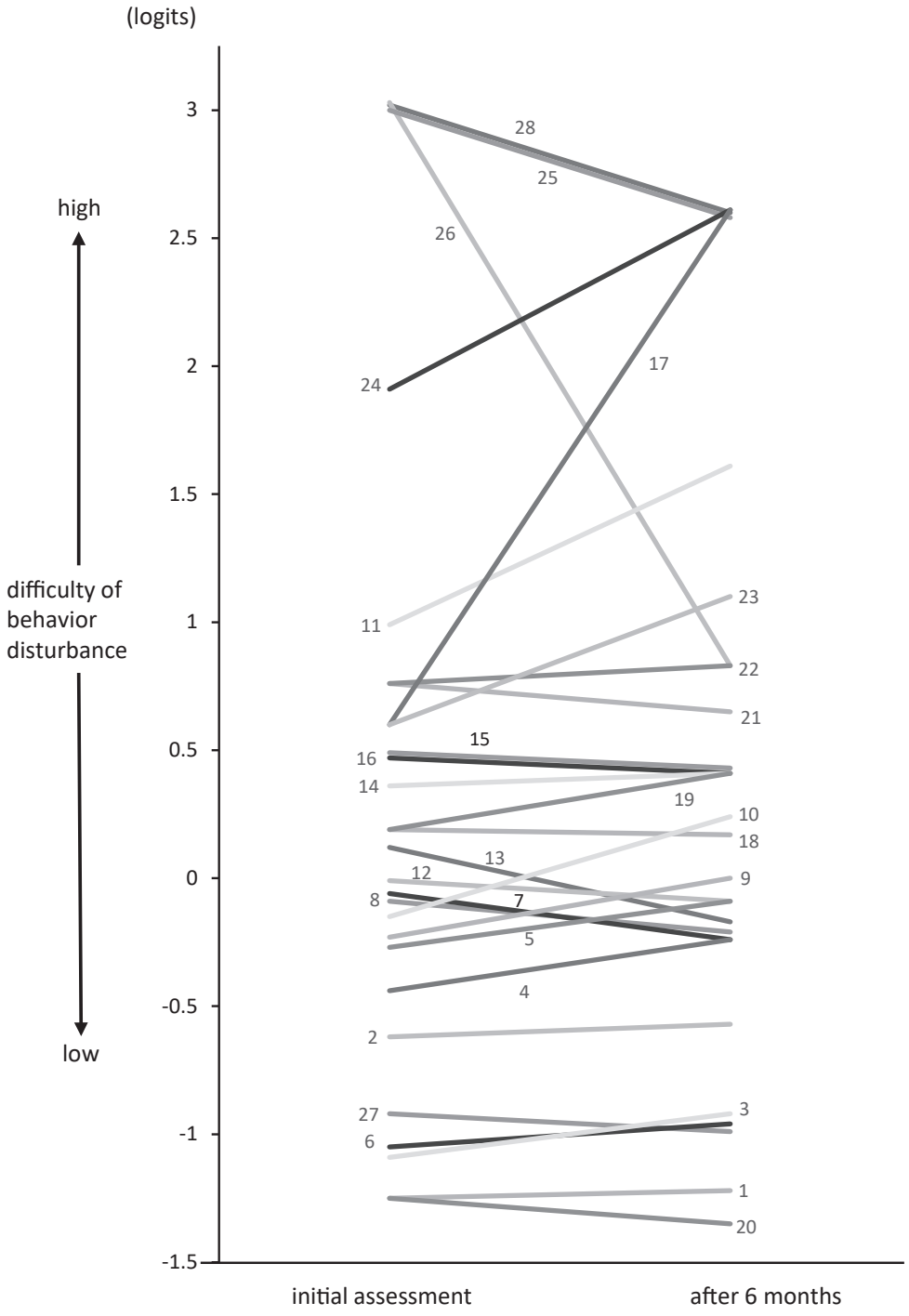

Fig. 1. Changes in difficulty of sub-items of the DBDS.

The number in the figure indicates the item number of DBDS. Item numbers and logits correspond to those in Table 2. DBDS difficulty rankings were compared between the two time periods: initial assessment and after 6 months. After 6 months, there were a few changes in difficulty of the DBDS sub-items, and distribution of logits showed 20 items between −1.00 and 1.00 logits (standard = 0 logits).

or clothing). Those of the lowest sub-items were −1.35 logits (item No. 20: Is incontinent of urine), −1.22 logits (item No. 1: Asks same question repeatedly), and −0.99 logits (item No. 27: Is incontinent of stool). At the initial assessment and after 6 months, the lower difficulty items had more participants with behavioral disturbances, and the higher difficulty items had fewer number of participants with more severe behavioral disturbances. Krippendorff's alpha coefficient in the difficulty of the DBDS sub-items at the initial assessment and after 6

Table 3 Difficulty of Sub-items of DBDS and Distribution of Logits.

difficulty ranking		DBDS		initial			6M			initial		6M	
initial	6M	number	sub-items	logits	infit Mnsq	Zstd	logits	infit Mnsq	Zstd	n	score	n	score
※	※	25	Exposes private body parts	3.03	maximum measure		2.61	maximum measure		0	0	0	0
※	4	26	Destroys property or clothing	3.03	maximum measure		0.83	1.96	1.10	0	0	1	3
※	※	28	Throws food	3.03	maximum measure		2.6	maximum measure		0	0	0	0
1	※	24	Makes inappropriate sexual advances	1.91	0.86	0.30	2.61	maximum measure		1	1	0	0
2	1	11	Cries or laughs inappropriately	0.99	1.23	0.50	1.61	0.75	0.30	3	6	2	4
3	5	21	Wanders aimlessly during the day	0.76	0.62	−0.30	0.65	1.00	0.30	6	9	3	6
3	3	22	Makes physical attacks (hits, bites, scratches, kicks, spits)	0.76	1.07	0.40	0.83	0.88	0.20	4	5	3	4
5	※	17	Gets lost outside	0.60	1.20	0.50	2.61	maximum measure		3	5	0	0
5	2	23	Screams for no reason	0.60	1.10	0.40	1.1	1.26	0.60	4	8	2	5
7	7	15	Empties drawers or closets	0.47	0.91	0.10	0.41	1.08	0.30	5	7	4	7
7	8	16	Wanders in the house at night	0.47	0.84	0.00	0.41	1.04	0.30	7	9	5	8
9	6	14	Moves arms or legs in a restless or agitated way	0.36	1.40	0.80	0.41	0.93	0.10	4	10	4	9
10	11	18	Refuses to eat	0.19	0.79	−0.20	0.17	0.91	0.00	6	9	5	9
10	9	19	Overeats	0.19	1.19	0.50	0.41	1.49	0.90	6	9	4	10
12	15	13	Hoards things for no obvious reason	0.12	0.97	0.10	−0.17	1.23	0.70	8	15	7	17
13	14	12	Refuses to be helped with personal care	−0.01	0.91	0.00	−0.09	0.72	−0.70	10	15	10	16
14	16	7	Paces up and down	−0.06	0.63	−0.90	−0.21	0.74	−0.70	12	19	11	23
14	18	8	Repeats the same action over and over	−0.06	1.17	0.50	−0.24	0.81	−0.50	9	16	9	21
16	10	10	Dresses inappropriately	−0.15	1.36	0.90	0.24	0.46	−1.10	9	16	7	9
17	12	9	Is verbally abusive, curses	−0.23	1.03	0.20	0	0.76	−0.50	11	20	9	15
18	13	5	Makes unwarranted accusations	−0.27	0.90	−0.20	−0.09	1.06	0.30	14	25	8	17
19	17	4	Wakes up at night for no obvious reason	−0.44	0.92	−0.20	−0.24	1.00	0.10	15	28	11	19
20	19	2	Loses, misplaces or hides things	−0.62	0.90	−0.30	−0.57	1.00	0.10	17	31	14	31
21	22	27	Is incontinent of stool	−0.92	1.30	1.50	−0.99	1.12	0.70	16	45	18	52
22	21	6	Sleeps excessively during the day	−1.06	0.86	−0.70	−0.95	1.12	0.70	25	55	24	51
23	20	3	Lack of interest in daily activities	−1.08	1.05	0.30	−0.94	1.23	1.20	25	57	20	50
24	23	1	Asks same question repeatedly	−1.25	1.23	1.30	−1.22	1.20	1.00	28	68	26	68
24	24	20	Is incontinent of urine	−1.25	0.95	−0.20	−1.35	0.93	−0.30	25	64	27	76

initial: initial assessment, 6M: after 6 months, DBDS: Dementia Behavior Disturbance Scale, infit Mnsq: information-weighted mean square fit statistic, Zstd: standardized as a z-score,
※: deleted items, maximum measure: too high a value not calculated.
The DBDS items are shown in the order of initial assessment.
Bolded values indicate logits within −1.00 to 1.00.

months was 0.857. Although there were a few changes in the difficulty of the DBDS sub-items after 6 months, the agreement between the initial assessment and after 6 months on the difficulty of the DBDS sub-items was high. Moreover, the distribution of the logits of item difficulty at the initial assessment and after 6 months each included 20 items between −1.00~1.00 logit.

Discussion

In this study, Rasch analysis of the DBDS in hospitalized Alzheimer's disease patients clarified the order of appearance of the DBDS sub-items as the index of frequency of appearance of behavioral disturbances. There was no significant difference in the DBDS, MMSE, and FIM between the initial assessment and after 6 months, and the correlation between the DBDS and MMSE was high. A previous study suggested that behavioral disturbances are thought to appear with the progression of dementia [30]. The DBDS was developed to evaluate the behavioral disorders that appear that are related to cognitive function, physical function, and psychic function [31]. Therefore, the behavioral disturbances listed in the DBDS are not caused by cognitive function alone but by a combination of factors. Previous studies showed that both the severity of cognitive impairment and the decline in the levels of behavioral independence influenced behavioral change in nursing home residents [32–33]. For this reason, it is important not to judge the behavioral disturbances of dementia by severity and cognitive function only but also to assess the behavioral disturbances to rehabilitate and care for patients with dementia.

The order of appearance of the sub-items was clarified in this study. If the logit in Rasch analysis is high, the behavioral disturbances are unlikely to appear, and if the logit is low, the behavioral disturbances are likely to appear. There have been many reports on the rate of appearance of behavioral disturbances. Yamaguchi et al. [11] investigated the rate of appearance of behavioral disturbances in 161 patients with Alzheimer's disease (age 80.8 ± 6.6 years, DBDS 18.1 ± 13.2 points) and found that the items related to memory impairment were the most frequent, followed by apathy, decreased interest, and decreased activity, and the frequency of violence and agitation was low. In addition, Kaufer et al. [34] reported that depression and apathy appeared more frequently, followed by anxiety and irritability in about 50%, and the frequency of disinhibition and abnormal eating behavior was low in 60 participants (age 76.1 ± 8.0 years, MMSE 18.4 ± 5.6 points). Other studies such as those of Godinho et al. [35] and Nukariya et al. [36] reported similar results, as did the present study. The results of this study, that participants were more likely to develop urine/stool incontinence, differed from previous studies. Other reports have included some participants with non-AD and MCI, and some studies have included patients living in the community. Therefore, it is not possible to make a general comparison with the present study because the conditions of the participants were different from those of this study. However, although the MMSE scores of the participants in this study did not differ significantly from those in other reports, many of them had the FAST 6 or 7 scores and had more severe AD, indicating a higher incidence of urine/stool incontinence in addition to the same results as those in previous studies. These results reflect the clinical course shown by the FAST and suggest that a higher frequency of behavioral disturbances may indicate lower severity of symptoms [14]. In addition, each assessment scale was re-assessed after 6 months and compared to the initial assessment. Even though many participants increased or decreased for each assessment scale, there was no major change in the order of item difficulty of DBDS between the initial assessment and after 6 months. It was possible to infer behavioral disturbance that is likely to appear in the future because the order of appearance of the behavioral disturbances did not change with time. However, behavioral disturbances do not always follow a constant path of change. Although the difficulty of the DBDS sub-items does not necessarily indicate the order of appearance of behavioral disturbances, it might be an indication of the next behavioral disorder that may appear. The logits in the DBDS sub-items were nearly the standard values, with 20 of the items within the range of −1.00 to 1.00 logit for both the initial assessment and that after 6 months, and the difference in logits between the items was relatively small. If dementia symptoms or behavioral disturbances appear, other behavioral disturbances with similar difficulty levels may also appear. However, if there is an improvement in some symptoms of the behavioral disturbance, it is possible to improve other symptoms as well. Based on the characteristics of the patients, we can select items from the behavioral disturbances that are appropriate for the individual patient and intervene, leading to improvements in other behavioral disturbances of similar difficulty. This will be a point of intervention in the patient's nursing care and rehabilitation. In this way, the DBDS is clinically useful as a means to improve symptoms in patients with Alzheimer's disease, which is a progressive disease, and as an indicator of interventions required in the patient's rehabilitation. In addition, because items of the DBDS focus on problematic behaviors that are a burden to the caregivers8), the DBDS may be useful as an indicator of the degree of caregiver burden. In the Rasch analysis,

five sub-items (Nos. 17, 24, 25, 26, and 28) were deleted in the initial assessment and/or after 6 months. These items were behavioral disturbances that did not appear or appeared in only a few patients. Item Nos. 17 and 24 are unlikely to appear because the participants were inpatients, and items Nos. 25, 26, and 28 were unlikely to appear because caregivers might prevent the patient from carrying out these actions. Therefore, these data were affected by environmental influences. If these symptoms appear, it is possible that the care situation is poor or that the patient's behavioral disturbances are more severe than originally thought.

One of the reasons for the decrease in the number of participants from 97 to 44 in this study was that many of the excluded patients could not be evaluated with the MMSE and their symptoms were more severe. This may have caused selection bias in that the severity of the dementia affected the possibility or impossibility of assessment. In addition, as the participants in this study included inpatients hospitalized for long and varied periods and who participated in rehabilitation almost every day, their current symptoms were influenced by their environment such as hospitalization. However, we considered the influence of these limitations on the results was low due to the various severities of symptoms and behavioral disturbances among the participants.

As a further study, if many facilities and a larger number of participants were added to the analysis, the changes in behavioral disturbances with Alzheimer's disease might be shown in more detail and generally adopted. Moreover, it is not possible to assert that the Rasch analysis alone in the DBDS sub-items accurately reflects the degree of difficulty of BPSD in Alzheimer's disease. The appearance of symptoms may be undeniable to vary depending on different situations since BPSD is a symptom that occurs based on biological, psychosocial, and environmental factors [37]. However, the difficulty of the DBDS sub-items in patients with Alzheimer's disease that we have shown in the present study is an important finding because it gives a new perspective that has not been shown previously. In addition, because the effects of disease progression and medication cannot be excluded in patients with Alzheimer's disease, we decided to investigate behavioral disturbances at two-time points in this study. In the future, if we can construct a prediction model with variables such as the amount of medication taken and functional changes shown in brain imaging, it should be possible to predict the behavioral disturbances of individual patients and provide specific support.

This study ranked the difficulty of the sub-items of the DBDS by Rasch analysis of DBDS data in inpatients with Alzheimer-type dementia. The systematic indication of the order of appearance of behavioral disturbances in the DBDS is a new finding. It may be possible to infer behavioral disturbances that are likely to appear in the future. This result is clinically useful as a means to qualitatively assess dementia and plan phases of rehabilitation and care because they can infer behavioral disturbances that may be an indication of the need for intervention.

Conflict of interest statement

The authors declare no conflict of interest.

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■ORIGINAL ARTICLE

Prism Adaptation Induces Allocentric Neglect-Like Behavior in Healthy Participants

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Abstract: Introduction: Prism adaptation (PA) is a promising treatment to improve unilateral spatial neglect (USN). Egocentric neglect and allocentric neglect are the two types of USN in terms of spatial reference frames, but no study was reported the PA affects allocentric frame selectively. This study therefore aimed to investigate whether the PA effect could be observed only on allocentric frame in healthy participants.
Method: Thirty right-handed participants (12 females and 18 males, mean age 22.6 years), wore the right wedged prismatic glasses that created an optical shift of 5.7° to the left. They were asked to reach two visual targets with the right index finger 100 times alternately. Outcomes were measured through the line bisection task where lines of two different lengths (200 mm and 50 mm) were presented one by one in front of or on the left or right side of the participants.
Results: The subjective midpoint on the 200-mm line shifted significantly to the right after the PA, but not on the 50-mm line. Additionally, the degree of rightward deviation was not affected by the position of the presented line regardless of its length.
Discussion: These results indicate that the PA task induced allocentric neglect-like behavior. Hence, PA affected only the allocentric frame among healthy participants. The results of this study may contribute to the evaluation and treatment of allocentric neglect.

Keywords: unilateral spatial neglect, prism adaptation, allocentric neglect, line bisection task, healthy participants

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Introduction

Unilateral spatial neglect (USN) is defined as a deficit in responding, orienting, or initiating action toward contralesional stimuli [1]. This condition is observed in 40–50% of patients who have right brain injury during hospitalization [2], and often leads to difficulties in daily living and rehabilitation, hindering the achievement of therapeutic goals [3–4]. Therefore, various treatments have been developed to manage USN [5–7].

One such treatment, prism adaptation (PA) is a promising treatment, as supported by randomized control trials [5–6] and stroke rehabilitation guidelines [7]. PA involves the use of prismatic glasses that create a rightward optical shift, and the repetitive reaching task for visual targets. This relatively simple task can be completed in a short time, yet be observed significant improvements in USN immediately after completion, which lasts for at least 2 hours [8]. These improvements have been observed in patients' paper and pencil task scores and functional performance, including postural imbalance [9], wheelchair driving [10], and activities of daily living [11]. Moreover, PA has been shown to improve USN symptoms on mental representation tasks [12], with additional effects on dichotic listening [13] and tactile extinction [14]. These findings suggest that adaptation to the prismatic shift induces amelioration of various aspects of USN and its related symptoms.

USN is classified into two types, based on the spatial frame of reference affected: egocentric and allocentric neglect. Egocentric neglect is characterized by inattention toward the contralesional side of space based on the patient's position [15–17]. Allocentric neglect is defined as inattention toward the contralesional side of stimuli, regardless of the patient's position [17–18]. These subtypes of USN can be assessed by a copying task [19], the Ota task [16], and the Apples test [20]. Ad-

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ditionally, Medina et al. [17] proposed that the administrating neglect tests to the left and right of the patient's midline can be used to distinguish between egocentric and allocentric neglect; patients with left egocentric neglect will tend to fail to respond to stimuli presented in their left trunk field, while responding to stimuli presented in the right trunk field. In contrast, participants with left allocentric neglect will tend to not respond to the left side of the stimuli regardless of where it is presented with respect to the patient.

Currently, the evidence on the effectiveness of PA on allocentric reference frames remains unclear. The first PA study, conducted by Rossetti et al. [8], revealed that the PA task ameliorated both egocentric and allocentric neglect on the Gainotti copying task [19]. However, in some studies that used the Apples test [20], PA only affected egocentric neglect [21–23]. Michel et al. [24] found that, in healthy participants, the PA task only affected the egocentric frame on the line bisection (LB) task, in which a line is presented at the front, right, and left sides of the participant, as the position of line presentation affected the decision of the subjective midpoint. However, it remains unknown whether PA affects the allocentric frame in healthy participants.

Previous studies revealed that the appearance of deficits in each reference frame depends on the task demands [25–26]. Even subtle changes in the stimuli or task instruction can alter the apparent reference frame. As changes in the deficits in each reference frame have been observed within a single participant, it has been suggested that participants can distribute attention flexibly and strategically assign a reference frame, depending on the demands of the task [25–26]. Based on these findings, in the LB task for healthy participants, the application of different line lengths and presentation on the left and right, as well as in the center, may elicit attention to the length of the presented line, but not its position, and result in the subjective midpoint being determined in relation to the allocentric frame. Therefore, it is hypothesized that by utilizing these LB task settings to assess the effect of the PA task, it may be possible to induce the PA effect in the allocentric frame among healthy participants.

This study aimed to reveal whether the PA effect appears only allocentric frame in healthy participants, using an LB task in which lines of two different lengths were presented individually in front, or on the left or right side, of the participants. We predicted that the subjective midpoints of the lines on the LB task after PA might show significant rightward deviations compared to that after a control task (flat lens; see *Repetitive reaching task* in the Materials and Methods), regardless of the position of the lines.

Materials and Methods

Participants

This preclinical study included 30 healthy volunteers (12 women and 18 men, age range 20–30 years, mean 22.6 ± 2.2 years) in the experiments. All participants were right-handed, as confirmed with the Flanders handedness test [27], had a normal or corrected-to-normal vision, and had no history of neurological or psychiatric illness. The study complied with the tenets of the Declaration of Helsinki and was approved by the local ethics committee of Sapporo Medical University (approved number: 30-2-29). Prior to their participation, all participants provided written informed consent.

Procedure

This study employed a crossover design, in which half of the participants were randomly assigned to either the prismatic condition or the flat lens condition, serving as the control condition, for the first experiment. Their assignments were reversed for the second experiment. As outcome measures, the open-loop pointing (OLP) and the LB tasks were performed immediately before and after a repetitive reaching task in each experiment. To eliminate any carryover effects of repetitive reaching tasks, a de-adaptation task was completed during the interval between experiments.

During the experiments, each participant sat at a desk with a height of 70 cm. The seat height was adjusted to ensure a vertical distance of 50 cm from the surface of the table to the root of the nose was maintained.

Repetitive reaching task (Fig. 1-A)

Two visual targets, blue on the right and red on the left, were presented on a black A3 sheet in front of the participants, positioned 8 mm in diameter and 10° to either side from the midline of the participants. The distance between the abdomen and each target was 51 cm. A black board was placed on the desk to obscure the extraneous movements of participants' index fingers, allowing them to only view their index fingers when they were reaching the targets. A thin non-slip mat (4.5 cm × 3.5 cm) that was easily found by tactile perception was placed in front of the participants as a starting place for their reaching movements.

In the prismatic condition, participants wore right-wedged prismatic glasses (Fuji Optical Co., Ltd., Sapporo, Japan) that created an optical shift of 5.7° to the left. This was the maximum angle of the commercially available lens. A previous study demonstrated the PA effect in patients with left USN using the same angle [28]. In the flat lens condition, participants wore flat lens glasses (Fuji Optical Co., Ltd., Sapporo, Japan) that cre-

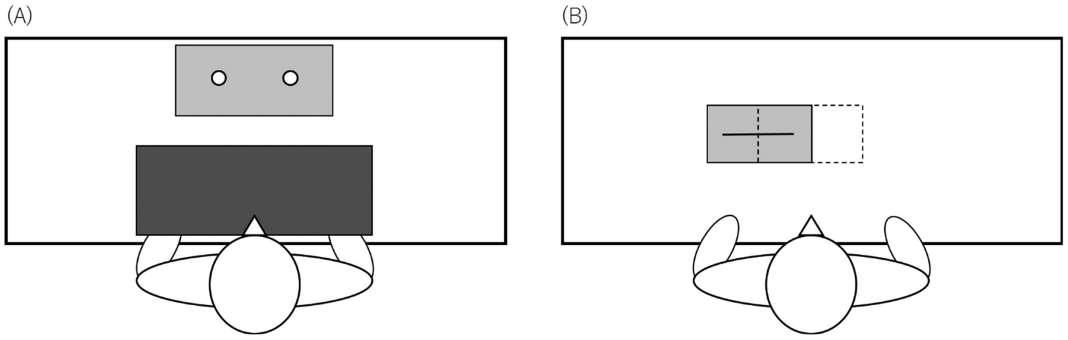

Fig. 1. A: Schematic view of the repetitive reaching task. The black rectangle represents a flat plate that limits the visibility of the trajectory of the reaching movement. The gray rectangle represents the monitor that displays the targets, with the white circles representing the targets. B: Schematic view of the line bisection task. The gray rectangle represents the placement of the tablet for presenting a line in the left position. The broken line rectangle represents the position of the tablet in the center position.

ated no optical shift. Participants were instructed to wear the assigned glasses and to repetitively reach the visual targets with their index fingers at a fast but comfortable speed. In both conditions, the reaching movement from the starting point to the targets was repeated alternately 100 times.

Outcome measures

OLP task

We employed this task to verify the alteration of hand-eye coordination by adapting the prismatic optical shift. An 8 mm diameter red visual target was placed on a desk at a distance of 40 cm in front of the participants. Participants were instructed to fixate on the target and memorize its location. They were then instructed to reach for it with their right index fingers with their eyes closed. The trial was repeated five times, and the experimenter manually recorded the position of the tip of their index fingers on a sheet placed on the desk using a marker. The lateral deviation from the midsagittal line to the terminal reaching position was measured to the nearest mm. The deviations of their finger to the right or left of the midsagittal line were represented as positive or negative values, respectively. The average values of the five trials from each participant were adopted for data analysis.

LB task (Fig. 1-B)

The LB task quantitatively evaluated the effect of the PA on the participants' perceptual-motor response. We presented a line in three different spatial locations to determine the effect of PA on egocentric and allocentric frames.

This task was performed using a tablet PC (Microsoft Surface Pro, sampling rate = 60 Hz, resolution = 1024 × 768 pixels, monitor size = 231 × 173 mm, 0.23 mm per 1 pixel). A camera in the PC display was covered to eliminate the possibility of judging the subjective midpoint of the presented lines. Two black lines of different lengths (50 and 200 mm) and 2 mm thickness were prepared to confirm the differentiating effect of PA on spatial attentional function compared to peripheral physical hand-eye coordination. The midpoint of each line was aligned with the center of the monitor and individually presented on the tablet. The tablet was placed in one of three locations: front, left, or right side of the participants. For these locations, the center, right side, and left side of the tablet were aligned with the midsagittal plane, respectively. The lateral displacement of the tablet to either side from the center position was approximately 115 mm. The distance between the xiphoid process of the participants and the tablet PC was 30 cm. Five trials were conducted for each combined condition of the line length and its location; in total, 30 trials were performed with a pseudo-random order of line presentation. For this task, each participant was instructed to place their chin on the chin rest to prevent movement of the head and trunk. Participants were then instructed to mark the subjective midpoint of a presented line using a dedicated tablet pen held in the right hand.

The deviation of the subjective midpoint from the true center was quantified in the nearest mm for each line. Positive values were assigned for rightward deviations from the midpoint, whereas negative values were assigned for leftward deviations. For each participant, the average values of the results of 5 trials with combined line length and position conditions were used for statistical analysis.

De-adaptation of repetitive reaching task

To eliminate the carryover effect of the repetitive reaching task, participants engaged in a different type of repetitive reaching task between experiments. The tablet PC used in the LB task was placed in front of the par-

ticipants. A singular green dot with a diameter of 8 mm was presented on the tablet monitor in a pseudo-random order. This visual target was presented for 1 s, and the subsequent target was displayed after a 1-s interval. Participants without experimental glasses were instructed to reach a dot from the thin non-slip mat. During the de-adaptation, the black board covering the desk was removed, thus allowing participants to discern the trajectory of their index fingers during the pointing task. The participants were given a 10 min rest following this task.

Statistical analysis

To determine the effect on the OLP task, the results of the task performed before and after the repetitive reaching task in each condition were compared using a paired t-test. Additionally, to confirm the de-adaptation, we divided the participants into two groups that first performed the prismatic condition (prismatic first group) and the flat lens condition (flat lens first group). Then, we compared the results of the task after the first repetitive reaching task and before the second repetitive reaching task in each group using the paired t-test or the Wilcoxon signed rank test.

The effect of PA was determined by comparing the results of the LB task using three-way repeated measure ANOVA, with *glass conditions* (prism or flat lens), *line locations* (left, center, or right), and *line lengths* (200 or 50 mm) as independent variables. In this analysis, the dependent variable was the value obtained when subtracting the result of the pre-task from that of the post-task. Post-hoc comparisons were performed using the Bonferroni test.

The normality of the distribution of the data obtained from each lens condition and divided groups in the OLP task, and the LB results obtained from each condition combining the line length and its position were assessed with the Shapiro-Wilk test. Additionally, the sphericity for each condition level in the LB task was assessed with Mauchly's test and Greenhouse-Geisser correction was used where appropriate cases. Data were analyzed with SPSS version 25 (IBM Corporation, Armonk, NY, USA). The level of statistical significance was set at $P < 0.05$.

Results

OLP task (Fig. 2)

In the prismatic condition, the mean responses ± standard deviation (SD) of pre- and post-task were −0.75 ± 18.0 mm and 23.11 ± 18.11 mm, respectively. They were significantly different ($t = -5.09$, $df = 29$, $P < 0.001$), indicating a rightward shift after the reaching task. On the other hand, no significant difference was observed between the mean responses ± SD of pre-and post-task (2.60 ± 18.25 mm, 2.90 ± 19.87 mm, respectively) in the flat lens condition ($t = 0.22$, $df = 29$, $P = 0.83$).

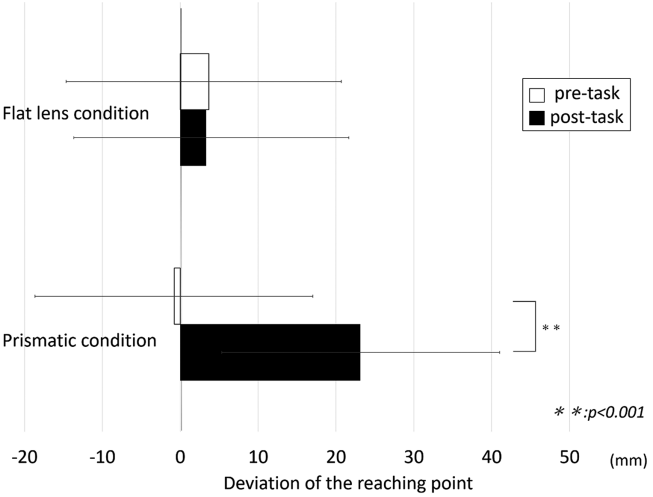

Fig. 2. Results of the open-loop pointing task. A significant rightward deviation was found only in the prismatic condition ($P < 0.001$). Horizontal bars indicate standard deviations.

Next, we confirmed the effect of the de-adaptation task. The mean response ± SD of results of the OLP task after the first repetitive reaching task and before the second task was 22.63 ± 4.51 mm and 0.76 ± 5.07 mm in the prismatic first group, and 5.92 ± 4.14 mm, 6.57 ± 3.79 mm in the flat lens first group, respectively. In the flat lens first group, the result before the second task was not normally distributed, thus we used the Wilcoxon signed rank test. It revealed they were significantly different ($t = 6.77$, $df = 14$, $P < 0.001$), indicating a leftward shift after the de-adaptation task. In the flat lens first group, the data followed the normal distribution ($P > 0.05$) and we used the paired t-test. No significant difference was observed between them ($t = 0.26$, $df = 14$, $P = 0.80$).

LB task

On the 200-mm line in the prismatic condition, the differences between the positions of the subjective midpoint before and after the repetitive reaching task were 0.77 (mean) ± 1.36 (SD) mm for the left position, 0.49 ± 1.32 mm for the center position, and 0.57 ± 1.56 mm for the right position, respectively. Under the flat lens condition, they were −0.08 ± 1.92 mm for the left position, −0.08 ± 1.31 mm for the center position, and −0.29 ± 1.39 mm for the right position, respectively (Fig. 3-A).

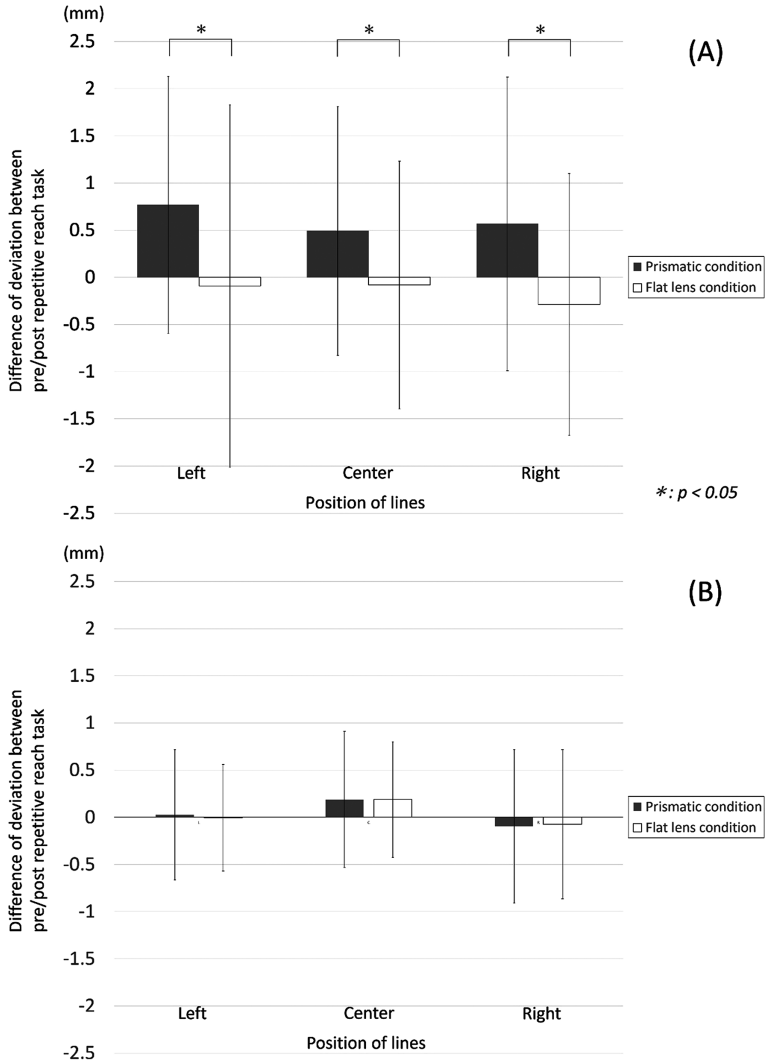

Fig. 3. Results of line bisection (LB) task. (A): Results of the LB task for 200-mm lines. Vertical bars indicate standard deviations. A significant rightward deviation of the subjective midpoint was found in the prismatic condition compared to that in the flat lens condition. However, the deviation did not differ according to the position of lines. (B): Result of the LB task for 50-mm lines. Neither PA nor the line presentation position had any observable effect.

On the 50-mm line under the prismatic condition, they were 0.03 ± 0.69 mm for the left position, 0.19 ± 0.72 mm for the center position, and −0.01 ± 0.81 mm for the right position, respectively. Under the flat lens condition, they were −0.01 ± 0.57 mm for the left position, 0.19 ± 0.61 mm for the center position, and −0.07 ± 0.79 mm for the right position, respectively.

As Mauchly's test of sphericity showed no significant difference ($P > 0.05$) except for *glass conditions* × *line locations* ($P = 0.003$), we adopted Greenhouse-Geisser correction for this analysis. Three-way repeated ANOVA showed the main effect of *glass conditions* ($F_{1,29} = 13.20$, $P = 0.04$) and a significant interaction between *glass conditions* and *line lengths* ($F_{1,29} = 8.52$, $P = 0.01$). Post-hoc comparison using Bonferroni correction revealed a significant difference between the prismatic condition and flat lens condition in 200-mm line length ($P = 0.01$) but not in 50-mm line length ($P = 0.98$). No main effects or interactions were found in the other factors (*line locations* $F_{2,58} = 0.78$, $P = 0.46$; *line lengths* $F_{1,29} = 3.10$, $P = 0.09$; *glass conditions* * *line locations* $F_{1.50,\ 43.34} = 0.15$, $P = 0.80$; *line locations* * *line lengths* $F_{2.58} = 0.68$, $P = 0.51$; *glass conditions* * *line locations* * *line lengths* $F_{2.58} = 0.17$, $P = 0.84$) (Fig. 3-B).

Discussion

In the present study, we evaluated the effect of PA on the allocentric frame in healthy participants using an LB task, which involved lines of two different lengths at three different positions. The results of the OLP task showed a significant rightward deviation in the prismatic condition only. The subjective midpoint of the 200-mm LB task showed significantly greater rightward deviation in the prismatic condition than in the flat lens condition, however, no significant difference was observed in the position of line presentation. The 50-mm LB task revealed no PA effect or line presentation position. This study is the first to demonstrate the effectiveness of PA on the allocentric frame only in healthy participants.

In the OLP task, deviation of the reaching point towards the right after the repetitive reaching task was found in the prismatic condition, but not in the flat lens condition. These findings suggest that rightward deviation was not caused by repetitive pointing itself, but by adaptation to the prism lenses through repetitive pointing.

Presuming that adaptation to prismatic lenses produces a simple physical after-effect, one would expect to observe deviation for both 200-mm and 50-mm lines. However, we found that a significant rightward deviation of the subjective midpoint was found only for the 200-mm line in the prismatic condition. A previous study showed a relationship between the displacement of the subjective midpoint on the LB task and the length of the presented line in a patient with left USN [29]. In this previous study, a larger rightward deviation of the subjective midpoint from the true center was found for longer lines than for shorter lines. Additionally, when a line of 2 inches (approximately 50 mm) was presented, the subjective midpoint was located near the true center. These behavioral characteristics of patients with left USN are consistent with the present results for the LB task using two different lengths of line. The present study indicates that an alteration in the distribution of spatial attention was induced by the PA task. furthermore, In the prismatic first group, the significant leftward shift after the de-adaptation task was confirmed. This could be interpreted as the PA-induced hand-eye coordination disappeared through the de-adaptation task, indicating that the first condition with the prism glasses had no after-effect on the second one with the flat lens.

As hypothesized, our results for the PA effect on the LB task in healthy participants were not affected by the position of line presentation. That is, PA induced allocentric neglect-like behavior. This is inconsistent with the results of Michel et al. [24], possibly due to the difference in LB task settings between the studies. Several studies on patients with USN suggest that task requirements can affect how deficits appear on different reference frames [25–26]. In particular, the foci and width of spatial attention are guided by task demands, which define the perceptual representation of the space [30–31]. In the study by Michel et al. [24], since only one type of line length was adopted in the LB task, participants may have gradually attended to its position in relation to their own position rather than the length of the line. In contrast, because two different line lengths were presented in the present study, participants might have needed to pay more attention to the line lengths. This task setting might lead participants to attend to the lines themselves regardless of their relative spatial positions, rendering the allocentric frame dominant.

Our findings may contribute to the assessment and treatment of patients with allocentric neglect. Abbruzzese et al. [23] stated that only a few tests are available for evaluating allocentric neglect. The Apples test [20] and Ota test [16], for example, are visual cancellation tasks that allow for the simultaneous evaluation of egocentric and allocentric neglect. In these tasks, allocentric neglect is determined by a failure to detect the missing left part of the targets. Another type of test is a copy task, comprising multiple items arranged side-by-side on a sheet, like Gainotti's task [19]. On these tasks, allocentric neglect is determined by a failure to detect the left portion of the sample item(s). All of these tests evaluate the degree of allocentric neglect by counting the number of false performances. In contrast, our LB task can evaluate the severity of allocentric neglect by measuring the lateral deviation of the subjective midpoint.

The present study has some limitations. Firstly, since this is the first study to focus on the immediate PA effect on the allocentric frame, the duration of these effects remains unclear. Additionally, as the PA effect in patients with left USN was not investigated, the generalizability of these findings may be limited. Further studies are needed to clarify the effect of PA on allocentric neglect in patients with left USN.

Conclusion

Our findings in this study indicate that the effect of PA, as measured by the LB task, was confined to the allocentric frame. This suggests that participants may attend to the length of the line itself, regardless of the presentation position. This implies that the PA affected the task processing of the reference frame. This result serves as evidence that the effect of PA depends on task settings. Finally, these findings may have implications for the evaluation and treatment of allocentric neglect.

Declaration of conflicting interests

The authors declare that they have no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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■ORIGINAL ARTICLE

Positional Stability of the Non-Dominant Hand is Associated with Difficulties in Daily Functioning in Schizophrenia

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Abstract: Background: Patients with schizophrenia have difficulty performing activities of daily living (ADLs) that require fine motor skills. This study investigated the hand instability of 24 patients with schizophrenia and 20 healthy controls during a finger opposition task.
Methods: We evaluated the path length of the hand position during the finger task from a motion capture system. Subjective difficulties in ADLs were assessed using a visual analog scale.
Results: The path lengths of both hands were significantly greater for patients with schizophrenia than for healthy controls. Significant associations were found between the path length of the non-dominant hand and subjective difficulties encountered by patients with schizophrenia while performing ADLs.
Conclusion: The findings suggest that instability in the non-dominant hand is a potential marker of daily functioning in schizophrenia.

Keywords: activities of daily living, arm posture, fine motor skill, hand stability

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Introduction

The most characteristic symptoms of schizophrenia are delusions, verbal hallucinations, and disorganized thinking. A growing body of evidence suggests that motor disturbances, which also affect fine motor skills, may be other symptoms of schizophrenia [1]. Traditionally, motor disturbances, such as dyskinesia and parkinsonism, have been regarded as side effects of antipsychotic treatment. However, some motor disturbances are independent of medication use. Disturbances in fine motor skills appear during the early developmental stages and in drug-naïve patients with schizophrenia [2, 3]. Moreover, children of patients with schizophrenia have shown impaired manual dexterity relative to typically developing children [4, 5], and adolescents at high risk for schizophrenia have shown reduced accuracy during a line drawing task [6]. Recent studies have revealed that motor disturbances in schizophrenia are associated with neuronal dysfunction. Specifically, impairment of fine motor skills is associated with frontostriatal dysconnectivity and dopaminergic activity in the striatum [7]. Thus, fine motor tasks, such as finger tapping tasks, are potential tools for detecting neuronal vulnerability in schizophrenia [8, 9]. Although the effects of antipsychotic drugs should be considered, impairment in fine motor skills is becoming increasingly understood as a symptom of schizophrenia [10].

Fine motor skills comprise fine finger movements and the maintenance of arm posture; however, little is known about the maintenance of hand posture while performing fine movements in patients with schizophrenia. Previous studies on fine motor skills have focused on the outcomes of fine motor performance at the behavioral and kinematic levels [7, 8]. Task-specific movements require the recruitment of specific muscle groups. The ratio and timing of the co-activation of

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specific muscle groups is called muscle synergy [11]. A dysfunction in the forearm muscle synergy causes a loss of dexterity during finger motion and instability of arm posture during fine motor tasks [12]. Fine motor skills require the minimization of positional errors at the endpoint. Arm posture stability during fine motor performance leads to high accuracy, speed of fine motor skills, and reduces the cost associated with completing tasks [13]. In addition, dominant and non-dominant hands play different roles in the activities of daily living (ADLs) [14]. The dominant hand performs fine tasks, such as writing and using chopsticks, more accurately than the non-dominant hand, while the non-dominant hand can hold objects and minimize positional errors for improved fine motor performance. Therefore, the study of fine motor skills should also focus on the positional variability of the non-dominant hand during fine motor tasks. However, the relationship between the ability to maintain hand position and the performance of ADLs in patients with schizophrenia is not fully understood. A previous neurological study reported functional connectivity between the sensorimotor cortex and the visual cortex during arm posture maintenance, suggesting that motor commands are adjusted based on sensory information [15]. Patients with schizophrenia show sensorimotor coordination dysfunction [16]. We hypothesized that the instability of the hand position in schizophrenia may cause unnecessary processing for sensorimotor integration and subjective difficulties with ADLs.

In this study, we aimed to compare hand stability in patients with schizophrenia and healthy controls (HCs) during a bilateral finger task. The finger task was set to perturb the position of the hand. We also investigated the relationship between hand instability and ADLs in patients with schizophrenia.

Participants and Methods

Participants

Patients with schizophrenia were recruited from a daycare center. They had been previously diagnosed by their respective psychiatrists according to the criteria of the Diagnostic and Statistical Manual of Mental Disorders. Age-matched HCs were recruited from the same local community.

Only individuals with clinically stable disease were included in the study. Stable disease was defined as not having required a change in medications within the previous month. The exclusion criteria were as follows: (a) essential tremor; (b) functional tremor and Parkinson's disease; (c) substance use and addictive disorders; (d) history of developmental delay; (e) neurological diseases and musculoskeletal problems of the upper limbs; (f) intelligence quotient score of < 80 according to a previous study [17] and Mini-Mental State Examination (MMSE) score of < 26; and (g) mixed handedness. Mixed-handed individuals were excluded to allow investigation of the difference in the relationship between the performance of ADLs and the stability of the dominant/non-dominant hand. Handedness was assessed using the Flanders Handedness Survey.

This study was approved by the Ethics Committee and Faculty of Medicine of the Kyoto University Graduate School (approval: R1639-1; date: 2018-10-4). All participants provided written informed consent.

Thumb-to-index finger opposition task

All participants completed a bimanual thumb-to-index finger opposition task. They sat on a chair and held their hands over the fast-tracking system (Leap Motion Controller [LMC]; Ultraleap, Mountain View, CA, USA). They were instructed to repeatedly tap the tip of their thumb to the tip of their index finger with both hands without resting their elbows on the desk, ten times. All participants performed five trials and rested for a minute rest between trials. We measured the center positions of each hand using an LMC connected to a personal computer (Windows version 10).

The LMC system allowed the detection and measurement of the three-dimensional positions of the hands within milliseconds [18]. This device consists of three infrared LEDs and a stereo camera, which can produce pairs of grayscale images at 60 frames per second. The disparity between the positions of the matching pixels in the two grayscale images produced real three-dimensional positions of each fingertip in each frame (Fig. 1). The center position of the hands was calculated from the positions of each fingertip based on the hand model created by the LMC. The LMC tracked the three-dimensional positions of the hands at 60 Hz. A previous study revealed that the LMC is a reliable measure of motor performance [19]. Interestingly, the LMC can measure the position of each hand without referring to the attached sensors or markers. Thus, the LMC can measure hand positions without disturbing the natural hand movements.

Subjective difficulties in ADLs

Subjective difficulties in performing ADLs were assessed using a visual analog scale for ADLs (VAS-ADL). The VAS-ADL used in this study was a modified version of the scale for patients with rheumatoid arthritis [20]. It consisted of 64 items (e.g., flipping a page, wringing out a towel, buttoning up a shirt, using chopsticks, and tying a string) with 11 domains (fine motor skills, gross motor skills, personal hygiene, face washing, reading

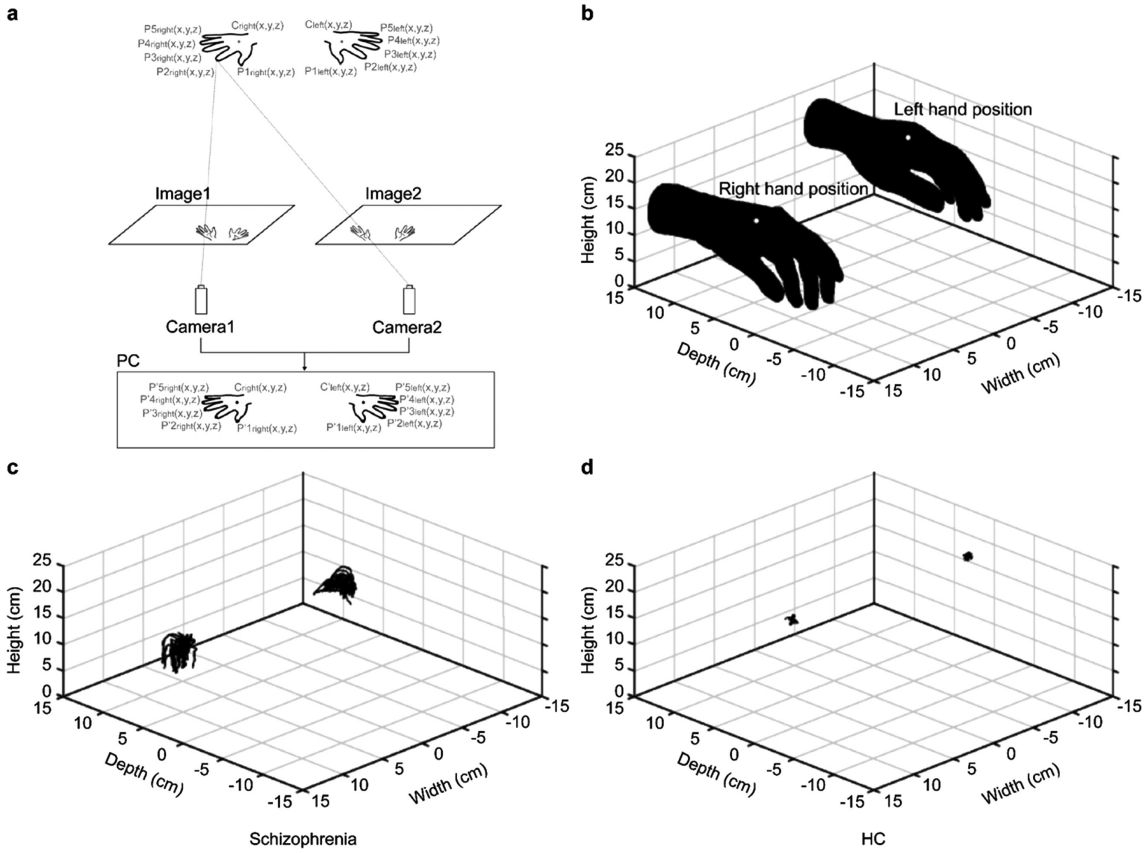

Fig. 1. Measuring the center position of the hands with the Leap Motion Controller (LMC) system. (a) Two cameras are installed in the LMC, which capture the fingertips. The 3-dimensional positions of the fingertip and the center of the hand are calculated from the baseline, and the disparity between the matching positions corresponding to the fingertip in the images is captured by the cameras. (b) The tridimensional coordination and the centers of both palms were assessed with the motion capture system. The zero point (0, 0, 0) in the graph represents the position of the motion capture camera. (c) Hand trajectories in a representative individual with schizophrenia. (d) Hand trajectories in a representative healthy control (HC). HC, healthy control; PC, personal computer.

books, writing and texting on a cell phone and personal computer, tool-using skills, dressing, preparing meals and feeding, toileting, and doing laundry) (Table 1). Each question was assessed with a straight-line scale from no difficulty (0 mm) to the worst possible difficulty (100 mm). The average of all the VAS-ADL scores was also calculated.

Statistical analysis

The sample size was calculated using a power analysis. We calculated the sample size based on an alpha error of 0.05 and a power of 0.8. We set the difference as 0.5 m between groups and the standard deviation as 0.58 m. The ratio of the numbers in the two groups was set at 1.2. The required sample included 24 individuals with schizophrenia and 20 HCs.

The present study assessed the stability of the hand position during a finger opposition task. The data that did not contain hand position information for more than one second were excluded from the analysis. For smoothing data, the moving average method was used (low pass below 3 Hz) to exclude artifacts, including drug-induced tremors [21]. The stability of the hand position was quantified based on the path length of the hand position during the finger opposition task. The path length until the beginning of the pinch motion was calculated as the baseline. All data were processed using MATLAB (version R2020a; MathWorks, Natick, MA, USA).

Student's t-test was used to assess group differences in the path length of the hand position. The path length at baseline was analyzed using Student's t-test. Spearman's rank correlation test was used to analyze the correlations between the path length of the hand position, VAS-ADL, and chlorpromazine (CPZ) equivalent doses in schizophrenia. The difference in the VAS-ADL score was examined using the Mann–Whitney U test. The significance level was set at $p < 0.05$. All statistical analyses were performed using SPSS version 25 (IBM, Armonk, NY, USA).

Table 1 Visual analog scale for activities of daily living

Domains	Items
Gross movements	Standing up from sitting with your hands; carrying 10 kg of objects with both hands; moving objects with hands
Reading-related movements	Holding a book while reading; flipping a page of book/paper/magazine
Self-care	Turning a faucet on/off; shower; wringing a towel; wiping face/body with a towel
Dressing	Wearing t-shirts, pants, skirts, or socks; buttoning a shirt; fastening buttons on sleeves; fastening a belt, watch, or bracelet; tying shoelaces; using fingernail clippers; brushing the teeth; cleaning the ears; shaving/applying make-up; self-administering eye drops; inserting contact lenses; combing the hair
Preparing meals and feeding	Eating with chopsticks or with a spoon; using a knife; lifting a bowl when eating; holding a mug; holding a glass; drinking from a cup; pouring tea; serving rice; serving soup; carrying plates; taking the lid off a bottle; unscrew a plastic bottle; washing the dishes; cutting with a kitchen knife; peel with a peeler; cooking with a frying pan
Tool using	Inserting a key; opening a lock; inserting a coin in a vending machine; pushing buttons in an elevator; using a calculator; pushing the buttons of a vending machine
Writing and texting on a cell phone and personal computer	Writing; drawing a straight line without a ruler; typing with a keyboard; typing with a cell phone
Toilet hygiene	Cleaning themselves in the washroom
Fine motor skills for sewing	Inserting a thread through the eye in the needle; hand-stitching; using a sewing machine
Laundry	Pouring laundry detergent as needed; hanging clothes; pinning clothes on a clothesline; collecting dry clothes; folding t-shirts; folding pants; reverse the laundry inside out.

Results

Participant demographics

Among the 44 participants who completed five trials of the finger opposition task, 24 had schizophrenia (15 men, 9 women; mean age, 39.58 ± 12.46 years) and 20 were HCs (12 men, 8 women; mean age, 41.70 ± 11.07 years). All patients with schizophrenia were clinically stable and were undergoing treatment with antipsychotic drugs (average CPZ equivalent dose, 536.11 ± 332.63 mg/day). Two patients received first-generation antipsychotics (levomepromazine maleate); the remaining participants were receiving second-generation medications (risperidone, olanzapine, and aripiprazole). The average time to complete the finger opposition task was 21.35 ± 7.75 for the patients with schizophrenia and 20.20 ± 8.25 seconds for the HCs. All participants were confirmed to be right-handed based on the Flanders handedness questionnaire responses. There were no differences in age ($p > 0.05$), MMSE score ($p > 0.05$), or duration of the finger opposition task ($p > 0.05$) between the patients with schizophrenia and HCs.

Path length of the hand position

For the HCs, the path length of the left hand was longer than that of the right hand ($t = 2.20$, $df = 19$, $p = 0.039$). For the patients with schizophrenia, there was no difference in the path length between the left and right hands ($t = 0.54$, $dt = 23$, $p = 0.60$). No significant difference in the path length at baseline was found between the groups (left: $t = 1.37$, $dt = 32.38$, $p = 0.18$; right: $t = 1.41$, $dt = 42$, $p = 0.18$). The path lengths of both hands were significantly longer for the patients with schizophrenia than for the HCs (left: $t = -4.069$, $df = 29.49$, $p < 0.001$; right: $t = -4.26$, $df = 28.49$, $p < 0.001$) (Fig. 2). No significant association was found between path length and CPZ equivalent dose in patients with schizo-

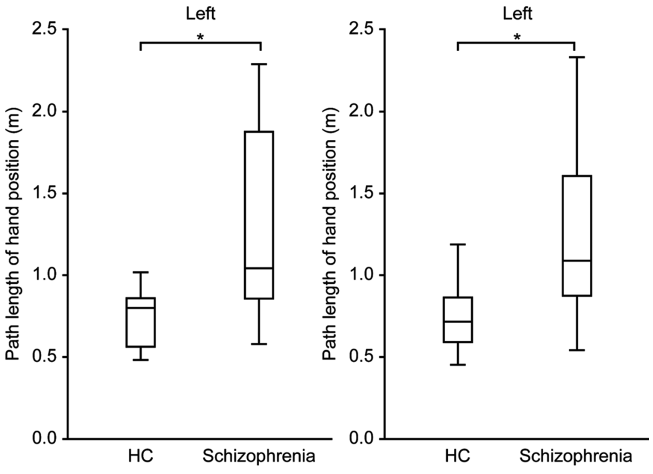

Fig. 2. The path length of the hand position during the finger opposition task. The path lengths of both hands were significantly greater in patients with schizophrenia than in healthy controls (HCs). *$p < 0.001$. HC, healthy controls.

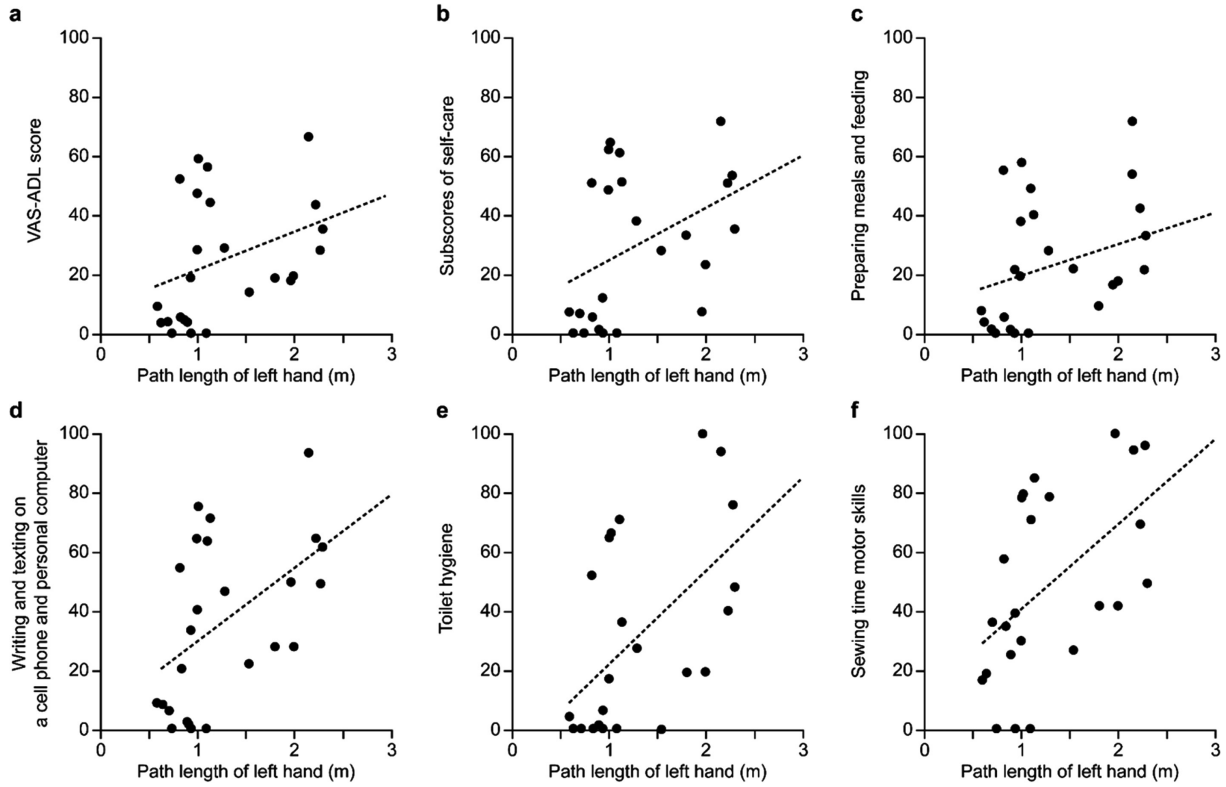

Fig. 3. Correlation between the hand position path length and the visual analog scale score for activities of daily living (VAS-ADL) score in patients with schizophrenia. Correlations between the path length of the non-dominant hand and (a) VAS-ADL average score and subscores of (b) self-care, (c) preparing meals and feeding, (d) writing and texting on a cell phone and personal computer, (e) toilet hygiene, and (f) fine motor skills for sewing. VAS-ADL, visual analog scale for activities of daily living.

phrenia (left: $r = 0.25$, $p = 0.24$; right: $r = 0.20$, $p = 0.35$).

VAS-ADL in schizophrenia

The Mann–Whitney U test revealed that all VAS-ADL subscores were significantly higher for patients with schizophrenia than for the HCs ($p < 0.001$).

Correlation between the finger task and VAS-ADL

In patients with schizophrenia, a significant correlation was found between the path length of the left hand and the average VAS-ADL score ($r = 0.48$, $p = 0.017$) (Fig. 3). Significant correlations were found between the path length of the left hand and the VAS-ADL subscore (self-care: $r = 0.51$, $p = 0.010$; preparing meals and feeding: $r = 0.45$, $p = 0.028$; writing and texting on cell phones and personal computers: $r = 0.55$, $p = 0.005$; toilet hygiene: $r = 0.60$, $p = 0.002$; sewing fine motor skills: $r = 0.62$, $p = 0.001$). The correlations are shown in Fig. 3. The path length of the right hand was only significantly correlated with the toilet hygiene subscore ($r = 0.43$, $p = 0.037$). There was no correlation between the CPZ equivalent dose and the VAS-ADL score ($p > 0.05$). In contrast, there were no correlations between the parameters and the VAS-ADL score of the HCs.

Discussion

The present study investigated hand instability during finger tasks. In HCs, the path length of the dominant hand was shorter than that of the non-dominant hand. In patients with schizophrenia, the dominant hand was not more stable than the non-dominant hand. This finding supports the report of a previous study showing that the fine skills of the dominant hand are not superior to those of the non-dominant hand in schizophrenia [22]. As hypothesized, patients with schizophrenia had a longer path length of the hand position than the HCs during finger tasks. This hand instability was not correlated with the CPZ equivalent dose; however, it was positively associated with subjective difficulties in performing ADLs requiring fine motor skills. Interestingly, the correlation between hand instability and VAS-ADL appeared stronger in the non-dominant hand than in the dominant hand. The findings improve our understanding of the relationship between subjective difficulties in performing ADLs and disturbances of fine motor skills in patients with schizophrenia.

The instability of hand positions in this study indicates motor variability in patients with schizophrenia.

These results suggest impairments in the correct timing of activation of proper muscle groups and suppression of others in patients with schizophrenia. A previous behavioral study indicated increasing instability of the arm position before pressing a button and excessive force when pressing a button in patients with schizophrenia [23]. Reduced regularity during finger tapping was also found in patients with schizophrenia [1]. Even with a simple movement, such as index finger flexion, the biceps and anterior deltoid are deactivated 100 ms prior to the onset of the movement itself [24]. This muscle preparation results in stable hand positions and accurate end-points of finger tapping. In muscle dyscoordination, voluntary motion includes the simultaneous involuntary contraction of other muscles, causing redundant motion and unsteadiness of the hand position. A previous study of healthy participants showed that the incorporation and separation of muscle contractions are vaguer in the non-dominant hand than in the dominant hand [25]. For this reason, the variation of hand position in this study indicated the incorporation of muscle contractions during finger task execution.

Two possible explanations for these findings are impairments of sensorimotor control when stabilizing hand positions. First, as mentioned above, several muscles in the upper limb are inhibited prior to finger tapping, but the dysfunction in the cerebellum prevents this muscular preparation [26]. Dysfunctional connectivity, including that in the cerebellum, is found in patients with schizophrenia [27]. Cerebellar–cortical hyperconnectivity in patients with schizophrenia is also related to deficits in the finger tapping task [28]. Postural instability has also been reported in patients with schizophrenia, which may be due to cerebellum dysconnectivity [29]. Second, this co-contraction for stabilizing hand positions is adjusted based on sensory feedback, such as visual and proprioceptive information, as well as the predicted sensory consequence of motion. A previous study on sensory processing demonstrated that the proprioceptive-evoked response was decreased in patients with schizophrenia [22]. This low response to proprioceptive stimuli can be observed following hand posture perturbation in patients with schizophrenia [30]. Recent neurological studies have revealed altered functional connectivity between the frontostriatal and parietal-motor cortices involving hand movement in patients with schizophrenia [7, 31, 32]. These findings suggest that patients with schizophrenia may not be able to effectively integrate proprioceptive information to stabilize the hand position. In addition, aberrant excitability in the motor cortex has been reported in patients with schizophrenia, regardless of whether they are unmedicated or medicated [33]. This hyperexcitability in the motor cortex leads to disturbances in motor control, suggesting decreased motor inhibition [34]. Stabilizing forearm posture against perturbation induced by a finger task demands the contraction of proper muscles and the suppression of inessential muscles due to sensory information. This control between activation and suppression can be realized with a balance of excitation/suppression in the motor cortex. Hand instability during a finger task has been suggested to be a dysfunction in muscle synergy [11]. The present results suggest that hand instability reflects an imbalance between inhibition and excitation in the motor cortex and impairment of sensorimotor integration.

The relationship between hand instability and difficulties in performing ADLs suggests that impairment of the non-dominant hand can affect the performance of ADLs. Upper limbs have functional asymmetry, known as hand preference and laterality. The non-dominant hand is more capable of maintaining the hand position than the dominant hand [35]. Fixation by the non-dominant hand reduces spatiotemporal coordination of fine motor skills [36]. Given this characteristic, the non-dominant hand improves and interferes with fine skills. Most ADLs have bimanual motion during bimanual performance. For example, scissors are held in the dominant hand and a paper is held in the non-dominant hand. The method of manipulating the non-dominant hand makes the shearing edge more visible. The non-dominant hand affects the accuracy and speed of performance in bilateral tasks. In this study, we found a correlation between the instability of the non-dominant hand and ADLs. Stability in the non-dominant hand requires additional motor control; in contrast, the dominant hand can absorb perturbation more efficiently [37]. This relationship between ADLs and the instability of the non-dominant hand suggests that instability in the non-dominant hand causes distress when performing ADLs in patients with schizophrenia.

This study has some limitations. The instability of the hand position is susceptible to drug-induced tremor and postural sway. In general, tremor in parkinsonism appears to resolve at 3–5 Hz and is suppressed during voluntary motion [38]. Tremors in tardive dyskinesia also appear at frequencies above 3 Hz [39]. Previous studies have reported postural instability in patients with schizophrenia [28]. For instance, an analysis of the path length of the center of pressure during standing revealed that patients with schizophrenia sway more than HCs. Moreover, patients with schizophrenia and alcohol dependence demonstrated greater postural sway [29]. A previous study reported that postural sway in patients with schizophrenia was above 8 Hz. In this study, all data were passed through a low-pass filter of 3 Hz to exclude tremor due to side effects and postural sway based

on a previous study [21]. Besides, tremor and additive disorder were excluded according to the exclusion criteria. Oscillations, including dyskinesia, parkinsonism, and postural sway, were removed in this study.

The method for measuring hand position in this study was advantageous for evaluating natural hand movements. The fast-tracking system can precisely detect three-dimensional positions without affecting natural motion. Further research is needed to investigate motor control in schizophrenia in detail to elucidate motor deficits caused by neuroleptic treatment and the neurodevelopmental aspects of schizophrenia.

In conclusion, positional instability of the hand is a key facet of daily outcomes in patients with schizophrenia. In particular, instability in the non-dominant hand may cause difficulties with ADLs. The longer path length of the hand position found in patients with schizophrenia may be related to an impairment in muscle synergy based on neural dysfunctions of motor control, although other side effects should also be considered. The important aspect of this study is that instability of the non-dominant hand may be used as a marker of daily functioning in patients with schizophrenia. The present findings can contribute to the understanding of difficulties in performing ADLs requiring fine motor skills in patients with schizophrenia.

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Disclosure statement

The authors declare no conflicts of interest.

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■REVIEW

Relationship between Occupations and Cognitive Impairment in Patients with Chronic Obstructive Pulmonary Disease: A Scoping Review

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Abstract: Background: The number of studies on cognitive impairment in patients with chronic obstructive pulmonary disease (COPD) has been increasing in recent years. However, no study has comprehensively examined the relationship between cognitive impairment and occupation. Thus, the relationship between cognitive impairment and occupation in patients with COPD remains unclear.
Objectives: This study aimed to conduct a scoping review and summarize the findings on the relationship between occupation and cognitive impairments in patients with COPD.
Methods: A scoping review of articles published in English from 2001 to 2020 was conducted in MEDLINE, PsychINFO, and OTseeker. A key search term was employed using "COPD," "occupation," and "cognitive impairment." Two investigators independently screened article titles and abstracts (primary screening) and then conducted full text review (secondary screening).
Results: After screening, 22 articles were included in the analysis. The results of the analysis of the relationship between cognitive impairment and occupations in patients with COPD revealed that many studies have examined inhaler use and medication management in patients with COPD, whereas only a few studies were conducted in areas such as activities of daily living (ADL) and driving.
Conclusion: Since occupations such as ADL and driving are critical for patients with COPD, further studies on these occupations are warranted.

Keywords: COPD, cognitive impairment, occupation, scoping review

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Introduction

Chronic obstructive pulmonary disease (COPD) is the third leading cause of death worldwide, and it is characterized by conditions requiring care and long-term medical treatment [1]. COPD is one of the conditions that chronically restrict activities and participations in daily life due to impaired respiratory and physical functions. In a study of the needs of patients with COPD, patients need interventions for activities of daily living (ADL) and instrumental activities of daily living (IADL) [2]. A study pointed that activity and participation limitations were caused by COPD-related cognitive, respiratory, and physical impairment [3]. Approaches to limited activities and participations in daily living are key issues in occupational therapy; thus, the current knowledge in occupational therapy for patients with COPD is a crucial topic.

In recent years, several studies have indicated the effectiveness of occupational therapy for patients with COPD. For example, occupational therapy interventions for ambulatory patients [4] and at home [5] were found to improve the ADLs of people with COPD. In addition,

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occupational therapy interventions for ADL, which consider the outcomes of cardiopulmonary exercise tests, were reported to contribute to prolonged lifetime in patients with severe COPD [6]. Thus, the effects of occupational therapy on patients with COPD are becoming more evident, and expansion of occupational therapy for patients with COPD is expected in the future.

Moreover, the number of studies on cognitive impairment in patients with COPD has been increasing in recent years. In a review on cognitive impairment in patients with COPD, the prevalence of cognitive impairment in patients with COPD ranged from 6% to 63% [7]. Cognitive impairments in patients with COPD were characterized by disorders of frontal lobe function such as attention and performance function [8]. Cognitive impairment has been reported to be related with disabilities of ADL and IADL [9–11], inhaler use [12], medication administration [13], and driving [14]. However, no studies have comprehensively reported the relationship between cognitive impairment and occupation. Thus, what occupations were related with cognitive impairments in patients with COPD, which should be studied to consider in future clinical practice, remain unclear. Moreover, it can be meaningful to systematically examine results of previous research studies and to summarize present knowledge about the relationship between occupations and cognitive impairment and COPD. This task will determine a research area where occupational therapy can be beneficial for patients with COPD.

A possible significance of this research will be explained. Cognitive impairment in COPD has been characterized by attention deficits, and some problems have been seen especially when acquiring new behavior patterns. Therefore, when supporting the acquisition of new behavioral patterns, which is also instructed in hospitals, it would be necessary to understand their cognitive function and consider a suitable guidance method, such as guidance on inhaler use, ADL, and exercise habits. By knowing problems of occupation with cognitive impairment, it may be possible to more clarify which areas occupational therapy will be required to contribute in the future.

To this end, this study mainly aimed to conduct a scoping review and summarize the findings on the relationship between occupation and cognitive impairments in patients with COPD, which would be necessary for further investigation and management of cognitive impairment in patients with COPD.

Methods

A scoping review was conducted to enable researchers map the current literature and identify gaps. The PRISMA Extension for Scoping Reviews: Checklist and Explanation [15] was used to guide the scoping review.

A. Criteria for the selection of target papers

This review included original peer-reviewed articles and excluded conference records. Review articles were also excluded because they were difficult to treat equally with original articles as primary literature.

Articles that dealt with patients diagnosed with COPD, as well as articles that comprehensively examined other diseases, were included in the review. Furthermore, cognitive impairment may be aggravated by an acute exacerbation of COPD, and a relationship between cognitive impairment at this period and occupations may be affected by factors from different those in the stable period [16]; therefore, we excluded research articles that included patients who had experienced acute exacerbations of COPD for ≤ 6 months. Articles that could be judged to have evaluated cognitive function were included. Evaluation methods and cognitive functions evaluated were not restricted. In addition, to extract occupations, the search terms of activity and occupation were used. Inhaler use and driving were indicated to be related to cognitive impairment in patients with COPD [12, 14]; thus, those words were also used as search terms.

B. Literature retrieval method

MEDLINE, PsychINFO, and OTseeker databases were searched for relevant articles. All articles were written in English, and the search period ranged from 2001 to 2020.

As a search condition, we extracted articles of which the study participants were diagnosed with COPD and which showed the relationship between cognitive dysfunction and occupation. In the database search, the search keywords were divided into three items, namely, COPD, occupations, and cognitive impairment, and the search was conducted. In the COPD item, “COPD” and “chronic obstructive pulmonary disease” were used. In the occupation section, six terms were used, namely, “occupation,” “activity,” “ADL,” “activity of daily living,” “inhaler,” and “driving.” In the “cognitive impairment” section, seven terms were used, namely, “cognitive performance,” “cognitive impairment,” “cognitive status,” “cognitive function,” “cognitive impairment,” “neuropsychological,” and “cognition.” The literature search date was conducted on September 6, 2021.

C. Selection method

The inclusion criteria were as follows: (1) research participants were patients with stable COPD without

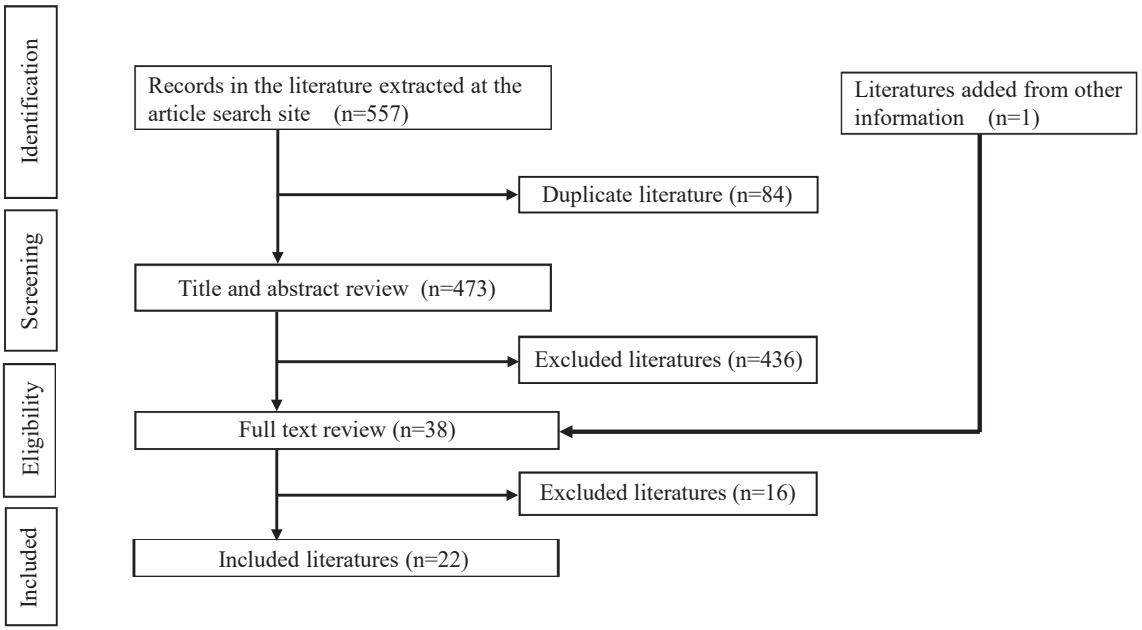

Fig. 1. Flow diagram

acute exacerbations for the previous 6 months, (2) cognitive function had been assessed, (3) association between cognitive impairment and occupation has been pointed out, and (4) papers were written in English. Review papers were excluded. In principle, when conducting a literature review, original articles should be used because raw information of the researchers should be highly prioritized rather than secondary information such as reviews [17].

In the primary screening, the titles and abstracts of the retrieved articles were checked by two independent authors according to the selection criteria. When the opinions of both authors were different, multiple authors discussed and decided on the selection.

The texts of articles selected in the primary screening were fully checked in the secondary screening by two independent authors. Articles with discrepancies in the judgment and opinions were reviewed by multiple authors and decided on whether to accept them. The following contents were extracted from the selected articles: authors, publication year, number of participants, assessment of cognitive function and results, and occupation, and these data were arranged in a chart. As this study focused on problems related to "occupation," our summary should be in the framework of "occupation." Thus, we referred to the category of "occupation" in the domain of occupational therapy in the Occupational Therapy Practice Framework: Domain and Process (3rd Edition) issued by of the American Occupational Therapy Association [18]. Articles that were determined to not fall under the category of "occupation" in this framework were excluded from this study.

D. Extracting occupations

From the included articles, we extracted occupations that were related to cognitive impairment. In addition, the number of participants and methods of cognitive function assessment were extracted from each paper, and the results were summarized in a table. These tasks were completed by two independent authors, and articles that were difficult to judge were examined by multiple authors.

Results

A flow diagram of this review is shown in Fig. 1. The literature search identified 417 articles in MEDLINE, 10 in OTseeker, and 75 in PsychINFO. Initially, 84 duplicate articles were excluded.

In the primary screening, 473 titles and abstracts were reviewed, of which 436 were excluded from the study. A total of 38 reports were selected as a result of adding one additional record from other articles were identified from the references of the included articles.

In the secondary screening, the full text of articles selected in the primary screening was checked. Accordingly, 16 articles were excluded and 22 were included for the analysis.

The reasons for exclusion in the secondary screening were as follows: seven articles could not be classified into the "occupation" domain, three did not involve patients with COPD, two did not examine cognitive

function, two did not examine occupation, one was a protocol study, and one was a review. For example, articles that could not be classified into "occupation" domain examined the relationship between cognitive functions and finger sophistication [19] and appropriateness of measuring spirometry [20].

Finally, 22 articles that were included in the analysis were categorized by occupations, and a summary of the number of participants in each article and cognitive assessments used is presented in Table 1. The Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) accounted for 68.1% of the total cognitive assessments employed in the articles included in this review, and many studies investigated other cognitive assessments. According to the occupation categories, 4 articles were classified as ADL, 17 articles as IADL, and 1 article as work. The results are described in detail in the following sections and are divided into categories.

A. ADL

Four studies have reported that cognitive impairment in patients with COPD was associated with ADL disability [11, 21–23]. Antonelli-Incalzi et al. [24] used the Katz Index to assess ADL, and the other three studies used a comprehensive questionnaire about ADL to ask about difficulties in each activity such as clothing and bathing [11, 22, 23]. In these studies, cognitive function was compared with one variable, which was a result of summarizing multiple items of ADL.

Gong et al. [22] examined cognitive function in detail and suggested that disorientation to time and reduced visuospatial ability may have significant effects on ADL impairment. Kobayashi et al. [23] reported that cognitive impairment was significantly worse in older patients with COPD than in younger ones, which was related to poorer ADL performance.

B. IADL

1) Health management and maintenance (healthcare and maintenance)

The healthcare and maintenance category included articles on inhaler use and medication management. A total of nine articles found associations between cognitive impairment and inhaler use. Seven investigated adherence to inhaler use. Moreover, six articles revealed a significant association between cognitive function and adherence [12, 25, 26]. However, Pierobon et al. [30] did not find any association between cognitive function and adherence to inhaler use.

Two articles reported significant associations between cognitive impairment and inhaler use techniques. Quinet et al. [31] indicated that inhaler use was inappropriate for patients who scored ≤ 24 points in the MMSE. A countermeasure of inappropriate inhaler technique was examined, and the study reported that an intensive training program significantly reduced the use of inappropriate inhalation techniques because of cognitive impairment [32].

2) Driving and community mobility (driving/mobility)

Three articles focused on the driving performance of patients with COPD. All articles that assessed driving performance using a driving simulator [14, 33, 34] showed a significant reduction in driving performance in patients with COPD. One study assessed cognitive function in patients with COPD, without a driving simulator [35]. The study suggested that significantly delayed response times to visual and sound stimuli and perceptual velocity relative to changes in traffic circumstances were associated with a risk of accidents while driving.

3) Other IADLs

Five articles examined the association between cognitive impairment and various IADL, including cooking, shopping, money management, and medication management [9, 11, 24, 36, 37]. All these articles also assessed medication management. Antonelli-Incalzi et al. [37] examined sub-items of MMSE. Disorientation to time and place, memory recall, and verbal fluency were significantly associated with inefficient medication and money management.

C. Work

Only one study examined work in a large cohort [38]. Patients with comorbid cognitive impairment and COPD were reported to experience more difficulties with work and social activities than those with cognitive impairment or COPD alone. This suggests that those with comorbid COPD and cognitive dysfunction may have severe disability to work.

Discussion

A review of 22 articles revealed that cognitive impairment in patients with COPD was associated with disabilities in some occupations regarding ADL and IADL, such as medication management, driving, and work. The results of this review are discussed in relationship between cognitive impairment and occupations in patients with COPD.

1) ADL

All four articles that assessed ADL in patients with COPD found associations between cognitive impairment and ADL abilities with COPD. However, a

Table 1 Summary of results

	Occupations	Authors (year of publication)	Number of subjetss	Cognitive assessment		
				MMSE	MoCA	Others
ADL	Toileting and toilet hygiene, swallowing/ eating, functional mobility, and personal hygiene and grooming	Gong B, et al. (2020) [22]	1022 patients with COPD	○		
		Kobayashi S, et al. (2014) [23]	279 patients with COPD	○		
		Martinez CH, et al. (2014) [11]	17535 patients (patients with COPD: healthy = 15870 patients: 1665 subjects).			The HRS cognitive instrument
		Antonelli-Incalzi R, et al. (2008) [24]	149 patients with COPD			※1
IADL	Health management and maintenance	Maricoto T, et al. (2020) [25]	130 subjects (including patients with COPD and healthy subjects)		○	
		Mochizuki H, et al. (2013) [26]	44 patients (aged 65 years and older with COPD)	○		
		Dulohery MM, et al. (2015) [21]	100 patients with COPD	○	○	
		Pierobon A, et al. (2017) [30]	84 patients with COPD	○	○	
		O'Conor R, et al. (2019) [27]	299 patients with COPD	○		
		Sulaiman I, et al. (2017) [28]	244 patients with COPD		○	
		Turan O, et al. (2017) [12]	121 patients (COPD: asthmatics = 88 patients: 33 patients)	○		GDS-15
		Moran C, et al. (2017) [29]	184 patients with COPD	○		MMAS-4
		Quinet P, et al. (2010) [31]	25 patients (aged 65 years and older with COPD)	○		
		Luley MC, et al. (2020) [32]	26 patients (aged 65 years and older with COPD)	○		
		Yazar EE, et al. (2018) [9]	91 patients with COPD	○		CDT
	Financial management (Monetary Control)	Feng L, et al. (2012) [37]	2450 (elderly subjects including patient with COPD)	○		Digit Span Spatial Span Verbal Learning Test Design Fluency Symbol Digit Modality Test
		Antonelli-Incalzi R, et al. (2007) [36]	149 patients with COPD	○		MDB
	Driving and community mobility	Pretto JJ, et al. (2008) [33]	30 patients (patients with COPD who have a driver's licence)			Driving Simulator PVT
		Prior TS, et al. (2015) [34]	32 subjects (including COPD, ILD, and healthy subjects)			Driving Simulator
		Orth M, et al. (2008) [14]	27 patients (patients with COPD: healthy = 17 patients: 10 subjects)			Driving Simulator
		Karakontaki F, et al. (2013) [35]	45 patients (patients with COPD: healthy = 35 patients: 10 subjectts)			Driving Simulator ※2
Work	Job performance/ Volunteer participation	Greenlund KJ, et al. (2016) [38]	105332 patients (patients with COPD: healthy = 10476 patients: 94856 subjects)			BRFSS

ILD: Interstitial lung disease, MMSE: Mini Mental State Examination, MoCA: Montreal Cognitive Assessment, GDS-15: Geriatric depression scale 15, MMAS-4: Morisky Medication Adherence Scales 4, CDT: Clock Drawing Test, MDB: Mental Deterioration Battery, PVT: Psychomotor vigilance task, BRFSS: Behavioral Risk Factor Surveillance System

※1: Raven's progressive matrices, Verbal fluency, Visual span, Verbal span, Verbal memory, Albert's test, Copying drawings, Copying drawing with landmarks, Immediate visual memory, Sentence construction.

※2: Viennese test system-based attention/alert test; selective attention test; sustained attention test; response times to acoustic stimuli; visual perceptual assessment.

comprehensive assessment of ADL abilities were used in all articles. Therefore, it has not been investigated how cognitive impairments in patients with COPD affect individual ADLs (e.g., clothing and bathing). The results suggest that assessment of each ADL activity remains a challenge. Moreover, as regards the reason why each individual ADL has not been examined, it could be considered that patients with minor ADL disabilities conspicuously lower their physical function, which might have masked their mild cognitive impairment. Since disability limitations are usually a major factor in ADL disability in patients with COPD, it is assumed that the association between ADL and cognitive impairment is less explored. However, given the indications of an association between ADL and cognitive impairment that emerged from this study, it is not unlikely that not only physical dysfunctions but also cognitive impairments affect disabilities in ADL in patients with COPD. Therefore, it could be necessary to comprehensively examine how cognitive impairment affects ADL disabilities.

2) IADL: Medication administration

This study found that many articles have examined the association between medication management and cognitive impairment in patients with COPD. Among all articles examined in this study, articles on IADL (adherence to medication and inhaler use, monetary and medication management) accounted for 59.1% of the total, which was the highest rate. Two possible reasons can explain why many studies have examined medication management. First, cognitive impairment can easily affect inhaler use because the process is complicated; thus, guidance and practice are needed for proper use of inhalers. Second, long-term medication management in COPD is important; pharmacists have evaluated competence, adherence, and compliance of patients to instruction at hospitals; thus, it may be easy to analyze the problem of inhaler use and management. For patients with chronic disease, medication management should be an important ADL. Considering the effect of cognitive impairment on medication management, occupational therapists should participate in the evaluation and intervention on inhaler use and medication management.

3) IADL: driving a car

Three articles investigated driving skills in patients with COPD using driving simulators and found a reduction in their driving performance. Although driving simulators have been validated for the assessment of driving performance, assessment by driving simulator alone may be unable to identify individual cognitive impairment such as working memory and attention. Unique cognitive impairment in patients with COPD is related to frontal lobe hypofunctions such as attention and working memory [8]. A possibility of diminished driving performance in patients with COPD could be considered because drivers use more frontal lobe functions such as attention and judgment. In addition, on the grounds that patients with COPD have reduced walking capacity and walking endurance, being able to drive could be crucial as a compensation for outside mobility. Moreover, driving is often utilized routinely, such as when shopping and hospital visits. Given these points, further studies incorporating cognitive tests are necessary to further clarify the relationship between cognitive function and driving in patients with COPD.

4) Summary of this review

The results of the analysis of the relationship between cognitive impairment and occupations in patients with COPD revealed that relatively many studies have focused on inhaler use and medication management, whereas only a few studies have investigated ADL and driving. Since these occupations are critical for patients with COPD, more studies on these topics are warranted in the future.

Limitations of this study

This scoping review included articles whose topics fall on the "occupation" domain. Therefore, several articles that did not focus on occupation were excluded. However, it could be important to focus on two studies to improve occupational therapy. First, Tomruk et al. [19] reported an association between finger dexterity and cognitive impairment in patients with COPD. Finger dexterity may affect various occupations, and relation between cognitive decline and finger function should also be focused on in occupational therapy in the future. Second, a study examined an association between cognitive function and appropriate use of spirometry [20]. This study suggested that a decreased MMSE score was correlated with inappropriate use of spirometry. Thus, awareness of the potential effect of COPD-related cognitive impairment is important, even in topics that do not fall within the occupation domain, as the topic may be medically significant, for example, physical functioning indirectly affect occupations. Although not addressed in the review, further studies on these topics are needed to better clarify the effect of cognitive impairment on patients with COPD.

As other limitations, this study focused on summarizing only reliable peer-reviewed articles and determining a research area where further studies will be needed. Therefore, the study did not include various literature materials such as gray literature, past review articles,

and papers reporting non-significant results between cognitive impairment and occupation. Furthermore, one of the limitations of this study is that there have been still few studies focusing on cognitive impairment with COPD, because the main factor in problems of occupations in patients with COPD is motor dysfunction. Especially in severe cases who have disabilities, it may have been less explored in the past, especially because the limitation of motor impairment may be more limiting of ADL than cognitive function. As the results, few studies which focused on relation between cognitive decline and ADL may have been reported. From these things, it was not possible to include more detailed and broad content materials on the relationship between cognitive impairment and occupation. Examining associations of cognitive function on specific occupations in individual cases will contribute to the improvement of occupational therapy for patients with COPD.

Conclusion

In this study, we conducted a scoping review of peer-reviewed articles published between 2001 and 2020 to comprehensively examine what occupations were associated with cognitive impairment in patients with COPD and to summarize the findings. The results of this study revealed that cognitive impairment in patients with COPD was related to ADL, IADL (such as inhaler use, medication management, and driving a car), and work. In addition, the current review revealed a scarcity on research in areas such as ADL and car driving. Thus, further studies are needed because these occupations are crucial for patients with COPD.

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■ORIGINAL ARTICLE

Learning Effects of Multiple Driving Simulator Runs in Older Adults

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Abstract: Driving simulators (DS) have been used in medical institutions to evaluate a participant's driving abilities. Despite the empirical fact that the learning effects of multiple DS runs have been observed in clinical practice, few studies have examined the learning effects. The learning effects of multiple DS runs were examined among 25 older adults and 27 young participants. The participants drove the same course thrice without receiving any advice on the operation. The older adults had significantly more accidents than the young ($p < 0.05$) in all the trials. The number of accidents was significantly higher ($p < 0.05$) among older adults in the first trial than in the second. No significant difference was observed in the number of accidents between the second and third trials ($p = 0.94$). No significant difference in the number of accidents was found among all trials in the younger age groups. Among the different types of accidents noted, "Rear-end collisions due to inadequate deceleration" were observed more frequently among the older adults. "Collisions with a wall or vehicle due to improper maneuvering when turning right or left" were observed more frequently among young drivers. The results suggest that, the older adults may reveal their true driving abilities after at least three trials in the course used in this study. Furthermore, the results suggest that the quality of accidents differ between the older adults and the young.

Keywords: older drivers, driving simulator, learning effect

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Introduction

Mobility support is one of the important roles of occupational therapists. Among the various means of transportation, driving a car greatly affects quality of life [1]. Recently, driving simulators (DS) have been used in medical institutions to evaluate a participant's driving abilities. DS can easily evaluate safe driving performance, such as maneuvering a car (operating the steering wheel, gas pedal, and brakes), hazard prediction, and compliance with laws and regulations. Although previous studies have found that DS can predict accidents and on-road driving performance [2–5], the findings are contradictory [6–7]. Possible reasons for these contradictory findings include differences in the attributes of the participants, type of DS used, indicators of on-road driving performance, and amount of prior practice. Despite the empirical fact that the learning effects of multiple DS runs have been observed in clinical practice, few studies have examined the learning effects.

To the best of our knowledge, only Kawano et al. (2012) [8] reported that habituation occurs during the third execution of a given course. However, the qualitative characteristics of driving performance on a DS were not analyzed by the authors. Additionally, the DS used in their study differed from those frequently used in Japanese medical institutions. Therefore, in this study, we quantitatively and qualitatively examined the effects of multiple DS sessions on the performance of participants using the DS that is frequently used by occupational therapists in Japan.

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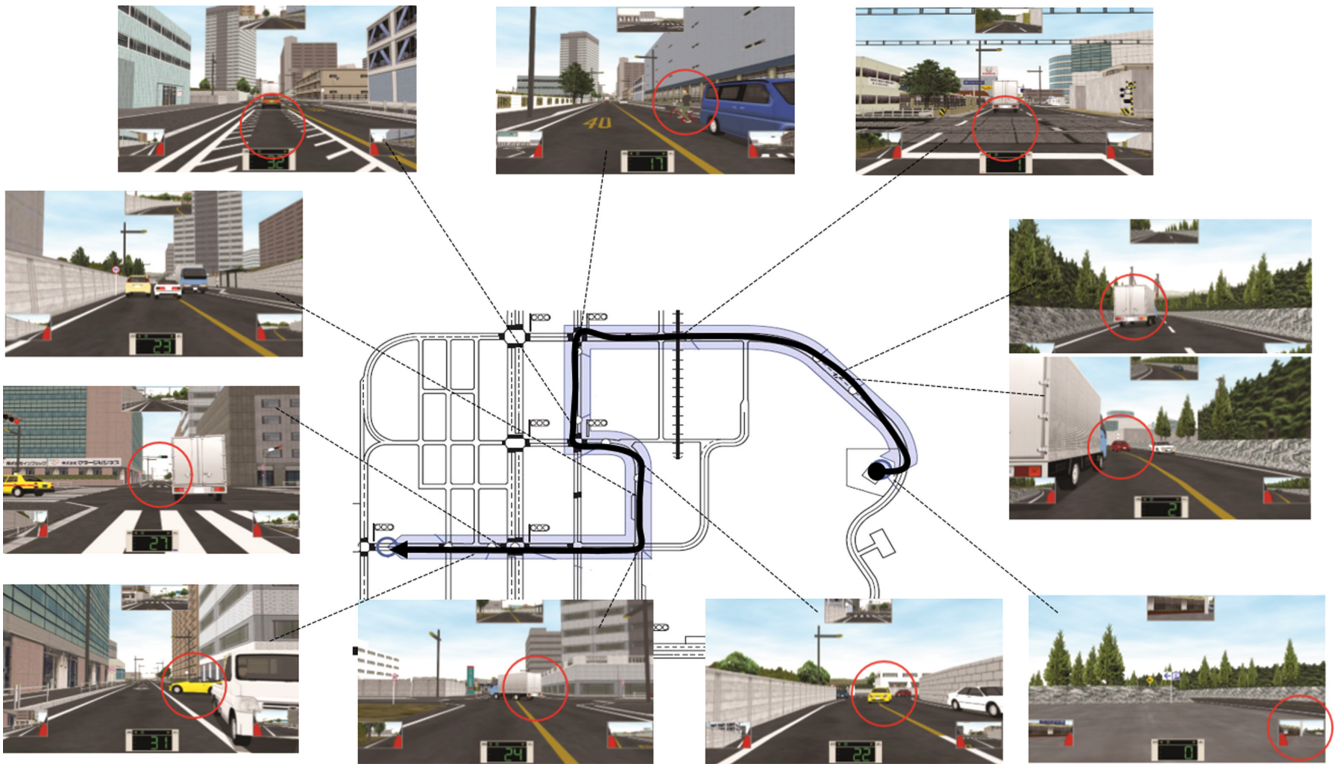

Fig. 1. Outline of the course. Edited by authors from [9].

Methods

Participants

Consent to participate in the study was obtained from 43 older adults with valid driver's licenses. Participants were recruited from community health promotion classes, public lectures, and the Silver Human Resource Center through oral and poster presentations. Of these, 18 participants who could not complete the scheduled number of DS trials (three trials) because of DS sickness were excluded (16 participants stopped after the first trial, while the other two stopped after the second trial) (DS sickness rate: 41.9%). Ultimately, 25 participants were included in the analysis. The mean age of the participants was 75.0 ± 6.0 years (range, 65–89 years; median, 74 years), and 20 were men. The mean score of mini-mental state examination (MMSE) was 27.5 ± 2.0 points (range, 23–30 points; median, 27 points). Additionally, 21 participants had valid licenses for more than 40 years, whereas the other four drivers had been driving for 20–30 years. Twenty-one participants drove daily, and the remaining four drove 3–5 days per week.

The comparison group consisted of 27 young adults with valid driver's licenses. A total of 57 second- and third-year university students were recruited to participate in the study, and 27 of them cooperated and consented to participate in the study. The mean age of the these participants was 20.3 ± 0.7 years (range, 19–21 years; median, 20 years), and eight were men. All participants had obtained their driver's licenses less than two years ago and drove only a few times a year. Additionally, none of the participants had any prior DS experience.

DS

The DS used in this study was Honda Safety Navi® (HONDA GIKEN, Japan). The course used was the KIKEN YOSOKU TAIKEN Course 6 (intermediate level, daytime, estimated distance of 1.2 km, and estimated driving time of 3 min). The course with the shortest driving time was selected taking into consideration the endurance of the older participants. The course content included entering the roadway from a parking lot; driving downhill, including straight lines and curves; overtaking stopped vehicles (with oncoming traffic); railroad crossing; sudden appearance of a bicycle from behind the car when turning left; turning left on a narrow road; dealing with oncoming traffic on a narrow road; and continuing straight after taking a right turn (with approaching vehicles and road crossers) (Fig. 1) [9].

Procedure

Prior to starting the session, the participants were told that if they felt sick, they could alleviate the symptoms by taking their eyes off the screen or taking a deep

breath, and that if they judged that it was difficult to continue, they could immediately stop the DS by reporting it. The DS included a fan blowing air from the left side and rear. After explaining about the steering wheel, accelerator, brake, blinkers, and how to read the screen (side and rearview mirrors and speedometer), the participants were given the following instructions, "We will not provide any advice in case of any accidents while operating the DS. Please familiarize yourselves with the operations. We plan to conduct the trial three times with a break of approximately 15 min. If you feel sick, please let us know and we will stop." Subsequently, a DS session was initiated.

Analysis

The number of accidents automatically measured by the DS was used as an indicator of the repeated learning effect. Inter-trial and intergroup comparisons included the number of accidents. Normality and equal variance for the number of accidents could not be confirmed; therefore, the Friedman test was used for comparisons between trials, and the Scheffé's method was used for multiple comparison methods. The Mann-Whitney U test was used for intergroup comparisons. The significance level was set at 5%. The effect size (r) was calculated for the amount of effect.

Results

The number of accidents in the older participants was 42, 17, and 15 in the three trials, respectively. The number of accidents in younger participants was 17, 6, and 5 in the three trials, respectively. The Friedman test revealed a significant difference in the number of accidents between trials between the groups (older participants: $X^2(2) = 19.1$, $p < 0.001$; younger participants: $X^2(2) = 6.0$, $p < 0.05$). Scheffé's method revealed that older participants had fewer accidents in the 2nd or 3rd trials than in the 1st trial (1st vs. 2nd trial: $X^2(2) = 12.9$, $p < 0.01$, r = 0.61; 1st vs. 3rd trial: $X^2(2) = 15.6$, $p < 0.01$, r = 0.67; 2nd vs. 3rd trial: $X^2(2) = 0.13$, $p = 0.94$, r = 0.11). Younger participants performance did not differ significantly between the trials. However, a moderate difference effect was observed between the 1st and 2nd trials and between the 1st and 3rd trials (1st vs. 2nd trial: $X^2(2) = 4.30$, $p = 0.12$, r = 0.38; 1st vs. 3rd trial: $X^2(2) = 4.76$, $p = 0.09$, r = 0.41; 2nd vs. 3rd: $X^2(2) = 0.01$, $p = 0.9$, r = 0.05). The Mann-Whitney U test revealed that older drivers had more accidents than younger participants in all trials (1st trial: $Z = 2.89$, $p < 0.01$, r = 0.56; 2nd trial: $Z = 2.93$, $p < 0.01$, r = 0.57; 3rd trial: $Z = 2.37$, $p < 0.05$, r = 0.46) (Fig. 2).

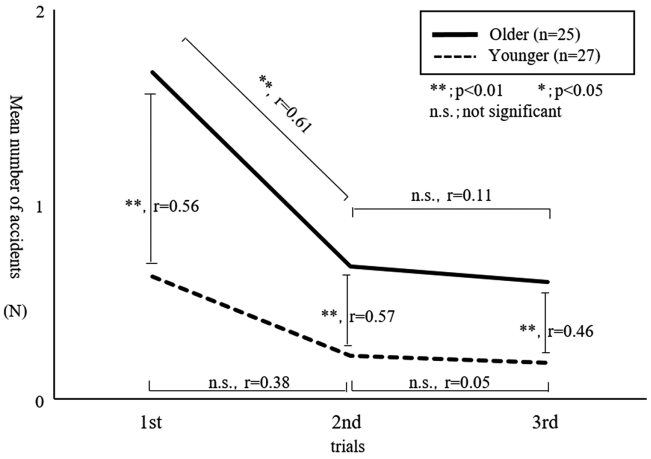

Fig. 2. The mean number of accidents

Regarding the qualitative parameters of the accidents, over 90% of the accidents in older participants group were observed in the first half of the course (between the starting point and railroad crossing), whereas most of the accidents in younger participants group occurred in the second half of the course. The ratio of the number of accidents in the first half of the course to the total number of accidents in the three trials were 97.6%, 94.1%, and 100%, respectively, in the older participants, and 52.9%, 50.0%, and 20.0%, respectively, in the younger participants (Fig. 3–5).

Overall, 102 accidents were noted and these were classified into the following four categories: (1) collision with a wall or vehicle owing to improper maneuvering when driving straight or turning, (2) collision with a wall or vehicle owing to improper maneuvering when turning right or left, (3) rear-end collisions owing to inadequate deceleration, and (4) rear-end collisions owing to improper entry into the road. Irrespective of the number of trials, older participants were most commonly involved in type 3 and rarely in type 2 collisions. In contrast, type 2 accidents were observed most frequently in younger participants, whereas type 3 accidents were rare. Type 4 accidents were observed in a certain number of older participants irrespective of the trial, whereas they decreased in younger participants in each successive trial (Fig. 6).

Discussion

This study is the first reports that show the learning effects of multiple driving simulator runs in older drivers using Honda Safety Navi® which is the most frequently used in Japanese medical institutions. The number of accidents decreased with successive trials for both the older and younger participants. In this study, a repeated learning effect was expected in the third trial. Kawano

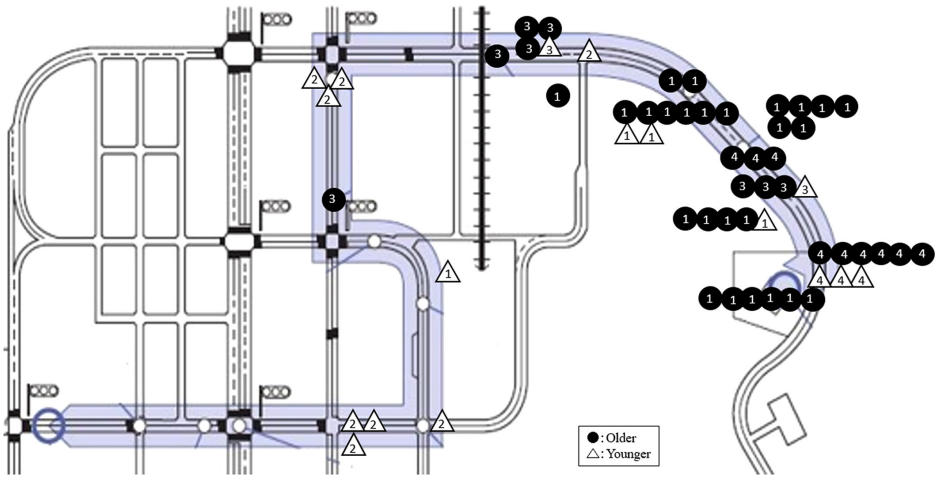

Fig. 3. Accidents observed in the 1st trial. Categories of accidents; 1; collision with a wall or vehicle owing to improper maneuvering when driving straight or turning, 2; collision with a wall or vehicle owing to improper maneuvering when turning right or left, 3; rear-end collisions owing to inadequate deceleration, and 4; rear-end collisions owing to improper entry into the road.

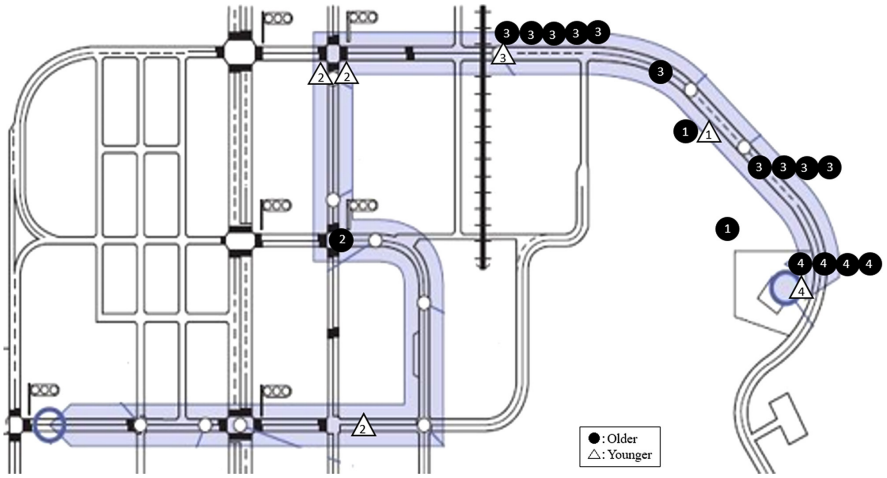

Fig. 4. Accidents in the 2nd trial.

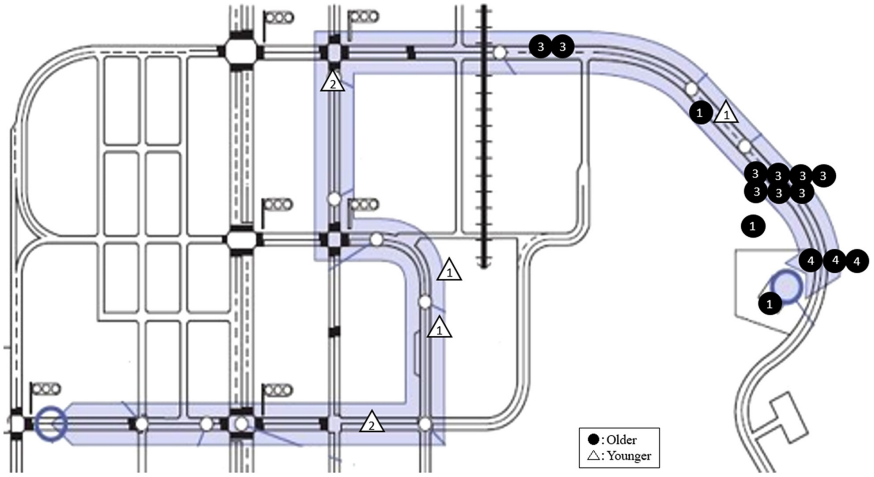

Fig. 5. Accidents in the 3rd trial.

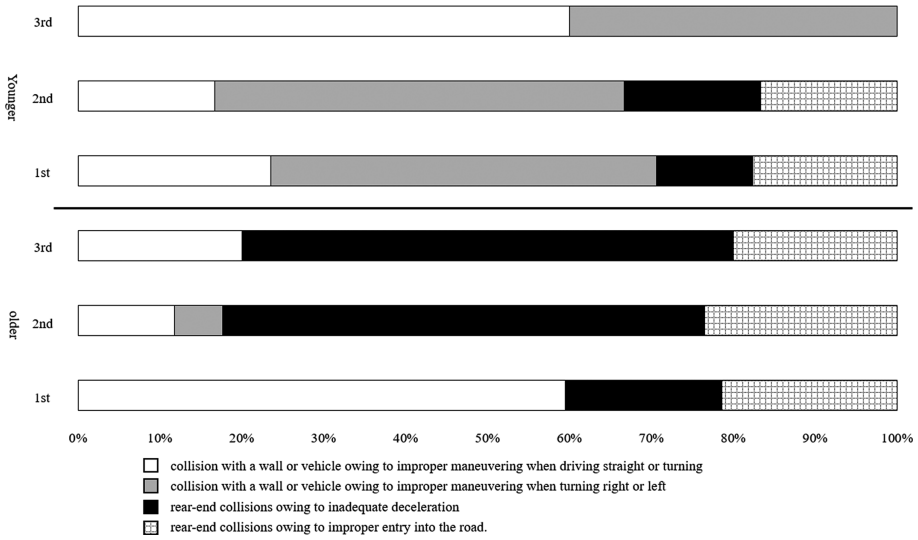

Fig. 6. The proportion of accidents across trials.

et al. (2012) [8] examined the effects of repeated sessions of DS on maintenance of speed (100 km/h) and lane position, and reported that older drivers become accustomed by the 4th trial. Despite differences in the experimental procedures, their results were similar to those of the present study.

DS is a visuomotor learning task that involves several brain regions, including the cerebellum, visual cortex, motor cortex, parietal lobe, hippocampus, and cingulate gyrus [10]. The refinements in this DS-related neural network are influenced by individual functional and age differences; older drivers take longer than younger drivers. Therefore, the possibility cannot be ruled out that a participant's performance may improve, albeit slightly, after the fourth trial in the DS course used in this study. Unsafe driving performance in the initial DS trials may be the result of a combination of both unfamiliarity with the DS operation and the participants actual driving ability. However, it is expected that after multiple trials (e.g., the fourth trial), the unfamiliarity component will decrease and the performance will more likely reflect the participants actual driving ability.

Two results were apparent in the analysis of the accident characteristics. First, accidents in older participants were predominant in the first half of the course (especially type 3 accidents were common in the 2nd and 3rd third trials), whereas accidents in younger participants (especially type 2 accidents) were predominant in the second half of the course (between the railroad crossing and the finish line). The first half of the course was characterized by driving downhill, adjusting the speed, dealing with stopped vehicles and oncoming traffic, and driving around curves in an unfamiliar DS environment. Older participants may have responded to the high cognitive load of operating the DS against the rapidly changing screen from the 2nd trial using inadequate deceleration [11]. By contrast, younger participants may have judged that they could cope with rapid changes on the screen without slowing down, although their DS operations were poor. This speculation is consistent with the finding that information processing speed decreases with age [12]; however, an in-depth analysis of the relationship between speeding locations and accidents is required. As in the first half of the course, in the second half the driver was required to deal with stopped vehicles and oncoming traffic, and to make multiple right and left turns on a flat road without curves. A sensory understanding of the steering wheel rotation angle and the left-right turn angle of the vehicle body depends on the driving experience; consequently, several accidents may have been observed in younger participants with less driving experience. In contrast, the older participants, even in an unfamiliar DS environment, were able to turn right and left without collisions at moderate speeds based on their previous experiences.

The second important accident characteristic was that a certain number of rear-end collisions due to improper entry into the road were observed in older participants, irrespective of the number of trials. Such accidents were not observed in the 3rd trial among the younger participants. In terms of traffic accident statistics, both novice and experienced drivers experienced the highest number of accidents due to unsafe driving, and the ratio of unsafe driving to all violations that led to traffic accidents was higher among experienced drivers [13]. Although the relevance of the results of this study is a matter of speculation, it is interesting to note that there were differences between the groups in acci-

dents related to safe driving awareness when entering the road. In the future, it will be necessary to measure and verify rearview-checking during DS sessions.

Limitations

This study has several limitations. First, the causes of accidents remain unclear. It is not clear whether the accidents were caused by unfamiliarity with the movements of the car on the screen in response to the DS-specific steering wheel and brake operations or by a lack of safety awareness, such as insufficient rear-checking when starting, or whether they were the result of the interaction of the two. The background factors of the repeated learning effect should continue to be analyzed by increasing the amount of data, including changes in the experimental methods, such as increasing the number of repetitions to four or more. Second, because the sample size was small and the age range of the older participants was large, the possibility cannot be ruled out that the number of repetitions until habituation may have differed between individuals of 65–74, 75–80, and ≥ 80 years of age. Third, it should be noted that the present findings are limited to HONDA Safety Navi®, KIKEN YOSOKU TAIKEN Course 6 (intermediate, daytime).

Ethical consideration

All participants gave their informed consent to participate in this study. Experimental procedures followed the ethical standards of the Declaration of Helsinki. This study was approved by the Research Ethics Committee of Hokkaido Chitose College of Rehabilitation (Approval No. 18008).

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Conflict of interest

The authors declared no potential conflicts of interest with respect to the research, and/or publication of this article.

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■ORIGINAL ARTICLE

Comparison of Stroke Patients' Motor Performance in the Dual Task Stepping Test Immediately after and Up to 15 Seconds after Cognitive Task Loading

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Abstract: Objective: This study identifies differences in the motor performance immediately after and 15 s after cognitive task loading during the dual task stepping test in patients who experienced a stroke.
Methods: Twenty-seven patients who experienced a stroke were included in the study. The paralyzed lower limb elevation was measured during the dual task stepping test. The task was performed for 30 s, with measurement time periods of 5 s immediately after starting the single task, 5 s immediately after cognitive task loading, and 5 s beginning 10 s after cognitive task loading. The mean lower limb elevation during each time period was determined. The amount of paralyzed lower limb elevation during each time period was compared, and correlations between the amount of change in each time period and assessment scores were examined. The relationships between the patients' walking abilities and the amounts of change during each time period were also analyzed.
Results: The amount of lower limb elevation decreased after cognitive task loading ($p < 0.01$). The change in lower limb elevation from the motor task to after cognitive task loading was negatively correlated with the attention rating scale score (rs = −0.40, $p = 0.04$). Patients who could walk independently had a significantly lower change in lower limb elevation immediately after cognitive task loading than patients who required walking supervision ($p < 0.01$).
Conclusion: Additional specific dual training assessments and their applications to dual task training must be investigated in future studies.

Keywords: stroke, dual task, evaluation, motor performance

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Introduction

Daily life involves a series of dual task movements, including walking while thinking or working while talking. These situations demand safe and precise motor performances. Dual tasks, in which motor and cognitive tasks are performed simultaneously, are widely used in rehabilitation to predict the risk of falling and to determine the degree of movement independence. Evaluation of the dual tasks is important for occupational therapists who help patients lead meaningful and safe lives. It has been reported that patients with brain injuries have a decreased ability to perform dual tasks [1, 2]. Therefore, the movement independence of these patients must be evaluated using dual task assessments, and these patients must undergo dual task training.

The Stop Walking When Talking Test developed by Olsson et al. [3], Timed Up and Go Test with an added cognitive task [4], and Trail Walking Test [5], in which participants walk a course of 15 randomly placed landmarks in order, are dual task assessments that have been reported to be clinically significant. Other assessment methods combine various motor and cognitive tasks [6–8]. The dual task stepping test, in which a cognitive task is performed while stepping in a sitting posture, was found to be correlated with the patients' abilities to perform activities of daily living (ADLs) [9]. This assessment can be performed easily and safely in 30 s and does not require special equipment. The risk of fall-

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Table 1 Patient characteristics and assessment results.

Patient characteristics	Age (years)	−	65.6 ± 11.8
	Sex	Male/Female	16/11
	Duration from stroke onset (days)	−	41.9 ± 35.6
	Diagnosis	Cerebral infarction	18
		Cerebral hemorrhage	9
	Disability	Right hemiplegia	12
		Left hemiplegia	9
		No paralysis	6
Assessment results	BBS (points)	−	48.1 ± 7.3
	Lower limb Br. stage	IV	3
		V	5
		VI	13
		No paralysis	6
	MMSE (points)	−	27.8 ± 2.6
	Attention rating scale (points)	−	4.6 ± 6.6
	Walking ability	Independent/Supervised	14/13
	FIM motor item total (points)	−	81 (71−88)
	FIM cognitive item total (points)	−	32 (27.5−35)

Data are shown as mean ± standard deviation or median (range).
Abbreviations: Berg Balance Scale; MMSE: Mini-Mental State Examination; FIM: Functional Independence Measure.

ing during the assessment is minimal, leading to a high safety level. The task's intra- and inter-rater reliability have also been confirmed, including for therapists with limited clinical experience [10], indicating that this assessment can be applied widely in clinical practice.

Traditional dual task assessment methods compare a patient's performance of a single motor task to the patient's performance of a dual task that includes a cognitive task. However, differences in the changes in performance immediately after the cognitive task and over time have not been examined. In clinical practice, some patients lose their balance immediately after being spoken to while walking, while others do so after a period of walking while talking. These phenomena are presumably caused by the interference of the cognitive task, which prevents brains with limited processing resources from adequately covering the load of the dual task. Understanding which of these phenomena occur in patients with stroke is important.

The accuracy of dual task assessment methods may be improved by measuring the patient's motor performance immediately after the cognitive task is added to the motor task and after a certain period of time has elapsed since the performance of the cognitive task. It is also important to consider these changes in motor performance when occupational therapists provide dual task training programs to patients to prevent falls.

This study examines the differences in the motor performance of patients who have experienced a stroke during the dual task stepping test immediately after cognitive task loading and up to 15 s after cognitive task loading.

Methods

Patients

Of 128 patients with stroke admitted to Hospital A's recovery and rehabilitation ward between January and December 2017, 27 met the study's inclusion criteria (Table 1). Patients who had experienced stroke between 2 weeks and 6 months at the time of the dual task assessment with no history of brain injuries were included in the study. All patients included in the study performed their ADLs independently prior to the stroke, were able to step by raising the lower limbs to a constant height for 30 s while sitting on the edge of a chair, were able to walk with supervision or independently, could follow simple verbal instructions, had no pain that affected the assessment results, and had not been instructed by a physician to limit their movement. The study was fully explained to the patients, who each provided informed consent prior to their participation in the study. Patients who did not meet the inclusion criteria and those who did not provide consent were excluded from the study. This study was approved by the appropriate ethics committee (approval number: 366) and was conducted following the principles of the Declaration of Helsinki.

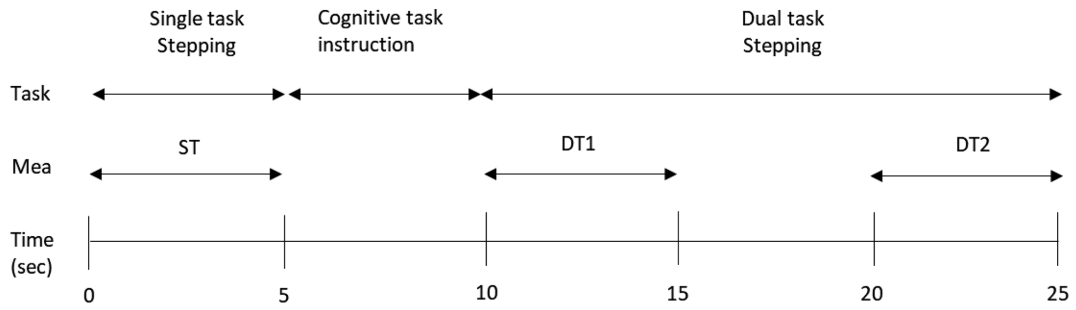

Fig. 1. Sections for measuring the lower limb elevation.

Study procedure

A video camera was used to record the patients during the dual task stepping test. The dual task stepping test was conducted by the patient responding to a cognitive task while stepping in a seated position and evaluated the patient's stepping performance. The procedure for the dual task stepping test was the same as that performed in a previous study [9], which has been shown to be reliable and valid. The assessment began with the patient sitting on a chair 40 cm from the ground. The examiner sat 3 m in front of the patient and instructed the patient to take alternating steps for 30 s at a comfortable speed, a consistent height, and a consistent pace. The patients were shown an example and practiced stepping for 30 s. Then, the examiner instructed the patient to continue stepping while they answered a question. Five seconds after the patient began stepping, the examiner asked, "What did you eat for breakfast today?" The examiner did not make any further statements and evaluated the patient's motor performance. Patients who could not maintain a constant lower limb elevation height during the single task owing to muscle fatigue or attention problems were excluded from the assessment.

To examine the change in motor performance immediately after the cognitive task loading and later, the distance the paralyzed lower limb was raised was measured during different time periods. The distance of vertical movement was measured using the height of the superior border of the patella. The measurements were obtained using three-dimensional motion analysis software (Dipp Motion V, version 1.2.6; DeTect, Inc., Panama City, FL, USA). Markers were placed on the superior border of the patella on the paralyzed lower limb to quantify the distance the knee was raised during each time period. The height of the superior border of the patella was measured for 5 s after the single task was initiated (the ST time period), for 5 s after cognitive task loading (DT1 time period), and for 5 s beginning at 10 s after cognitive task loading (DT2 time period) (Fig. 1). The mean vertical distance traveled by the marker during each time period was analyzed.

Patient age, sex, health course since the stroke, diagnosis, and disabilities were obtained from the medical records. The Berg Balance Scale (BBS) [11], a useful balance assessment; Mini-Mental State Examination (MMSE) [12], a cognitive function assessment; Motor-Functional Independence Measure (MFD) [13], an attention function assessment; and Motor-Functional Independence Measure (M-FIM) and Cognitive Functional Independence Measure (C-FIM), which assess ADL, were conducted within two days of the dual task stepping test.

Analytical methods

Comparison of lower limb elevation heights during each time period

The distances that the paralyzed lower limb was elevated during the ST, DT1, and DT2 time periods were compared.

Correlations of changes in lower limb elevation during each time period with patients' characteristics and assessment scores

Changes in paralyzed lower limb elevation between the ST and DT1 time periods are expressed as ΔST/DT1 (ST/DT1), those between the DT1 and DT2 time periods are expressed as ΔDT1/DT2 (DT1/DT2), and those between the ST and DT2 time periods are expressed as ΔST/DT2 (ST/DT2). The correlations of each change and patient age, days since the stroke, BBS score, MMSE score, attention rating scale score, M-FIM score, and C-FIM score were determined.

Comparison of changes in lower limb elevation during each time period, patient characteristics, and assessment scores between patients with different walking abilities

The patients were divided into the independent-walking and supervised-walking groups based on their abilities. Patients who scored ≥ 6 on a FIM motor item (walking) were included in the independent walking group. Those who scored ≤ 5 were included in the supervised-walking group. The ΔST/DT1 (ST/DT1), ΔDT1/DT2 (DT1/DT2), ΔST/DT2 (ST/DT2), age, sex, days since the stroke, diagnosis, disability, BBS score, MMSE score, attention rating scale score, M-FIM score, and C-FIM score were compared between the groups.

Statistical analysis

Continuous variables are expressed as mean and standard deviation, and categorical variables are expressed as number and frequency. Spearman's rank correlation coefficient was used to examine the correlations between the variables. The Mann–Whitney U test and Fisher's exact test were used to compare the groups. The Kruskal–Wallis and Steel–Dwass tests were used for multiple comparisons. All analyses were conducted using JMP Pro statistical software (version 16; SAS Institute Inc., Cary, NC, USA). Statistical significance was set at $p < 0.05$.

Results

Comparison of lower limb elevation during each time period

The mean number of steps during each time period were 5.1 ± 1.8, 5.0 ± 2.2, and 5.1 ± 2.5 in the ST, DT1, and DT2 time periods, respectively. The mean heights during the ST, DT1, and DT2 time periods were 7.6 ± 3.4, 6.5 ± 3.2, and 6.0 ± 3.1 cm ($p < 0.01$), respectively (Fig. 2). The lower limb elevation decreased as time passed after the cognitive task loading ($p < 0.01$).

Correlations of changes in lower limb elevation during each time period with patients' characteristics and assessment scores

ΔST/DT1 (ST/DT1) was negatively correlated with the attention rating scale score (rs = −0.40, $p = 0.04$) (Table 2); patients with lower attention scores had a higher percentage of reduced lower limb elevation immediately after the cognitive task loading. ΔDT1/DT2 (DT1/DT2) and ΔST/DT2 (ST/DT2) were not correlated with patient characteristics or assessment scores.

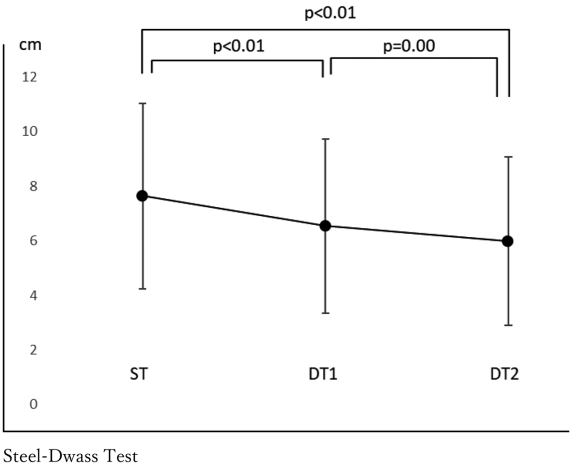

Fig. 2. Comparison of lower limb elevation in each section.

Comparison of walking ability with changes in lower limb elevation during each time period, patient characteristics, and assessment scores

The independent walking group included 14 patients, and the supervised-walking group included 13 patients. The BBS scores ($p < 0.01$), MMSE scores ($p = 0.02$), and attention rating scale scores ($p < 0.01$) were significantly different between the groups (Table 3). Patients in the supervised-walking group had a significantly greater ΔST/DT1 (ST/DT1) than those in the independent-walking group ($p < 0.01$).

Discussion

In this study, the motor performance of patients who had experienced a stroke declined immediately after cognitive task loading and declined even more beginning 10 s after cognitive task loading during the dual task stepping test. Woollacott et al. [14] reported that, in general, older adults tend to prioritize cognitive tasks in dual task environments and that the motor performance of older adults is affected by secondary tasks. Immediately after cognitive task loading, the patients' attention was prioritized to the cognitive task, resulting in a decline in motor performance. Patients with lower attention rating scale scores had a lower motor performance immediately after cognitive task loading, suggesting the involvement of attention functions, especially the ability to instantaneously and appropriately allocate attention to the motor and cognitive tasks. The results of this study emphasize the importance of assessing the motor task and dual task abilities of patients with impaired attention after a stroke to determine their movement independence.

Although the patients' motor performance declined further as time passed compared to immediately after

Table 2 Correlations of change in lower limb elevation during each time period with patient characteristics and assessment results.

		ΔST · DT1		ΔDT1 · DT2		ΔST · DT2	
		Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
Patient characteristics	Age	−0.09	0.65	0.11	0.60	−0.06	0.75
	Duration from onset	0.17	0.39	0.19	0.36	0.11	0.42
Assessment results	BBS	0.27	0.18	−0.11	0.57	0.17	0.40
	MMSE	0.31	0.11	−0.12	0.55	0.28	0.15
	Attention rating scale	−0.40	0.04*	0.06	0.77	−0.38	0.05
	M-FIM	0.30	0.13	−0.05	0.81	0.26	0.19
	C-FIM	0.22	0.28	−0.10	0.62	0.21	0.29

Abbreviations: ST: 1–5 s from starting evaluation of the single task; DT1: 10–15 s immediately after cognitive task loading; DT2: 20–25 s after cognitive task loading; ΔST · DT1: change in ST and DT1 (ST/DT1); Spearman's rank correlation coefficient; ΔDT1 · DT2: change in DT1 and DT2 (DT1/DT2); ΔST · DT2: change in ST and DT2 (ST/DT2); BBS: Berg Balance Scale; MMSE: Mini-Mental State Examination; M-FIM: Motor-Functional Independence Measure; C-FIM: Cognitive- Functional Independence Measure.

Table 3 Comparison of changes in lower limb elevation during each time period, patient characteristics, and assessment results based on walking ability.

		Independent walking group N = 14	Supervised walking group N = 13	*p*-value	Effect size
Change in lower limb elevation (cm)	ΔST · DT1	1.01 ± 0.35	0.69 ± 0.33	< 0.01*	0.26
	ΔDT1 · DT2	0.89 ± 0.11	1.11 ± 0.81	0.42	0.08
	ΔST · DT1	0.91 ± 0.36	0.64 ± 0.36	0.10	0.10
Patient characteristics	Age (years)	61.9 ± 12.0	69.7 ± 10.5	0.09	0.17
	Male/Female	10/4	6/7	0.25	0.13
	Duration from stroke onset (days)	39.3 ± 39.3	49.2 ± 31.1	0.21	0.09
	Cerebral infarction/ cerebral hemorrhage	11/3	8/5	0.41	0.09
	Right hemiplegia/left hemiplegia/ no paralysis	7/4/3	5/5/3	0.88	0.08
Assessment results	BBS (points)	51.6 ± 4.8	44.3 ± 7.1	< 0.01*	0.26
	Lower limb Br. stage IV/V/VI/no paralysis	0/8/3/3	3/2/5/3	0.07	0.22
	MMSE (points)	28.9 ± 1.6	26.6 ± 2.9	0.02*	0.18
	Attention rating scale (points)	1.6 ± 2.6	7.9 ± 8.1	< 0.01*	0.27
	M-FIM (points)	83.1 ± 7.7	73.3 ± 13.2	0.06	0.20
	C-FIM (points)	31.8 ± 4.6	29.9 ± 5.9	0.31	0.10

Mann–Whitney U test, Fisher's exact test

Abbreviations: ST: 1–5 s from starting evaluation of the single task; DT1: 10–15 s immediately after cognitive task loading; DT2: 20–25 s after cognitive task loading; ΔST · DT1: change in ST and DT1 (ST/DT1); Spearman's rank correlation coefficient; ΔDT1 · DT2: change in DT1 and DT2 (DT1/DT2); ΔST · DT2: change in ST and DT2 (ST/DT2); BBS: Berg Balance Scale; MMSE: Mini-Mental State Examination; M-FIM: Motor-Functional Independence Measure; C-FIM: Cognitive-Functional Independence Measure.

cognitive task loading, the amount of change was not correlated with patient characteristics or assessment scores, suggesting that the patients' performances declined over time due to a combination of factors or highly individualized problems. Various cognitive tasks have been used during dual task training in patients after a stroke, including serial mental arithmetic tasks [15, 16], auditory Stroop tasks [17], and visual tasks [18]. The serial mental arithmetic tasks are characterized by the sustained loading of a single cognitive task, while the auditory Stroop tasks and responses to visual stimuli are characterized by the repeated loading of new cognitive tasks. During dual task training, the cognitive task should be selected based on the reason the patient performs poorly in dual task assessments.

When evaluating a patient's walking independence, the risk of falling must be considered. Patients who have experienced a stroke have a higher risk of falling than healthy elderly people due to physical and cognitive function difficulties [19]. Falls during hospital stays

are more likely to occur when a new task is added, such as having the patient change direction or pick up objects, compared to when walking straight [20, 21]. In the current study, patients in the supervised-walking group had a greater decline in their motor performance after cognitive task loading than patients in the independent-walking group. Although the usefulness of the dual task method for determining walking independence in patients who have experienced a stroke has been reported [3–5], evaluating the performance immediately after cognitive task loading is useful to determine a patient's walking independence with greater accuracy. The findings of our study may be useful for occupational therapists who assist patients with stroke to safely perform their ADLs. In addition to walking, it is necessary to examine the relationship between other ADLs, such as toileting and bathing, and evaluate performance immediately after the loading of the dual task cognitive challenge.

This study has some limitations. First, the appropriate sample size was not determined. Second, we did not eliminate the effects of fatigue on motor performance. Third, the study was conducted at a single institution, resulting in a lack of external validity. Fourth, the measurements were not repeated.

Despite these limitations, the results of this study demonstrate changes in motor performance immediately after cognitive task loading and after time had passed during a dual task assessment in patients who experienced a stroke. More specific methods to evaluate motor performance immediately after cognitive task loading must be investigated and applied during dual task training.

Conclusion

The differences in the motor performances during the dual task stepping test immediately and at 10–15 s after cognitive task loading were analyzed in patients who had experienced a stroke. The motor performances of patients decreased immediately after cognitive task loading and 10–15 s after cognitive task loading, and the decline in performance immediately after the task was associated with the patients' attention rating scale scores. In addition, patients in the supervised-walking group had a greater decline in motor performance immediately after cognitive task loading than patients in the independent-walking group. Additional dual task assessment methods and their application to dual task training should be investigated in future studies.

Conflicts of interest

There are no conflicts of interest to disclose with regards to this study.

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■ORIGINAL ARTICLE

Characteristics of Occupational Therapists' Advice in School Consultations: Content Analysis of Advice for Consultation on Problem Behavior in a Special Needs School for Intellectual Disability

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Abstract: Introduction: This study examined consultations by occupational therapists (OTs) regarding problem behaviors in a school for special needs education (Intellectual Disabilities) to clarify (1) the kind of advice provided, (2) the extent to which advice is put into practice in the classroom, and (3) the characteristics of the advice most frequently put into practice.
Methodology: In total, reports on 78 school consultations conducted in 2015 and 2016 were examined; advice provided by the OTs was analyzed using Berelson's content analysis method. The OTs gave advice on the following: introducing and changing activities, adjusting the environment, ways of interacting to increase desirable behaviors, responding directly to problem behaviors, methods of talking with and instructing students, methods of visual support, and introducing alternatives to satisfy sensory needs.
Results: Advice on methods of visual support and advice on introducing alternative ways to satisfy sensory needs were especially linked to practice.
Conclusion: The results also indicated that the kind of advice frequently implemented in practice was that in which "who, what, when, and how" were clearly stated. Furthermore, it was found that discussing classroom feasibility with teachers based on specific advice improved the efficiency of consultations.

Keywords: special needs education, developmental disability, occupational therapy in school

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1. Introduction

1.1. Special needs education and occupational therapy

In April 2007, a new system of special needs education was established in Japan through an amendment to the School Education Act, and efforts have since focused on utilizing personnel inside and outside of schools, while cooperating with related organizations, to provide education tailored to individual needs. Due to the declining birthrate and aging population, the total number of children attending Japanese schools has decreased. Nevertheless, the number of children receiving a special needs education continues to increase [1]. In particular, there has been an increase in the numbers of children with autism spectrum disorder (ASD) and attention deficit hyperactivity disorder, and occupational therapists (OTs), who specialize in supporting children with these conditions, are now expected to apply their expertise in school settings. In "The Third Five Year Strategy for

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Occupational Therapy," the Japan Association of Occupational Therapists identified "occupational therapy for children with special needs enrolled in mainstream schools" as a key focus area [2], and the task of training OTs to leverage their expertise in special needs education was positioned as a priority goal.

1.2. Occupational therapist consultation in schools

The United States led the way in deploying OTs in schools with its "The Education for All Handicapped Children Act" law, established in 1975, which included occupational therapy as one of the services to be provided where necessary in education for children with disabilities [3]. OTs now work in many schools across the United States, and the American Occupational Therapy Association has developed three interventional models that OTs provide in regular schools (direct intervention, monitoring, and consultation).

Consultation refers to the process by which multiple practitioners with different areas of expertise examine the problems of the support targets and discuss better ways of providing support. According to Dunn, OTs working in schools often employ direct therapeutic interventions, whereas consultation is the least familiar method employed [4]. However, studies have also focused on the benefits of consultation. For example, Kemmis et al., demonstrated that consultations held in collaboration with teachers were effective for achieving students' goals in diverse areas; moreover, in addition to therapeutic goals, OTs play a role in linking educational goals and support [5]. Davies et al., found that consultations were not only beneficial for the target students but could also play a role in changing attitudes and behaviors among consultees (teachers) [6]. However, these studies were based on weekly interventions by OTs employed at target schools, and the context differs considerably from the way in which OTs are involved in schools in Japan today.

As a result of various initiatives, the number of OTs involved in educational settings has increased; however, in Japan, the number of OTs working in schools remains very low throughout the country [7]. Primarily, OTs provide support by visiting the school and supporting target students indirectly through consultations. In recent years, an interview study of OTs who delivered interventions for students attending regular classes [8] and questionnaire studies targeting teachers of regular classes [9, 10] revealed that OTs tend to provide indirect support by proposing improvements to environmental settings, tools/equipment, and strategies of support, and that teachers' understanding and awareness with respect to OTs is increasing. OT consultations take place during one-off visits, which limits the range of opportunities for providing support. Thus, OTs are required to (1) understand a situation based on the details of the requests they receive and (2) provide advice that can be put into practice, within a limited time.

However, questions regarding research on OT consultation for special needs education, such as how often advice is put into practice and which types of advice are more likely to be put into practice, remain unanswered.

1.3. Research purpose

When the authors examined the content of consultations by OTs in a school for special needs education (intellectual disabilities), it was found that consultations on "problem behaviors" were the most common type in both the elementary and lower secondary divisions of the school [11]. In this study, we examined problem behavior consultations by OTs in special needs schools (i.e., schools for people with intellectual disabilities), and we used content analysis to determine (1) the kind of advice provided, (2) the extent to which the advice was put into practice in the classroom, and (3) the characteristics of the advice most frequently put into practice.

2. Methods

2.1. Research design

This study employed a mixed type design (backward-looking research study based on the report).

2.2. Research field

We examined the reports from 78 teacher-initiated consultations conducted by OTs in special needs school B, City A, in the academic years 2015 and 2016 (including 40 consultations in the elementary division and 38 in the lower secondary division of the school). These reports were prepared in collaboration with the teacher, mainly by special education coordinators, based on the assessments and advice given by OTs during the school consultations. Specifically, the special education coordinators prepared content for teacher consultation, informed the OT in advance, and accompanied the OT during the consultation. At the end of the consultation, the OT and the special education coordinator took time to review the target student's assessment and advice, which was videotaped for sharing and confirmation. Information regarding the (1) *attributes of the target student*, (2) *content of the consultation* (information recorded before consultation and details added at the time of the consultation), and (3) *advice provided* was entered into the report before the end of the month in which the consultation took place, and details of (4) *actions implemented* and their (5) *results* were added in the report before the end of the academic year. This enables third

parties to get details about the content and the results of each consultation.

City A is actively promoting the use of external specialists to support children with special needs by dispatching external specialists in response to the needs of elementary and lower secondary schools in the local area. Since 2010, a team of eight OTs, including the authors, has been involved in this project as external specialists, and currently delivers around 20–40 consultations per year; speech therapists and clinical psychologists are also involved in the project. In the academic year 2015, four OTs provided services at Special School B, for 70 students in the elementary division and 117 students in the lower secondary level. Although data were not available on the breakdown of disorders and disabilities, the Special Needs Education Coordinators confirmed that ASD was the most common disability type, present in more than half of all consultations. Intellectual disabilities (ID) were present in almost all cases, and many students in the elementary division had moderate or severe/profound ID. In the lower secondary division, about half of the students had previously attended special needs classes at local elementary schools, and ID was present in varying degrees. There were four students per class in the lower elementary grades and five or six for the middle elementary grades and above; two teachers were assigned to each class, and depending on the situation, another teacher would join them when available.

2.3. Data collection

The (1) *school year and gender of the target student*, (2) *content of the teacher-initiated consultation(s)*, and (3) *advice provided by the OT* were extracted from the reports. Instances of advice given in response to consultations on problem behaviors were included for analysis, with reference to previous research in which the content of consultations was categorized [11]. In addition, the (4) *actions implemented*, and their (5) *results* sections of each report were examined, and consistency with the advice provided was verified to determine whether action was taken based on the advice provided and whether it was effective. If the *results* sections demonstrated a negative change or no change in the student, it was considered "ineffective." Similarly, if the sections did not contain anything that corresponded to the *actions implemented* sections, it was considered "ineffective." At this point, steps were taken to ensure that the opinions of the lead and co-authors (a total of five OTs) were aligned.

2.4. Data analysis

2.4.1. Content analysis of advice

To identify the kind of advice provided, the content of advice dispensed by OTs was analyzed using Berelson's content analysis method. Berelson's content analysis technique is used to describe the content of communication in an objective, systematic, and quantitative manner [12], and was considered a suitable method for systematically organizing the content of advice expressed in various ways. The specific work tasks and procedures are as follows:

Organization of target data: If two consultations were conducted for the same student, any advice that had already been dispensed was excluded from the analysis.

Creation of recording units: The lead author categorized the OT advices extracted from the report into recording units to ensure that each sentence had only one meaning.

Consolidation of similar recording units: The lead author grouped identical and similarly worded recording units as well as assigned labels to these units.

Consolidation into record unit groups: The lead author organized the recording units into groups of similar recording units and assigned labels based on the similarity of the semantic content.

Categorization: The lead author consolidated similar groups of recording units and assigned category names based on the similarity of the semantic content.

Review and revision of results: Three authors with expertise in research, and more than five years of practical experience in the field of special needs education, confirmed that the names assigned to the groups of similar recording units and categories aptly reflected the semantic content of the recoding unit labels, and made corrections where necessary.

Verification of reliability: Two OTs with more than five years of practical experience in the field of special needs education classified the recording unit codes into categories and assessed the reliability by calculating Cohen's kappa value.

Calculation of the frequency of appearance: The frequencies of recording units, groups of similar recording units, and categories were calculated.

Calculation of the implementation and effectiveness rate of advice: The rate of implementation of advice was calculated for each category (instances of implemented advice/instances of advice × 100). The rate of effectiveness of advice was calculated for each category (instances of effective advice/instances of implemented advice × 100).

2.4.2. Comparison of implemented and non-implemented advice

To clarify the characteristics of advice most fre-

quently put into practice, the recording units were assigned to an "implemented" group (advice that was implemented) and a "non-implemented" group (advice that was not implemented), and these groups were compared. Based on the Person-Environment-Occupation model, it was considered that specificity regarding person ("who" should carry out the action), environment ("where" and "when" it should take place), and occupation (the "reason/purpose" as well as the necessary "objects" and procedures) would influence whether the advice provided was implemented. Next, judgments were made as to whether there were clear and specific references to the five items of *time*, *person*, *object/behavior*, *place*, and *reason/purpose* that could be extracted from the content of the recording units. For example, "Do not react when bad behaviors occur (the child throws an object, etc.), and respond with praise when the child tidies up well," which was a recording unit for consultations related to "throwing objects," was classified as [time O], [person ×], [object/behavior O], [place ×], and [reason/purpose ×]. The frequency of [O] classifications for each item was calculated for the "implemented" and "non-implemented" groups, and the two groups were compared on each item using the chi-squared test and residual analysis. IBM SPSS Statistics Ver.24 was used for the statistical analysis, and statistical significance was set at $P < 0.05$.

2.5. Ethical considerations

This study was approved by the research ethics committee of the primary author's affiliation. We explained the study in writing and orally to the principal of special needs school B and obtained his consent. The reports were provided and used in an anonymized form.

3. Results

3.1. Attributes of the OTs, target students, and teachers

Four OTs (not including the author) conducted a total of 78 consultations. The average years of experience in occupational therapy was 22.5 ± 9.4, and the average years of involvement in special needs education was 5.3 ± 2.9. The involved OTs were relatively experienced, and they had experience in using sensory integration, applied behavior analysis, the Treatment and Education of Autistic and Related Communication Handicapped Children (TEACCH) program, and activity analysis in therapy. Consultations were conducted for about 77 target students (one student was discussed in two separate consultations) and involved 88 teachers (44 classes). Of these, 41 students and 56 teachers (28 classes) were involved in consultations related to problem behaviors. Overall, 27 students were boys, nine were girls, and there were five students whose gender was not stated; 12 students were studying in the elementary division and 29 in the lower secondary division of the school (Table 1).

Table 1 Distributions of students and teachers involved in consultations across the year groups.

Year	Student (n = 41)			Teacher (n = 56)
	Boy	Girl	Unknown	
E 1	0	0	0	0
E 2	1	0	0	2
E 3	1	0	0	2
E 4	4	0	0	4
E 5	3	0	1	8
E 6	2	0	0	4
LS 1	5	0	3	12
LS 2	7	6	1	16
LS 3	4	3	0	8
Total	27	9	5	56

Note. The number of consultations related to problem behavior is indicated.

3.2. Content analysis of advice

In total, 67 consultations related to problem behaviors were conducted about 41 students. The main content of the consultations was inappropriate behavior, taking frustrations out on objects, harming others, control of emotions, behavior switching, fastidiousness, etc. (in the order of frequency of occurrence in previous studies [11]). The content analysis of the advice yielded 148 recording units, approximating two items of advice per consultation. Out of these, six units consisted of praise or affirmation of the teachers, or instructions to continue the current support, and were therefore excluded from the analysis. From the remaining 142 recording units, 92 recording unit codes, 29 groups of similar recording units, and 12 categories were extracted. Cohen's kappa coefficient was 0.84, indicating adequate agreement among the coders. Category names, numbers of recording units, frequencies, implementation rates, and examples of advice are shown in Table 2. Implementation was confirmed for 58 of the 142 recording units (41.1%), among which 53 were considered effective, corresponding to an effectiveness rate of 91.2%. Categories with high rates of implementation were *methods of visual support* (frequency 8.5%, implementation rate 58.3%), *introducing alternative ways to satisfy sensory needs* (frequency 7.7%, implementation rate 54.5%), and *ways of interacting to increase desirable behaviors* (frequency 13.4%, implementation rate 52.6%). Categories with low rates of implementation were *proposals to parents* (frequency 7.0%, implementation rate 10.0%), *adjusting*

Table 2 Content analysis of advice, implementation rates, and examples of advice.

Category	NRU	FR	PAI	Example of advice (excerpts from the advice implemented)
Introducing and changing activities	21	14.8	38.1	Introduce activities, such as trampoline play during break time
Adjusting the environment	20	14.1	35.0	Keep stimuli that might encourage out-of-seat behavior, such as sound-emitting picture books, in locked locations
Ways of interacting to increase desirable behaviors	19	13.4	52.6	Respond with praise when the child tidies up well
Direct responses to problem behaviors	19	13.4	42.1	Do not react when bad behaviors occur (the child throws an object, etc.)
Methods of talking to and instructing the child	13	9.2	46.2	Try using a countdown as a way to stimulate action
Methods of visual support	12	8.5	58.3	Use a voice meter visual containing facial expressions because it is difficult for the child to compare voice levels
Introducing alternative ways to satisfy sensory needs	11	7.7	54.5	Attach patches to clothing to satisfy tactile needs
Proposals to parents	10	7.0	10.0	Suggest that parents bring forward the morning medication time (to prevent forgetting to take medicine)
Others	17	4.2	16.7	It is necessary to understand hyperesthesia and take steps to prevent careless contact, etc.
Total	142	100	41.1	

Note. NRU = number of recording units; FR = frequency (%); PAI = percentage of advice implemented. Units with a frequency of less than 5% are included in the others category.

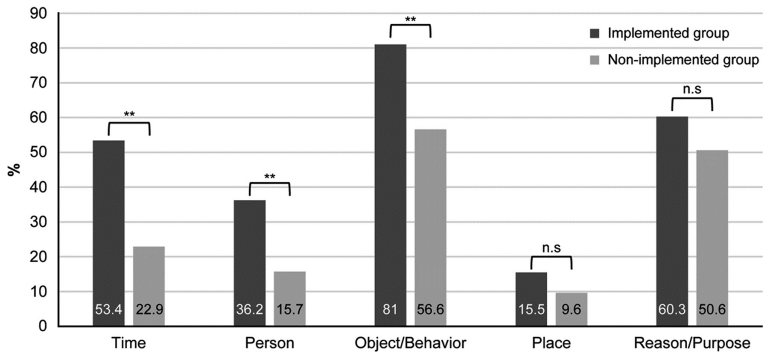

Fig. 1. Proportions of Recording Units with Clear and Specific References; ** $p < 0.01$.

the environment (frequency 14.1%, implementation rate 35.0%), and *introducing and changing activities* (frequency 14.8%, implementation rate 38.1%).

3.3. Comparison of implemented and non-implemented advice

The proportions of recording units with clear and specific references to *time*, *person*, *object/behavior*, *place*, and *reason/purpose* for the "implemented" and "non-implemented" groups are shown in Fig. 1. The chi-square test and residual analysis indicated that the proportions of recording units with specific references to *time*, *person*, and *object/behavior* were significantly higher in the "implemented" group. Although the rates of recording units with specific references to *place* and *reason/purpose* were higher in the "implemented" group, the differences were not statistically significant.

4. Discussion

4.1. Subject attributes and characteristics of the field

Male students outnumbered female students by a ratio of 3:1. There were many children with ASD in the target field. Given that the male-to-female ratio in ASD is reported as 4:1 [13], the sample distribution in this study, where the children were attending a school for special needs education in the ID category, was not significantly skewed; however, it should be noted that the

distribution of students was somewhat skewed toward the secondary division of the school.

4.2. Characteristics of frequently implemented advice

The results of the study revealed that OTs proposed about two items of advice per consultation on problem behaviors, and approximately 40% of this advice was put into practice. Though this overall rate of implementation was by no means high, almost all advice that was implemented was effective to some degree; therefore, it would seem important to consider how OTs can offer advice that is more likely to be put into practice. *Methods of visual support*, the category with the highest implementation rate, included many instances of advice that focused on helping students think ahead, through visualization and structuring of schedules. One supporting framework used by OTs to provide visual support and structure is the TEACCH program [14]. Visual support and structuring for ASD is also common in the field of education [15], and in the present study, the ease by which theoretical underpinnings could be shared between OTs and teachers may explain the high rate of implementation observed in this category. The category with the second highest implementation rate was *introducing alternative ways to satisfy sensory needs*, which included many items of advice aimed at reducing problem behaviors rooted in sensory needs by satisfying these needs in other ways. Previous research has shown that sensory modulation disorder leads to problem behaviors [16]. OTs tend to be skilled in interpreting the underlying causes of certain behaviors from the perspective of sensory integration [14], and were thus able to give advice in a form that teachers could easily understand. In addition, since methods of interacting with children, such as tapping on the back, can be implemented easily, whereas it was far more difficult to implement advice, such as introducing objects that the child could chew, it would seem necessary to consider the ease with which alternative methods can be introduced when giving advice. The category with the third highest implementation rate was *ways of interacting to increase desirable behaviors*, which had a high frequency and often appeared in the advice given by the OTs. Such advice was intended to increase desirable behavior and reduce problematic behavior through positive feedback in response to good behavior and has its theoretical roots in applied behavior analysis. Applied behavior analysis is a support approach backed by substantial evidence that aims to identify environmental variables that influence certain behaviors and induce behavioral change by controlling aspects of the environment that act as triggers [17, 18]. This approach has been shown to be effective in consultations with children who display behavioral problems and have a high affinity with OT interventions [19]. Consultations on problem behaviors often focused on reducing, or increasing, certain behaviors, and the results of the study suggested that advice grounded in applied behavior analysis is frequently implemented as a form of top-down support.

4.3. Issues in hard-to-practice advice

Proposals to parents, which was the category with the lowest implementation rate included a large amount of content related to the adjustment and consideration of medication. As these changes cannot be accomplished by the school alone, but also require the involvement of parents and/or healthcare facilities, it is reasonable to assume that the barriers to implementation were high in this category. In cases where such proposals are made, it may be necessary to keep written records of specific interactions with parents and healthcare facilities. *Introducing and changing activities* and *adjusting the environment* were key methods of intervention employed by OTs, and although the frequencies of these categories were high, the implementation rates were relatively low at 38.1% and 35.0%, respectively. For *introducing and changing activities*, advice, such as "playing with trampolines or bicycles during break time," was often implemented, whereas other break time activities that required a teacher to accompany the child, such as walking or stretching, were less likely to be put into practice. Trampolines and bicycles are concrete objects and are often incorporated into break time activities; therefore, we can assume that both teachers and children could easily imagine how they might be used, culminating in a higher frequency of implementation. This highlights the importance of ensuring that advice can be implemented through small changes, using existing objects and equipment, and considering what manpower would be required to implement the change. Regarding advice on *adjusting the environment*, which mainly concerned the position of seats, people, and objects, advice to change the specific seating positions or tidy away objects that might serve as stimuli was frequently implemented, whereas advice to adjust the allocation of teachers or the system itself was less likely to translate into action.

4.4. Key points to be considered while proposing support strategies

The comparison of advice that was and was not implemented revealed that the proportion of advice with clear and specific references to *time*, *person*, and *object/behavior* was significantly higher in the implemented group than in the non-implemented group, and this proportion was more than two times higher for *time* and *person*. Thus, it is reasonable to conclude that clarifica-

tion of when an action should be taken, and who should take it, led to discussions on whether the advice could be implemented in the school setting and was effective in increasing the implementation rate. In the Occupation Therapy Manuals issued by the Japanese Association of Occupational Therapists, it is recommended that OTs focus on "5W1H" when proposing specific support strategies [20], and the results of the present study add weight to this idea. The results of the study indicated that, even in the "implemented" group, only about 40%–50% of advice included clear references to *time* and *person*, leaving room for further improvement in specificity, and the effectiveness of consultations could be improved by endeavoring to give advice in which "who, what, when, and how" are clearly and specifically stated.

4.5. Limitations of this study

The results of this study are limited to consultations initiated in response to problematic behavior at a single special needs education school. Further, the four people involved in the consultation were relatively experienced OTs. It is expected that the content of the consultation will be influenced by their experience as OTs. Therefore, a more comprehensive survey is needed to generalize the results of the present study. Moreover, as the analysis focused on the content of reports, the method is limited as a means of examining whether teachers understood the advice given by OTs and whether each individual item of advice was implemented. However, these reports were compiled based not only on records created by OTs after the consultations, but also on video-based communications. Thus, it can be considered that the reports were written in detail and were largely free from omissions, and that the content of the consultations was easy to understand. Accordingly, the findings can be regarded as a valid representation of the analysis results of how the OT consultations were understood and how the advice was implemented, by the consultee-teachers.

5. Conclusion

OTs provide a wide range of advice in school consultations initiated in response to problem behaviors. Advice on methods of visual support and advice on introducing alternative ways to satisfy sensory needs were often put into practice. While advice on *introducing and changing activities* and *adjusting the environment* was frequently dispensed, the results suggested that introduction of new activities or activities that required manpower or adjustments in the deployment of the personnel at school were less likely to be implemented. The findings show that when providing this kind of advice, it is important to ensure that advice can be implemented through small changes using existing resources and considering manpower requirements. The results also indicated that the kind of advice that was frequently put into practice was advice in which "who, what, when, and how" were clearly stated, and that discussing classroom feasibility with teachers based on specific advice can improve the efficiency of consultations.

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■ORIGINAL ARTICLE

Occupational Balance and Quality of Life Among Hospital-Based Occupational Therapists During the COVID-19 Pandemic

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Abstract: The Coronavirus disease (COVID-19) pandemic has affected the practice of hospital-based occupational therapists (OTs) and this may have influenced their occupational balance (OB) and quality of life (QOL). There is limited literature exploring OTs' OB, QOL, and the relationship between these. This study aimed to measure OB and QOL and their relationship among hospital-based OTs during the pandemic. Using a descriptive-correlational and cross-sectional design, n = 64 participants answered electronic versions of the Occupational Balance Questionnaire-11 (OBQ11) and World Health Organization Quality of Life-BREF (WHOQOL-BREF). Friedman test with a post-hoc pairwise Wilcoxon signed-rank test was used to compare QOL domain scores within-group. Independent t-test and Mann-Whitney Test were used to compare the subgroups' OB and QOL, respectively. 54.69% were classified to have low OB. Mean overall QOL score was 3.59 ± 0.68. QoL domain scores were relatively moderate: 66.67 ± 11.41 (physical); 55.58 ± 15.60 (psychological); 64.48 ± 21.81 (social); and 62.42 ± 14.74 (environmental). OB was significantly correlated with overall QOL ($p < 0.001$), physical health domain ($p < 0.001$), psychological domain ($p < 0.001$), social domain ($p = 0.022$), and environmental domains ($p = 0.005$). Low OB and moderate QoL, regardless of sex, work schedule, and hospital funding type, validates the need for improved personal strategies and enhanced organizational support. The positive correlation between OB and QoL contributes to occupational science providing extant evidence on how occupations support health and well-being. Our findings have implications for developing programs that support hospital-based OTs during the pandemic period and beyond.

Keywords: occupational balance, quality of life, occupational therapists, hospital, COVID-19

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Introduction

The Coronavirus disease (COVID-19) pandemic has affected the practice of different health industry professionals and occupational therapists (OTs) are no exception [1]. Among the different practice settings, OTs working in hospitals were found to be especially vulnerable to the pandemic's direct effects due to the higher risk of exposure to COVID-19 and altered work routines [2–4]. OTs faced work disruption and adoption of new roles related to service delivery for both COVID and non-COVID clients [3–5]. This shift in practice as a response to the pandemic has been reported to have affected the lives and well-being of OTs [6–9].

Occupational balance (OB) is defined as the subjective life experience of individuals in having the right amount of occupations and variation between occupations that they want to, need to, or are expected to do [10, 11]. This has been measured in several populations including OTs. Prior to the pandemic, there has been evidence that hospital employees and OTs have difficulty achieving and maintaining OB [12, 13]. This may lead to OTs to consider new employment, or worse, leave the profession altogether [13, 14]. Thus, ample OB may contribute to the well-being of OTs.

Quality of life (QOL) refers to the "individuals' perceptions of their position in life in the context of

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the culture and value systems in which they live and concerning their goals, expectations, standards and concerns" [15]. QOL entails looking beyond well-being to include other domains of an individual's life (i.e., physical health, psychological state, social relationships, and environment) [16]. Prior to the pandemic, it has been reported that OTs have adequate to good professional QOL, globally [17]. However, there is a dearth of studies on the current QOL among OTs during the time of the pandemic, at the time this study was conducted.

Both OB and QOL can support an individual's health, well-being, and engagement in occupations [18, 19]. Conceptually, they may be related to such functions. Previous studies have been limited to studying these concepts in isolation. To the best of our knowledge, the relationship between OB and QOL among hospital-based OTs is at best, yet to be explored. Nevertheless, there is convincing evidence that OB and QOL are related among other populations (i.e., nursing home residents, older adults, adults, and adults with chronic diseases) [19–22].

Inquiry on the OB and QOL, and consequently their relationship, among OTs are limited. Pandemic effects may likely influence these outcomes among OTs, especially those working in hospitals. Thus, this study aimed to describe the OB, QOL, and their relationship among hospital-based OTs at the time of the COVID-19 pandemic.

Methodology

Design

This study used a descriptive cross-sectional correlational research design.

Ethical Considerations

Ethical approval from the University of Santo Tomas College of Nursing Ethics Review Committee was initially sought. Participants' informed consent was collected electronically.

Participants and sampling

We used a purposive homogeneous convenience sampling design to recruit n = 64 licensed Filipino occupational therapists. Recruitment was accomplished through social media, contact person coordination, and email dissemination through the Philippine Academy of Occupational Therapy, Inc. (PAOT, Inc.), the national professional organization for occupational therapists. Inclusion criteria for the participants were the following: (1) license to practice as an occupational therapist under the Professional Regulation Commission, (2) performance of functions related to occupational therapy, and (3) employment in hospitals located in Metro Manila.

Based on the 2017 workforce survey by PAOT, Inc., there may be a total of 121 members, which fit the inclusion criteria [23]. The target sample size of the study was a minimum of 50% (n = 60) of the eligible population to ensure adequate representation of the target population [24].

Research instruments

We used several instruments in this study, which include a participant demographic questionnaire, Occupational Balance Questionnaire-11 (OBQ11), and World Health Organization Quality of Life-BREF (WHOQOL-BREF). The authors sought and were given permission from the original authors to use the instruments prior to data collection.

OB was measured using the OBQ11, a tool that measures different aspects of OB [25]. It is an 11-item questionnaire with each item being rated from four ordered response categories (0 = strongly disagree, 1 = disagree, 2 = agree, 3 = strongly agree); a higher score indicates a higher OB. For the purposes of this research, the median score was used as the cut-off for high and low OB [26, 27]. OBQ11 was found to have good reliability by a previous study [25]. Participants were asked to accomplish an electronic form version of the OBQ11 and asked to think of their OB in the past two weeks. The electronic version of the OBQ11 used in this study had good internal consistency ($\alpha = 0.87$).

QOL was measured using the WHOQOL-BREF, a culturally sensitive 26-item questionnaire that contains two items (on QOL and health satisfaction) and 24 items on each of the domains of QOL (i.e., physical health, psychological, social relationships, and environment) [15]. Each item is rated on a five-point scale (1 = very dissatisfied, 2 = dissatisfied, 3 = neither satisfied nor dissatisfied, 4 = satisfied, and 5 = very satisfied). Four domain scores are derived, with each score representing the individual's perceived QOL in each domain. Higher scores imply higher perceived QOL. The WHOQOL-BREF was found to have good to excellent reliability and validity [28]. Participants were asked to accomplish an electronic form version of the WHOQOL-BREF and asked to think of their QOL in the past two weeks. The electronic version of the WHOQOL-BREF used in this study had good internal consistency ($\alpha = 0.89$).

Data collection

We developed comparable electronic versions of the OBQ11 and WHOQOL-BREF using Google Forms. Along with the consent form and participant demographic questionnaires, a survey link was sent to the participants. They were given one week to accomplish

the survey, with reminders sent by the researchers for follow-up. Participants were instructed to answer the survey within the past two weeks as context. The electronic survey was conducted within Metro Manila in March 2021, where national and local quarantine protocols were currently enforced.

Data analysis

Descriptive statistics (i.e., measures of central tendency, standard deviation) were used to summarize participant characteristic variables and scores on the OBQ11 and WHOQOL-BREF. To compare QOL domain scores within-group, we used the Friedman test with a post-hoc pairwise Wilcoxon signed-rank test. In comparing subgroups, we used measures of differences (i.e., Independent t-test, Mann-Whitney Test). Correlation was assessed using Spearman's and Pearson's correlation coefficients. Quantitative data were analyzed statistically using SPSS 23.0. The significance level was set at $p < 0.05$.

Table 1 Participant Demographics

Variable	*n*	Percentage
Age		
21–25	18	28.13%
26–30	35	54.69%
31–35	6	9.38%
46–40	3	4.69%
41–45	2	3.13%
Sex		
Female	44	68.75%
Male	20	31.35%
Type of work done*		
Clinician	64	100%
Manager	5	7.81%
Researcher	3	4.69%
Administrator	1	1.56%
Others**	4	6.25%
Work Schedule		
Full-time	45	70.31%
Part-time	19	29.69%

* OTs may perform more than one role in the hospital setting.
** Other identified roles include "clinical supervisor" and "educator."

Results

We analyzed data from n = 64 hospital-based OTs whose mean age was 28.05 ± 4.63 yr. There were more females (68.75%) among the sampled participants who are employed across 31 hospitals in Metro Manila, with a majority (60.94%) coming from government-owned institutions. Table 1 summarizes other participant characteristics.

Occupational balance among hospital-based OTs

The range of the total OBQ11 score among the participants was between 6–32. The mean score is 18.86 ± 5.14 and the median score is 19. Given this cut-off median score, 54.69% (n = 35) were classified to have low OB. There was a significant difference in OB between the high OB group (M = 23.34, SD = 2.94) and the low OB group (M = 15.14, SD = 3.22); $t(62) = 10.55$, $p \leq 0.001$). Table 2 shows the summary of the OBQ11 scores.

Quality of life among hospital-based OTs

The mean of the overall QOL scores was 3.59 ± 0.68. The physical health domain (66.67 ± 11.41) had the highest score, while the psychological domain (55.58 ± 15.60) was the lowest. The WHOQOL-BREF domain scores are summarized in Table 3. Given the sample size and normality of our data, we computed for dependent samples (n = 64) multivariate differences (QoL domains). The results of the Friedman test indicate significant QoL multivariate domain differences ($\chi 2$, $p < 0.000$). Follow-up Wilcoxon signed rank tests for paired univariate comparisons are further summarized on Table 4.

Table 2 Descriptive Statistics of OBQ11 Scores

	Total	Low OB	High OB
n	64	35	29
Mean Score	18.86	15.14	23.34
SD	5.14	3.22	2.94
95% CI	17.5–20.14	14.04–16.25	22.23–24.46

Table 3 Descriptive Statistics of QOL Domain Scores

	Mean Score	Standard Deviation	Mean Score (T-100)*	Standard Deviation (T-100)	95% CI
Physical Health Domain	3.67	0.47	66.67	11.41	63.82–69.82
Psychological Domain	3.23	0.61	55.58	15.60	51.68–59.47
Social Relationships Domain	3.57	0.86	64.48	21.81	59.04–69.93
Environmental Domain	3.43	0.58	62.42	14.74	58.74–66.10

* Mean score on a transformed-100 scale.

Table 4 Friedman Test and Wilcoxon Signed-Rank Test of QoL Domains

	Friedman Test		Wilcoxon signed-rank test											
			D1-D2		D1-D3		D1-D4		D2-D3		D2-D4		D3-D4	
	$\chi 2$	sig	Z	sig	Z	sig	Z	sig	Z	sig	Z	sig	Z	sig
QOL (D1–D4)*	29.775	< 0.000	−5.615	< 0.000	−0.740	0.459	−2.294	0.022	−3.808	< 0.000	−3.082	0.002	−0.924	0.355

* QOL refers to the multivariate Quality of Life dimensions (Dimensions 1–4) on the WHOQOL-Bref;
D1 = Physical dimension, D2 = Psychological dimension, D3 = Social dimension, D4 = Environmental dimension.

Table 5 OB and QOL Comparison Among Subgroups

	Mean OB Score (SD)	OB Sig.*	Median QOL Score	U	QOL Sig.*
Sex					
Male (n = 20)	18.65 (5.09)	0.83	4.00	412.00	0.64
Female (n = 44)	18.95 (5.21)		4.00		
Work Schedule					
Part-time (n = 19)	19.16 (4.21)	0.77	4.00	403.00	0.68
Full-time (n = 45)	18.73 (5.52)		4.00		
Hospital Type					
Private (n = 25)	18.48 (4.87)	0.24	4.00	456.00	0.62
Government-owned (n = 39)	19.10 (5.35)		4.00		

* All significance tests are 2-tailed.

Comparison of occupational balance and quality of life among hospital-based OT Subgroups

We conducted several measurements of subgroup (i.e., sex, work schedule, type of hospital) differences for OB and QOL. No significant statistical differences were observed. Table 5 summarizes the subgroup analysis.

Correlation between occupational balance and quality of life among hospital-based OTs

This study discovered several significant correlations between OB and QOL among hospital-based OTs (Table 6). There was significant moderate positive correlation between OB and overall QOL, ($r(62) = 0.56$, $p < 0.001$). We also found significant moderate to good positive correlation between OB and the physical health QOL domain, ($r(62) = 0.66$, $p < 0.001$); and OB and the psychological QOL domain ($r(62) = 0.61$, $p < 0.001$). A significant fair positive correlation between OB and the social relationships QOL domain ($r(62) = 0.29$, $p = 0.022$); OB and the environmental domain ($r(62) = 0.35$, $p = 0.005$) was found as well.

Table 6 Correlations Between OB and QOL

Correlations	Correlation Coefficient (r)
OB and overall QOL*	0.56
OB and Physical Health Domain*	0.66
OB and Psychological Domain*	0.61
OB and Social Relationships Domain**	0.29
OB and Environmental Domain**	0.35

* $p < 0.001$
** $p < 0.05$

Discussion

This study describes the OB, QOL, and their relationship among hospital-based OTs during the time of the COVID-19 pandemic. There was low OB among most of the sampled participants. Stability of OB and QOL was observed across subgroups. OB was significantly correlated with overall and domain-based QOL.

Among the sampled hospital-based OTs, 54.69% exhibited low OB. This experience has varied results compared to research done prior to the pandemic. The participants' median score was 19 while Swedish OTs had a median score of 13 (Lexen et al., 2020) and Swedish women had 12 (Magnussen et al., 2020). The participants' mean score of 18.86 ± 5.14 also had comparable results to mothers of children with cerebral palsy who averaged 16.88 ± 5.07 on the OBQ11 (Günal et al., 2021) and adults with arthritis who averaged 15.89 ± 7.50. In other studies, OTs reported having difficulty managing their OB [29] and achieving OB [12]. Lack of time to accomplish their tasks in the workplace was reported [30, 31]. These already existing working

conditions may have been exacerbated by pandemic-related changes. In the Philippines, the implementation of national and local quarantine protocols has directly affected the delivery of OT services. During the lockdown, telehealth emerged as a popular mode of service delivery to reduce physical contact between therapists and patients. This is despite the multiple hindrances to its implementation in the country, such as slow internet speed, limited acceptance, and lack of e-health policies [8]. Public transportation has also been limited by the national government [32] which possibly affected the daily schedule of OTs. Compliance with the proper donning and doffing procedures of personal protective equipment and the appropriate disinfection procedures [33] enforced by the national government may have contributed to increased workload for OTs, especially those in understaffed hospitals. These findings resonate with a survey wherein it was found that 41% of OTs underwent work disruption and 25% adopted new roles during the pandemic [3]. Given these changes and consequences, OTs may need to employ the same strategies they teach their clients to achieve OB. This is an area of research and clinical practice that will be interesting to explore later. Nevertheless, adequate organizational support towards hospital-based OTs is needed for them to transition and engage in new practice patterns [14].

On average, this study found that hospital-based OTs view their overall QOL as moderate during the pandemic. Previous research focused on the professional QOL of OTs rather than their overall well-being [34]. While professional QOL may provide information on the work-related well-being of OTs, it is a reductionist point of view that fails to consider the variety of occupations individuals engage in. However, data is available on other healthcare workers. Hospital staff in the same subregion of Asia as our participants reported significantly higher mean scores across all domains prior to the pandemic [35]. During the pandemic, healthcare providers reported a similar overall QOL score as our participants [36]. Filipino OTs are surmised to have experienced lower QOL given the ongoing public health crisis in the Philippines [37] and their increasing mental health issues and worsened financial state [9].

This research provides a unique perspective on how QOL may be viewed for OTs. The proximity of the score to the midline at the time of the pandemic may indicate that the QOL among hospital-based OTs is at the cusp of marginal indication for support. This will need clinical and research attention later. Nonetheless, future research on QOL among OTs may need to ground itself on occupational science to inform its development and methodologies.

Among the QOL domains, psychological QOL scored lowest among hospital-based OTs. This is supported by recent research which found increasing mental health concerns among Filipino OTs at the time of the COVID-19 pandemic [9]. The uncertainty of the current contexts may likely cause psychological concerns [7]. Qualitative inquiry to support the findings in this study may be needed in the future to further extrapolate information that can be used to develop programs aimed at improving QOL among hospital-based OTs.

The physical health QOL domain had the highest score. While previous authors have suggested that OTs are prone to work-related pain [38] and have an increased risk of musculoskeletal disorders [39], the current telehealth set-up adopted across hospitals may have lessened the commonly experienced physical fatigue and risk of injury. Hospital-based OTs reduced their time of face-to-face patient care as shorter contact hours have been recommended to reduce the risk of infection [40]. Nevertheless, this finding should not be taken in isolation. QOL outcomes encompass a holistic approach and thus need to be interpreted along with the other QOL domains.

The results from this present study showed a significant correlation between OB and overall QOL. Hospital-based OTs with better OB also showed higher QOL. This is further supported by evidence found on the correlation between OB and the different QOL domains. To the best of our knowledge, no current studies have focused on similar outcomes among hospital-based OTs.

The study's findings are supported by literature despite differences in their population, methodologies, and context. A quantitative study among older adults found that OB was an independent variable that had an indirect effect on QOL [21], while a mixed methods research on individuals with chronic disease found a relationship between spirituality, health-related QoL, and OB [22]. OB was also found to influence QOL, participation, health, and stress [19]. Although Langenberg [41] found no statistically significant relationship between QoL and OB, their study presented a different interpretation of OB as it defined OB based on time instead of perceived experience. This definition has been criticized as it overlooks nuances in personal interpretation [42, 43]. Although there was reported to be no significant difference in the OB and QOL of different hospital-based OT subgroups, the findings of the current study may be attributed to the protocols set by the national government and institutions. This includes quarantine protocols, lockdowns, use of personal protective equipment, and new service delivery models.

The results of the study could be used as evidence to support that achieving the right amount and variation between occupations may ultimately lead to improved

quality of life despite the imposed challenges, such as the pandemic. The results affirm that OB reflects the complex and multidimensional nature of individuals. This has implications for informing and guiding the development of strategies to ensure OB, during the COVID-19 restrictions and even later in a post-pandemic work scenario. Future research is recommended to test this among complex interventions that address OB and QOL and its domains among OT.

Limitations and recommendations

There are several limitations in the conduct of this study that need to be addressed in future research. Our findings are limited to Filipino OTs practicing in hospitals. There will be a need to determine the generalizability of our results to other practice areas in other cultures and contexts. The pandemic restricted us to use electronic versions of the instruments. While this study established good internal consistency of the electronic versions, future research may be needed to validate this administration mode of the OBQ11 and WHOQOL-BREF. The research was done during the pandemic hence, results are not completely comparable to studies done prior to the pandemic. Lastly, while we are able to describe the OB and QOL of hospital-based OTs, we recommended including qualitative information in the future to further understand the depth, breadth, and meaning of these quantitative data.

Conclusion and significance to the profession

During the period of the COVID-19 pandemic, most hospital-based OTs had lower OB. On average, their overall QOL was moderate. The physical health QOL domain ranked highest, while the psychological QOL domain was last. This study provides supporting evidence on the relationship between OB and QOL. Our results provide supporting evidence that the ability to organize and participate in valued and meaningful occupations can support an individual's overall QOL and its domains. This has implications for developing strategies and programs that support hospital-based OTs during the period of the pandemic and beyond.

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■ORIGINAL ARTICLE

Relationship between Activities of Daily Living and Psychological Aspects at Discharge from a Convalescent Rehabilitation Ward

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Abstract: Discharge support currently focuses on the independence of activities of daily living (ADL) in the convalescent rehabilitation ward. However, understanding the psychological aspects is important for suitable discharge interventions. The objective of this study was to clarify the relationship between ADL independence level and psychological aspects when patients' discharge from convalescent wards was confirmed. A cross-sectional survey was conducted with 80 patients in convalescent wards to examine the relationship between ADL independence level using functional independence measure (FIM) values and responses to eight questions about psychological aspects. The results revealed that the ADL independence level is correlated with "mental preparation for discharge" and "consultation during hospitalization." The details correlated with "mental preparation for discharge" differed depending on the disease. "Awareness of ADL independence" was correlated in cerebrovascular diseases and "awareness of physical recovery" in motor diseases. The results suggest the importance of comprehending patients' concerns during hospitalization and changing the perspective to providing psychological support according to disease.

Keywords: convalescent ward, discharge support, ADL support, psychological support

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1. Introduction

At least 20 years have passed since the convalescent rehabilitation ward (hereafter, convalescent ward) was established in Japan. Currently, there are approximately 2,000 convalescent wards with 90,000 beds [1] and more than 6,000 occupational therapists [2]. This corresponds to 10% of the members of the Japanese Association of Occupational Therapists. The convalescent ward, where many occupational therapists work, is characterized that the purpose of hospitalization of patients, such as improvement in activities of daily living (ADL), prevention of becoming bedridden, and return to home [3]. Occupational therapists are required to provide such as ADL training including eating meals, excretion, and bathing, and instrumental activities of daily living (IADL) training including housework, and outing [4]. Therefore, occupational therapists working in convalescent wards emphasize support for ADL independence. A few studies have examined the relationship between basic movement ability and ADL independence level [5] and investigated the ways to improve the independence level by specifying ADL items such as toilet and dressing activities [6]. Many studies related to convalescent wards have reported on ADL independence, revealing that sex, age, side of paralysis, balance ability, and walking ability affect functional recovery and independence [7]. However, occupational therapy aims to promote the health and well-being of patients through practice [8]. Therefore, it is important to support ADL independence focusing not only on the restoration of physical function, but also the psychological aspects. Approximately 25% of all patients in convalescent wards are depressed [9]. However, the severity of depression in patients does not necessarily correlate with the severity of their diseases [10]. When people receive medical care, their minds are involved not only with psychiatric diseases but also with physical diseases [11]. Although there are few studies on the psychological aspects of patients in convalescent

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wards, there are surveys on anxiety at discharge, anxiety of families, motivation and satisfaction, and quality of life (QOL) [12–14]. A qualitative study by Kawai et al. [15] has revealed that the anxiety felt by patients and their families before discharge from a convalescent ward is mostly related to "patient's ADL," "nursing care ability," "nursing care services," "outlook for diseases and disabilities," and "social participation of patients".

The relationship between patients' ADL independence and their psychological aspects in convalescent wards has not yet been clarified. There is significant psychological stress on patients while performing occupational activities, including ADL [10]; therefore, it is important to ascertain whether they experience anxiety as long as they are independent with ADL, and whether they are satisfied upon discharge based on their independence level. In particular, interventions and psychological support considering individuality may be necessary for patients at the time of discharge. The objective of this study was to clarify the relationship between ADL independence level and psychological aspects of patients at the time of discharge from the convalescent ward.

2. Subjects and Methods

2.1 Ethics

This study was conducted with approval from the Ethics Review Committee of the International University of Health and Welfare and each cooperating institution.

2.2 Study Design

This is a cross-sectional study using a questionnaire for patients in convalescent wards.

2.3 Survey Target

Cooperation was requested, and consent received, from seven institutions registered as regular members of the Kaifukuki Rehabilitation Ward Association as of April 2018. The subjects included occupational therapists and patients in convalescent wards who would be discharged within one month. However, we excluded patients with language disorders and cognitive impairment who had difficulty expressing their intentions and patients who had previously been hospitalized in convalescent wards.

2.4 Survey Method

The survey lasted five months, from August 1 to December 31, 2018. The author explained the study purpose to the occupational therapists of each cooperating institution and requested them to conduct a questionnaire survey. The purpose of the study and the voluntary nature of participation were explained to the patients both in writing and orally by the occupational therapists. Responses were collected from the patients by the occupational therapists, from whom they were collected by the author during and after the survey. The questionnaire was so designed that the subjects could complete it independently. Thus, the questionnaire content was not known to others.

2.5 Survey Details

2.4.1 Objective patient information

To understand the patients' condition, the occupational therapists were asked to enter the age, sex, disease name, ADL independence level (functional independence measure value; hereafter, FIM value), duration of hospitalization in the convalescent ward, and residence after discharge.

2.4.2 Subjective patient information

A questionnaire survey was conducted to determine how the patients accepted their conditions after their discharge had been decided. The questionnaire was prepared by selecting questions based on previous studies and survey data on anxiety and psychological aspects at discharge, and adding new questions. The questions on subjective information included: (1) "Are you mentally prepared for discharge?" (mental preparation); (2) "Do you think you have recovered physically?" (awareness of recovery); (3) "Can you handle your personal matters independently?" (awareness of ADL independence); (4) "Do you have anxiety now?" (anxiety); (5) "Do you understand your disease?" (understanding of disease); (6) "Have you acquired the skills necessary to cope with your future life?" (future coping measures); (7) "Could you consult about what you want to do in the future during hospitalization?" (consultation during hospitalization); and (8) "Do you think you can do what you want to do, or do something worthwhile, in the future?" (worthy things). The patients were asked to respond using a 7-point Likert scale ranging from "strongly disagree" to "strongly agree."

2.6 Statistical Analysis

Descriptive statistics were performed to analyze the objective and subjective information of the patients. Spearman's rank correlation coefficient was calculated to examine the correlation between the FIM values and questionnaire items to clarify the relationship between ADL independence level and psychological aspects. The same analysis was performed by dividing the analysis target into cerebrovascular diseases and motor diseases to clarify the characteristics by attribute. Furthermore, Spearman's rank correlation coefficient was calculated

Table 1 Patient attributes

Attribute (n = 80)	Mean (range)
Age (years)	76.0 ± 12
Sex (%)	
Male	42.5
Female	57.5
Disease classification (%)	
Cerebrovascular diseases	50.0
Motor diseases	42.5
Other	7.5
FIM value (point)	107.0 ± 14
Durat ion of hospitalizat ion in a convalescent ward (days)	75.0 ± 41
Residence after discharge (%)	
Home	86.3
Other	13.7

for the correlation between Question 1 "mental preparation" and the other seven questions, and analysis by disease was performed to examine the psychological aspects toward discharge. IBM SPSS Statistics 25.0 was used for statistical processing. The level of significance was set at 5% for all the results.

2.7 Definitions of terms

In this study, the term "psychological aspects" refers to the patients' perception of their own conditions, including their emotions.

3. Results

3.1 Collection of questionnaire sheets and patients' attributes (Table 1)

A total of 81 patients participated in the survey, and 80 patients completed all items. The mean age of the patients was 76 (± 12) years. The study included 34 men (42.5%) and 46 women (57.5%). The disease classification was as follows: cerebrovascular diseases in 40 patients (50%), motor diseases in 34 patients (42.5%), and others in six patients (7.5%), showing approximately 50% each for cerebrovascular diseases and motor diseases. The mean FIM value was 107 (± 14), and the mean duration of hospitalization in the convalescent ward was 75 (± 41) days. Residence after discharge was home for 69 patients (86.3%) and others for 11 patients (13.7%).

3.2 Relationship between ADL independence level and psychological aspects

A high percentage of patients chose in the questionnaire (strongly agree-agree) for "mental preparation," "awareness of ADL independence," and "understanding of disease", indicating that their feelings about discharge were balanced. However, responses for "anxiety," "future coping measures," and "consultation during hospitalization" were varied. A few patients chose strongly disagree for "awareness of recovery" and "worthy things," indicating that there were patients who did not feel that their condition was satisfactory. Figure 1 shows the distribution of responses.

According to the results of the correlation analysis to clarify the relationship between ADL independence level and psychological aspects, a correlation was observed between the FIM value and "mental preparation" at r = 0.409 ($p < .001$), and between the FIM value and "consultation during hospitalization" at r = 0.416 ($p < .001$). According to the results of analysis by disease, in patients with cerebrovascular diseases, the correlation was observed between the FIM value and "mental preparation" at r = 0.509 ($p < .01$), between the FIM value and "awareness of ADL independence" at r = 0.478 ($p < .01$), and between the FIM value and "consultation during hospitalization" at r = 0.481 ($p < .01$). In contrast, in patients with motor diseases, a correlation was observed between the FIM value and "consultation during hospitalization" at r = 0.545 ($p < .01$). The results are presented in Table 2.

3.3 Psychological aspects toward discharge

"Mental preparation" was correlated with other questions regarding the correlation between questions in the questionnaire. As a whole, the correlation coefficient was the highest in "awareness of recovery" at r = 0.650 ($p < .001$), followed by "awareness of ADL independence" at r = 0.647 ($p < .001$), and "anxiety" at r = 0.622 ($p < .001$). By disease, the correlation with "mental preparation" in patients with cerebrovascular diseases was the highest for "awareness of ADL independence" at r = 0.726 ($p < .001$), followed by "anxiety" at r = 0.648 ($p < .001$), and "awareness of recovery" at r = 0.579 ($p < .001$). In patients with motor diseases, the correlation with "mental preparation" was the highest in "awareness of recovery" at r = 0.737 ($p < .001$), followed by "future coping measures" at r = 0.721 ($p < .001$), and "worthy things" at r = 0.650 ($p < .001$). The results are presented in Table 3.

4. Discussion

4.1 Basic attributes of patients

According to the fact-finding survey by the Kaifukuki Rehabilitation Ward Association in 2015 [16], the mean age of patients in nationwide convalescent wards was 75.8 (± 13.3) years, and the sex ratio was 42.5% men and 57.5% women. In terms of disease classification, cerebrovascular diseases accounted for

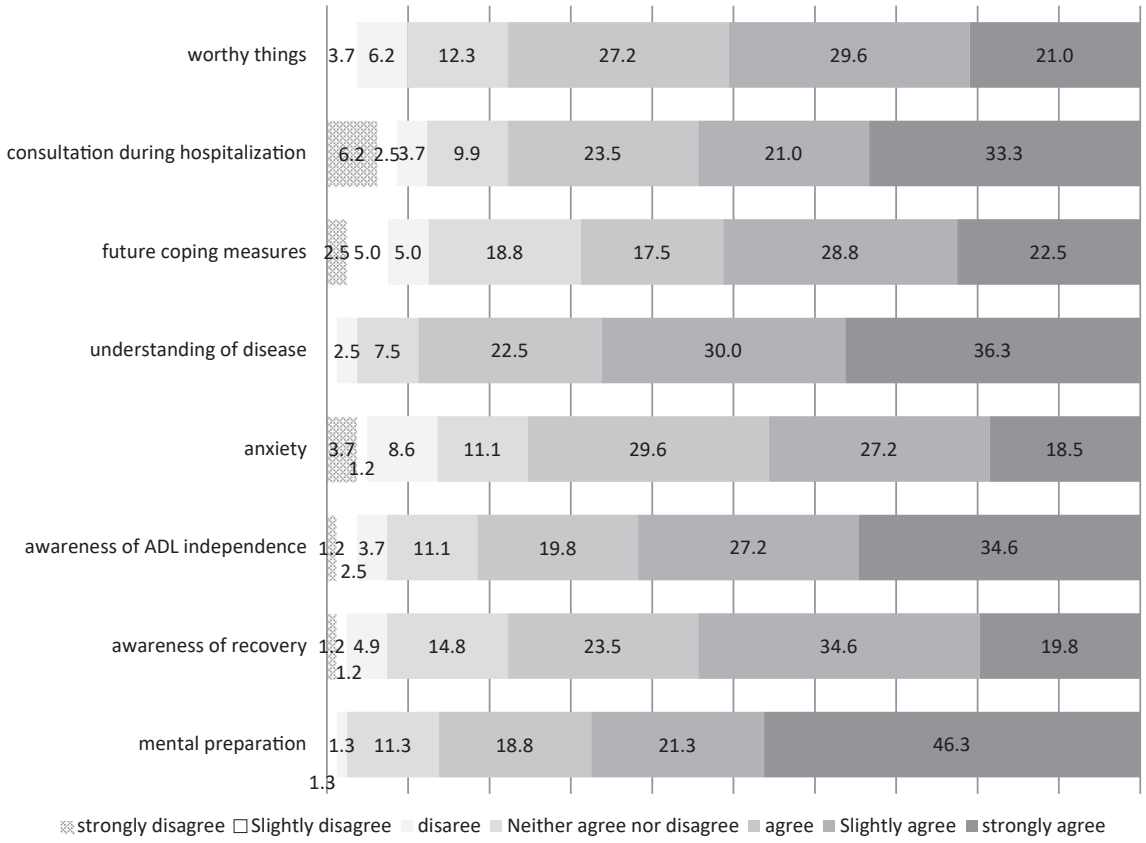

Fig. 1. Distribution of answers to the questionnaire.

Table 2 Correlation between FIM values and questions

	Mental preparation	Awareness of recovery	Awareness of ADL independence	Anxiety	Understanding of disease	Future coping measures	Consultation during hospitalization	Worthy things
Overall FIM value	**0.409**	*0.159*	*0.249*	*0.302*	*0.172*	*0.207*	**0.416**	*0.300*
FIM value in cerebrovascular diseases	0.509	*0.208*	0.478	*0.354*	*0.321*	*0.276*	0.481	*0.410*
FIM value in motor diseases	*0.409*	*0.338*	*0.176*	*0.359*	*0.238*	*0.330*	*0.545*	*0.426*

Spearman's rank correlation coefficient **Bold p < .001** Standard p < .01 *Italic n.s.*

Table 3 Correlation between questions in the questionnaire

	Awareness of recovery	Awareness of ADL independence	Anxiety	Understanding of disease	Future coping measures	Consultation during hospitalization	Worthy things
Overall mental preparation	**0.650**	**0.647**	**0.622**	**0.412**	**0.602**	**0.517**	**0.585**
Mental preparation in cerebrovascular diseases	**0.579**	**0.726**	**0.648**	*0.285*	*0.478*	**0.552**	0.526
Mental preparation in motor diseases	**0.737**	0.557	**0.605**	**0.601**	**0.721**	0.484	**0.650**

Spearman's rank correlation coefficient **Bold p < .001** Standard p < .01 *Italic n.s.*

47.3%, motor diseases accounted for 44%, and disuse syndrome and others accounted for 8.7%. The mean FIM value was 91.1, and the mean duration of hospitalization in the convalescent ward was 71.4 (± 42.4) days. Residences after discharge included home (69.3%), home-based service facilities (9.6%), hospital transfer (8.2%), and rehabilitation facility for the elderly (7.5%). With the exception of the FIM value and percentage

of residence after discharge, the basic attributes of the study subjects were similar to the national average for convalescent wards. Therefore, they were considered appropriate for the analysis. However, high mean FIM value and large number of patients who were discharged home are possibly influenced by the exclusion of patients with language disorders and cognitive impairment. Cognitive impairment is considered a factor contributing to ADL independence. The mean FIM value increased because patients with severe cognitive impairment were not included in the study. Accordingly, the percentage of patients discharged home was considered to have increased.

4.2 Relationship between ADL independence level and psychological aspects

This study examined the relationship between ADL independence and psychological aspects. The results showed that FIM values, which indicate ADL independence, were correlated with "mental preparation" and "consultation during hospitalization." Our results are significant because no previous study has shown the relationship between ADL independence and psychological aspects related to discharge. Although a causal relationship cannot be discussed, two hypotheses were proposed based on the results. The first hypothesis was that there is a relationship between ADL independence and mental preparation for discharge. Kajitani et al. [17] reported that patients and their families are sometimes forced to decide about the place of care after discharge without having sufficient images of recovery or recuperation. Even if the future state is vague, ADL independence enables them to easily imagine their living state and mentally prepare for discharge. However, as the previous studies shows, even patients and their families with a clear idea about home care since the beginning of hospitalization are often annoyed before discharge [18]. Thus, even if discharge is confirmed, it will be difficult to imagine life after discharge and tough to be mentally prepared for it without ADL independence.

The second hypothesis is that patients with ADL independence are more likely to have consultations or that patients with sufficient consultation are more likely to be ADL independent. Kudo et al.[19] pointed out that patients' lives after discharge may not align with the perspectives of therapists, who tend to focus on physical functions. Patient who consult in detail about matters that they, not the therapist, consider important at the time of discharge, may receive ADL support according to their individuality, thereby increasing their independence level. In a study on the roles of nurses in the convalescent ward, Sakugawa et al. [20] reported that nurses tended to focus on care functions such as ADL expansion toward return to home and were not aware of consultation services. Although all associated professionals understand the importance of providing consultation about patients' and their families' concerns in the convalescent ward, consultation services are lacking in the current situation, which is an issue.

Therefore, it is important for occupational therapists to provide support aimed at the life of patients after discharge. This raises patients' ADL independence level, which, in turn, facilitates their mental preparation for discharge. This is consistent with the findings of Kamoto et al.[21] regarding a gap in life after discharge experienced by patients with cerebrovascular diseases. In occupational therapy in a convalescent ward, it is necessary to provide interventions that match patients' specific life images from the time of admission, so that they can perform activities independently after discharge.

4.3 Psychological aspects toward discharge

The analysis exploring the psychological aspects toward discharge showed that Question 1 on "mental preparation" was correlated with all other seven questions. When patients' information was analyzed according to their disease, it was hypothesized that among patients with cerebrovascular diseases, those who are mentally prepared for discharge tend to be aware of their ADL independence and have no anxiety. According to Sakai et al. [22], who analyzed the common experiences of patients with cerebrovascular diseases, patients follow the following psychological course during the period from the onset to discharge: (1) perceiving their survival, (2) becoming aware of their difficulties and recovery, and (3) feeling glad to be alive. This psychological process for disease acceptance appears to be consistent with the results of this study that analyzed the psychological aspects at the time of discharge and showed that patients were aware of their ADL independence and had no anxiety. Furthermore, regarding the psychological process after discharge, Sakai et al. reported that although patients face obstacles of real-life hardship, they are supported by their experience of the joy of living and can continue making efforts. Sakai et al. pointed out the importance of providing support for psychological recovery during hospitalization. In this study, the analysis by disease revealed a correlation between "mental preparation" and "awareness of ADL independence" in patients with cerebrovascular diseases. Therefore, to promote awareness of ADL independence, support and oral encouragement that make patients feel that they can perform activities necessary for them "by themselves" can become helpful psychological supports. On the other hand, it was hypothesized that among

patients with motor disorders, those who are mentally prepared for discharge tend to be aware of their physical recovery and think that they have acquired the ability to apply future coping measures. Therefore, to make patients with motor disorders believe they can feel "this way enables me to do" teaching a specific way that allow patients to perform the activities necessary for them can become helpful psychological supports. Iida et al. [23] reported that healthcare professionals are required to empathize with the patients' wavering feelings and support them in developing positive attitudes. In the future, we will further analyze the data and like to propose specific methods of support based on disease-specific approaches.

4.4 Limitations of the study

As this study was conducted only in cooperating convalescent wards, its results cannot be generalized. Additionally, the results could be biased because the occupational therapists in each institution selected only those patients who could communicate effectively; those with communication problems were excluded. Therefore, it may be necessary to re-examine the survey method and selection of subjects. Additionally, while responding to the questionnaire on the psychological aspects, patients' subjectivity for the questions might have impacted the quantitative analysis. Therefore, an additional qualitative survey is necessary in the future.

5. Conclusion

We investigated the relationship between the ADL independence level and psychological aspects after the decision to discharge patients in convalescent wards. The results suggested that "there is a relationship between ADL independence and mental preparation for discharge" and that "patients with ADL independence are more likely to have consultation or patients with enough consultation are more likely to be ADL independent." Mental preparation for discharge differs according to the disease. In patients with cerebrovascular diseases, "a patient with mental preparation for discharge tends to be aware of ADL independence and has less anxiety," whereas in patients with motor disease, "a patient with mental preparation tends to be aware of physical recovery and feel that he/she has acquired future coping measures." Improvement areas for occupational therapy include listening to patients' concerns about life after discharge and having the perspective to talking to patients according to disease so that they do are peaceful when discharged.

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Declaration of interest

The authors affirm that there were no conflicts of interest related to this study.

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■ORIGINAL ARTICLE

Occupational Therapists' Perceptions of Quality of Life Among Stroke Clients: A Qualitative Descriptive Study

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Abstract: Background: Occupational therapists' perceptions of the 'quality of life' of stroke clients are not uniform, and therefore appropriate quality of life support is not always provided. The purpose of this study was to clarify occupational therapists' perceptions of quality of life of stroke clients and to help develop a new disease-specific quality of life scale and corresponding occupational therapy practice.
Method: The research design used was qualitative descriptive study. Inductive content analysis was used for the descriptive data obtained from the semi-structured interviews. The 12 participants included nine authorized by the Japan Association of Occupational Therapists with experience in working with stroke clients and three quality of life expert researchers.
Results: The qualitative analysis revealed that occupational therapists' perceptions of stroke clients' quality of life were based on the concepts of 'Adaptation to meaningful occupation', 'Good personal causation', and 'Family happiness and good relationships'.
Conclusion: Occupational therapy researchers and clinicians can use the three concepts identified in this study to develop new quality of life measures and to develop occupational therapy practice to improve the quality of life of stroke clients.

Keywords: stroke, quality of life, occupational therapy, qualitative descriptive study

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Introduction

In the field of occupational therapy, research on quality of life (QOL) has increased over the recent decades [1]. Occupational therapy, as a profession that promotes health and well-being, has significantly focused on enhancing QOL [2, 3].

The Occupational Therapy Practice Framework Domains and Processes 4th Edition (OTPF-4th Edition) explicitly places QOL and wellbeing alongside participation and work performance as desirable outcomes of the occupational therapy process [4]. There is also a report that emphasises the importance of Patient Reported Outcomes (PROs) as outcomes of occupational therapy, which are "reports of the patient's health status obtained directly from the patient, without interpretation of the patient's response by the therapist or others" [4]. As PROs is a general term for patient-reported clinical trial outcomes such as subjective symptoms, physical functioning, health satisfaction and QOL [5], we can say that QOL is one of the PROs of occupational therapy outcomes.

In order for occupational therapy to become a leader in health care that promotes health, well-being, and QOL, Pizzi states that it must define itself not as a rehabilitation specialist, but as an expert in QOL and well-being [6]. This model is referred to as the environment-health-occupation-well-being (E-HOW) model, which incorporates occupational participation, such as occupational demands, roles and performance, environment, such as social, physical and cultural contexts,

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and individual and group health as components of well-being and QOL framework [7, 8].

Therefore, if occupational therapy is to evolve as a contemporary and meaningful service, it must pay more attention to QOL and well-being, which are important for all human beings. In particular, we believe that this should be a priority for the continued development of occupational therapy for stroke clients, who are often involved in the physical disability field.

However, a review of QOL research in occupational therapy interventions states that QOL needs to be redefined and reevaluated from an occupational therapy perspective because of inconsistencies in the definition of QOL and the scales used to measure it [9]. In addition, although limited to Japan, occupational therapy intervention studies using QOL as the main outcome found that the definition of QOL was not standardized, and furthermore, the QOL scale as an outcome of occupational therapy was not unified among the 19 articles included [10]. Furthermore, in the only previous study that asked rehabilitation professionals about the concept of QOL and their perceptions of the profession, the differences in QOL as perceived by physicians, physiotherapists and occupational therapists were classified, but the details of the concept of QOL of stroke clients as perceived by occupational therapists were not clarified [11]

As described above, the concept of QOL has not been established as an important factor in occupational therapy outcomes and the occupational therapy process, despite its special value for occupational therapy and the fact that specific models are being created. We believe that one of the reasons for this is that occupational therapists have different and not unified perceptions of the QOL concept, i.e. the QOL as perceived by occupational therapists has not been clarified.

By examining and analysing this issue, it will be possible to have a more in-depth discussion about the QOL of stroke clients in a common language with other professions. In addition, the results of this study, together with developmental research on the concept of QOL as perceived by stroke clients themselves, may contribute to the development of a disease-specific QOL scale that can be discussed with other professions, which in turn may improve the QOL of stroke clients receiving occupational therapy services.

Therefore, this study focused on the QOL of stroke clients, who are most frequently involved in the field of physical disability, and aimed to clarify the quality of life of stroke clients as perceived by occupational therapists and QOL specialists who have been deeply involved with stroke clients.in addition The study was conducted after approval by the Research Ethics Committee of A University.

Research Method

Identification of the research method

This study adopted a qualitative descriptive approach to elicit occupational therapists' perceptions of the complex concept of QOL among stroke clients and help them describe their perceptions [12]. To obtain a wide range of codes, purposive sampling was used, with a target of approximately 10 ± 2 respondents, to ensure individuality and diversity.

Data saturation method was employed to continue the interviews using additional participants until no new subcategories appeared. When no new subcategories appeared, we included two or three additional interviewees to ensure the credibility and reliability of data saturation. This qualitative descriptive study was based on the 32-item checklist of the Consolidated Standards for Reporting Qualitative Research [13].

Participants

Practitioners as study participants

Only Authorized Occupational Therapists (AOTs) certified by the Japan Association of Occupational Therapists participated in this study. This certification assures that the practitioner has a specific level of competence in clinical practice, education, research, and the administration of occupational therapy. To ensure the reliability of the data, this definition was used to select the target population, assuming that occupational therapists with a specific level of competence in clinical practice would be the most reliable in recognising QOL. The number of licensed occupational therapists in Japan was approximately 100,000 as of 2021, of which 1,175 were AOTs and 54 were in X Prefecture (https://www.jaot.or.jp/member/ninteiList/qualificate/).

Purposive sampling was conducted, and the AOTs who fulfilled all the participation criteria were enrolled. The inclusion criteria were as follows: each participant must (1) work as an AOTs in a medical institution in X prefecture, (2) have at least three years of experience working in a rehabilitation ward as an occupational therapist, (3) agree with the purpose and main idea of this study, and (4) be willing to participate in the study.

To confirm that the selected participants fulfilled the above criteria, we consulted the AOTs list on the website of the Japan Association of Occupational Therapists to identify the names and affiliations of AOTs in X prefecture. The facilities with AOTs who had experience working in recovery rehabilitation wards were invited to participate. When obtaining consent for participation, the principal investigator explained the purpose and intent of the study in writing, and the study was conducted after informed consent was obtained from both

Table 1 Interview guide (Questions)

• H ow do you think about the QOL of clients with cerebrovascular disease?
• As an occupational therapist, what interventions have you performed for the QOL of cilents with cerebrovascular disorders?
• What is your most memorable experience of intervention for QOL?
• Do you think that there are cilents for whom it is easy to intervene in QOL and clients for whom it is difficult to intervene in QOL?
• What are the key words regarding the QOL of cilents with cerebrovascular disease?

the participants and their affiliated facilities. Specifically, we contacted 14 facilities in X prefecture via phone or email to request their participation. The facilities that did not provide consent were excluded. Therefore, AOTs from these facilities were excluded, even if the individuals agreed to participate.

Experts as participants

To clarify the perceptions of occupational therapists on QOL among stroke clients, we interviewed practitioners and QOL researchers (experts). This was to gain broader and deeper insights into QOL among stroke clients by adding researchers' (experts) perspectives to those of practitioners.

We enrolled participants meeting the inclusion criteria for purposive sampling. The inclusion criteria for participants were as follows: (1) qualified occupational therapist, (2) published at least three original papers including QOL as a topic, (3) had conducted practice or research on stroke victims, and (4) agreed with the purpose and objectives of the study and were willing to participate.

The principal investigator contacted potential participants via email or phone to arrange an appointment for each in the facility to which they belong. When obtaining consent for participation, the principal investigator explained the purpose and intent of the study in writing, and proceeded only after obtaining consent. Facilities that did not provide consent were excluded.

Data collection

Data were collected through semi-structured interviews based on an interview guide developed by the researcher. The creation of the interview guide was based on a framework [14], which included (1) the identification of the assumptions for the use of semi-structured interviews. Therefore, It was decided that semi-structured interviews would be appropriate for investigating the perceptions of the complex and abstract concepts of QOL. (2) Search for and use of prior knowledge: Extensive literature research regarding occupational therapy and QOL was conducted to identify what is known and what is unknown. (3) Formulation of a preliminary semi-structured interview guide: To obtain the richest possible data, the questions in the interview guide involved broad questions regarding QOL among stroke clients, and the questions were carefully designed to be clear, straightforward, open-ended, and elicit spontaneous and unique responses. (4) Pilot test of the interview guide: A pilot test of the interview guide was conducted by one of the participants, and it was concluded that the content of the guide was appropriate for the research questions and that it was adequately comprehensive to answer the questions we intended to ask. (5) Presentation of the completed semi-structured interview guide: From steps (1) through (4), we produced a relatively clear and complete interview guide for data collection. The decision to complete the interview guide was made following discussions with the collaborators. Additionally, the interview guide was mailed to the participants before the interview so that they could respond promptly (Table 1).

All the interviews were conducted online using Zoom, and the interview content was recorded as notes in a field notebook. The interviews were conducted over a period of approximately seven months, from 1 May 2021 to 4 December 2021.

Data analysis

The researcher conducted an inductive content analysis to explore occupational therapists' perceptions of QOL among clients with cerebrovascular disease [15]. The interviews were recorded using the Zoom, an online video conferencing platform, and the recordings were transcribed verbatim. When preparing the verbatim transcripts, the researcher checked for discrepancies between the recorded content and the transcripts. Data collection and analysis were carried out simultaneously, with data analysis commencing immediately after each subject was interviewed.

Open coding of the qualitative content analysis process was followed. The first step involved conceptualising the content of the data in short sentences, which were intercepted in several chunks. The second step involved grouping and defining the emerging concepts, combining similar ones. The third step involved developing the grouped categories and organising them into a hierarchical structure of subcategories, main categories, and core categories to build a coding frame [16]. This method has been shown to increase the reliability of the

Table 2-1 Overview of the research participants (Practiciners)

ID	Sex	OT Experience (Years)	Stroke intervention experience	Interview time (Min, Sec)	Engaged Stroke Phase	Cliant Age Group	Degree
A	Male	15	10	49`49	Recovery	elderly	Master
B	Female	16	5	85`15	Recovery	elderly	Doctorate
C	Male	16	3.5	83`9	Acute/Recovery	elderly	Doctorate
D	Male	10	9	56`30	Recovery	elderly	Advanced special
E	Female	36	3.5	35`52	Acute/Recovery	elderly	Master
F	Female	30	15	64`42	Acute/Recovery	elderly	Doctorate
G	Male	14	11	59`24	Recovery	elderly	Doctorate
H	Male	16	10	53`27	Recovery	elderly	Doctorate
I	Male	14	9	102`41	Recovery	elderly	Master

Table 2-2 Overview of the research participants (Researchers)

ID	Sex	OT Experience (Years)	Experience in QOL research (Years)	Interview time (Min, sec)	Number of peer-reviewed articles on QOL (eds.)	Total citations	Areas of work	Degree
J	Male	16	10	52`50	8	3	Training school teachers	Doctorate
K	Male	22	17	70`40	14	4	Training school teachers	Doctorate
L	Male	21	14	45`15	10	3	Training school teachers	Doctorate

coding process. It also determines the frame of classification, thereby allowing others to analyse the data similarly [16, 17].

To ensure the reliability of the analysis, coding was conducted together with the co-researchers and discussed to the satisfaction of the researchers. Additionally, the results were re-communicated to the participants for member checking, and the analyses of codes, subcategories, main categories, and core categories were repeatedly revised until consensus was reached, thereby ensuring the validity of the analyses. From open coding to the creation of coding frames, NVivo (USACO Corporation) was used as an adjunct to qualitative data analysis software.

Data saturation

Throughout the course of the analysis, 18 subcategories were generated at the end of the discussion involving the ninth subject. After completing discussions with the tenth participant, we confirmed that the data tended to fit into the existing subcategories and there was no need to generate new categories. Therefore, two additional participants were included in the study, and as it was confirmed that there were no additions to the existing coding frame and the data were considered saturated.

Findings

Overview of the participants

There were 12 study participants: nine AOTs as practitioners (ID: A-I) and three quality of life researchers as QOL experts (ID: J-L). Nine participants were male and three were female. The average interview time for all participants was 62.75 minutes. The average years of experience of the participants as occupational therapists was 18.8 ± 7.4 years. The degrees held by the participants were eight doctoral degrees, three master's degrees and one advanced professional degree.

The average number of years of occupational therapy practice with stroke clients for AOTs as practitioners was 8.4 ± 3.8 years. The participants' main stage of stroke involvement was recovery, with three participants indicating that they also had experience in the acute phase of stroke; the ages of the stroke clients with whom the AOTs were primarily involved were all elderly (Table 2-1).

The average years of experience of researchers on QOL was 13.6 ± 3.5 years, and the number of peer-reviewed articles on the subject of QOL was 8 (total citation 3) for J, 14 (total citation 4) for K and 10 (total citation 3) for L in the study, which The inclusion criteria for being a QOL expert (researcher) in this study were judged to be met (Table 2-2).

Occupational therapists' perceptions of QOL among stroke clients

Qualitative content analysis revealed 125 codes, 18 subcategories, six main categories, and three core categories. Occupational therapists' perceptions of QOL among stroke clients extracted from these coding frames were divided into three core categories: adaptation to

meaningful occupation, good personal causation, and family happiness and good relationships. These three core categories are described below (Table 3).

(1) Adaptation to meaningful occupation

The two main categories were as follows 'To be able to live the life you want' and 'being able to engage in the role'. These core categories have one thing in common: they are based on what the client wants and what the client (stroke victim) can do to adapt to their previous role.

In the main category, 'To be able to live the life you want', participants described stroke ' QOL as an experience of life shaped by their wants, values and needs. They also tended to perceive QOL as being about returning home and regaining control over one's lifestyle, rather than QOL when a person is hospitalised or admitted after a stroke. In addition, opinions about the ability to perform activities of daily living (ADLs), such as "I do not think that improving ADLs leads to improved QOL" and "Honestly, I did not feel clinically that ADLs support improved QOL", were not the main concepts of QOL.

In the other main category of 'being able to engage in the role', it was recognised that it is vital for stroke victims to engage in the roles of a stay-at-home spouse, e.g., cooking, cleaning, and performing other tasks that are required by their family and relatives. They also recognised that engaging in leisure activities and hobbies was important for enhancing QOL among stroke victims.

Based on these two main categories, we extracted core categories, such as 'adaptation to meaningful occupation'.

(2) Good personal causation

The two main categories associated with this core category were as follows: 'have an accurate perception of life and abilities', and 'have a sense of self-efficacy regarding their future life'.

'Have an accurate perception of life and abilities' reflects that many of the participants indicated it was imperative to continue their pre-stroke lifestyle, more realistic perception of their functional impairment and disability caused by the stroke was crucial to their QOL. They also emphasised that it is important for stroke clients and their families, supporters, and stakeholders to correctly understand their abilities.

In addition, two participants stated that 'have a sense of self-efficacy regarding their future life' had a significant impact on their quality of life, suggesting that self-efficacy is one of the aspects needed to improve stroke patients' QOL.

From these two categories, the concept of quality of life was extracted as 'Good personal causation', which indicates a state of high self-efficacy and a correct perception of the loss of function and ability due to stroke.

(3) Family happiness and good relationships

The two main categories—good personal relationships and a sense of happiness in the family—had one concept in common: family happiness and good relationships. The participants recognised that good relationships, especially among family members, are crucial to enhancing QOL. For example, when a daughter was the stroke patient's key person, some of the participants asserted that they ensured the daughter and the stroke patient did not get on badly and they supported the pair through occupational therapy aimed at maintaining their relationship.

In the category: a sense of happiness in the family, three participants perceived happiness and satisfaction within the family and by the stroke victim as indications of good QOL. One participant asserted that it was imperative to consider the security and happiness of family members, especially in the case of severe stroke victims who could not talk. Additionally, this participant argued that QOL is an interactive process, whereby the happiness of the caregiver (family) and that of the stroke victim must be harmonised.

The core category: family happiness and good relationships, describes a state of satisfactory interactions and happiness among stroke victims and their family members.

Discussion

This qualitative descriptive study aimed to identify the way in which occupational therapists perceive QOL among stroke clients. The results enabled the development of a novel disease-specific QOL scale for stroke clients and the identification of six main categories and three core categories that may be useful in enhancing QOL among stroke clients.

The first category of QOL among stroke clients as perceived by occupational therapists was the core category 'adaptation to meaningful occupation', which was generated from the main categories 'To be able to live the life you want' and 'being able to engage in the role'. This core category reflects the overall aim of occupational therapy, which is to enable clients to 'do' what they *want* or what they *must* [18]. The aims of occupational therapy can be considered similar to those aimed at improving clients' QOL. At first glance, this finding may seem obvious. However, clinicians may assume that because occupational therapists are

Table 3 Occupational therapists' perceptions of the quality of life of stroke clients

Core category	Main category	Sub category	Code
Adaptation to meaningful occupation	To be able to live the life you want	The happiness of living the life you want	• The part about what he wants to do or what he wants to do next is important. • It's about getting them closer to the life that they want, the life that they want to lead. • It's about what they were doing before the illness, what they want to do, what they want their life to be like. • How they want to live their life. • I think it's about how you want to live a good life, how you want to live a rich life. • How have you lived? What do you want to do, what are your characteristics? • I think it's important to make it possible for the patient to do what they want to do, what they wish to do. • If the patient feels good or happy, I think we are getting closer to QOL. • Not only in daily life, but also in what you want to do and what makes you happy, I think this will lead to QOL. • When the patient said he wanted to play futsal and drive, we did exactly that. • I think goals are very important. • First of all, what the patient thinks is the most important thing. • How does the person feel? It is a self-perception of one's life. • Quality of life is basically a subjective perception of the person's own life. • It's the person's sense of well-being. Whether the person feels happy or not. • QOL is mainly subjective, what do you want to do, what makes you happy? • I think that QOL is created by being able to achieve what you want to do. • I think OT is the only person who can do what he wants to do, what makes him happy and how he can communicate.
		Doing the daily activities you want after leaving hospital	• Think about life after discharge from hospital from the point of view of what kind of life is desirable for this person. • We think about how the patient is living at home. We think about the person's life after discharge. • The OT manages the patient's life, such as how we want the patient to live one year from now, and how we want the patient to spend their time at home. • We want to do this by focusing on their life after they go home. • I don't know if QOL will improve during hospitalization, but I think it will lead to QOL after returning home. • I think it would be easier to approach QOL after the recovery period is over and the patient is discharged from the hospital, when they become independent. • Not only in the recovery ward, but also after returning home, it is important to look at QOL in a linear manner rather than in terms of points. • I think it is better to call the patient after the recovery period, or to have tea with him/her after a few years, and to see how his/her QOL is in the end. • I think it is better to see how the patient feels about life after returning home. That's what we are here to support. • In the recovery stage, we need to know what the patient will be like when they return home one month after discharge. • I think it will be a little while before we can see the results of QOL, so I think the results of the support in the recovery phase will be seen three months after discharge. • There was a patient who had to go back to Okinawa, so I asked him about his home situation in detail, and thought about what I could do to help him stay in Okinawa. I asked him about his home and how he could spend his time in Okinawa.
		Wanting more than just ADLs; to live a full life	• Are you able to see what the patient is satisfied with, other than the ADL items? I don't think it's recognized that much. • In the first place, improving ADL is a matter of course in the recovery stage, and I don't think it is a goal to be given to individuals. • It is the mission of the recovery ward to improve ADL, so what are you saying that that is the goal? I think you have to set a goal based on what you want to do with the person's life. • There are people who say, "We have to improve ADLs," but since this is a ward like that, we should aim for more than that, don't we? • I thought it would be better to use theories such as the human work model to support the QOL of patients who are relatively independent in their ADL. • I don't think that improving ADL will lead to better QOL. • I think that raising ADL in order to get a performance index is itself harmful, and I think it may cause QOL to decline in the future. • To be honest, I didn't feel clinically that the ADL support was improving QOL. • If all you want is to be able to eat or change your clothes, or if you just want to be able to do things without any help from us, then in the true sense of the word, QOL is not about improving ADL first. • It's not just about raising ADLs, that's what I'm saying. • If it's a kind of uniform ADL training in the training room, well, as an occupational therapist, I think it's probably not QOL just to intervene there. • I'm just saying that you don't necessarily need a foundation of ADLs to improve QOL.
		Identify what arises from need and value	• Quality of life depends on each person's sense of value, and while quality of life may be valuable to one person, it may be of no value to another. • It is important to think about the value of the work and the value of the person. • When we think about QOL, we think about the value of the person and the achievement of the person's work. • I think it's important to uncover the latent needs of the client. • I think it's important to uncover the latent needs of the client. • It's been a bit difficult to provide quality of life support to people who have difficulty in eliciting their needs.

Core category	Main category	Sub category	Code
Adaptation to meaningful occupation	To be able to live the life you want	Be yourself in the way you live	• Quality of life is about how to live a life that is rich, how to be happy, how to be yourself. I think it's about how you can live your life, how you can be happy, how you can be yourself. • I think it's about the future, or rather, looking at a person's life in the future, and supporting them in their own way, their own identity, and their own happiness. • I would like to place importance on the person's own identity and happiness. • Indicators to help people and their families to live their own lives • Personality, or the way of life of the person. • What is the meaning of life for the person? • It means that the person walks on his or her own feet, in his or her own way.
	Being able to engage in the role	Be able to carry out the role	• By consciously assessing what the person needs to do, I think I naturally picked up on what the person wants to do. • There are roles and habits and things like that, so I think that's a very good part of the cost of interviewing and setting up these situations, as a skill for us. • The QOL was to regain the roles in the family and things like that. • There are many women who feel that they are the last housewife in the family, so we think that focusing on their own role will improve their QOL. • I think it's important to acknowledge the value of the client's existence, and to interact with them in such a way that they can maintain their role, even if only a little. • It is important to recognize the value of the client's existence. • When I thought about QOL, I thought that we should work towards regaining the role of the family and social participation. • To be able to participate in meaningful occupation.
		To do the important occupation that is required	• Being able to do the work that is important to the person, and thinking about why it is important, is linked to QOL. • I think that this will lead to the identity of the OT and the QOL of the patient. • A high quality of life is achieved when a person is satisfied with the work that they consider important. • What does the client want to do? Thinking about what are the important tasks, and being able to do them.
		To take up a role as a hobbyist	• The higher the leisure activities and hobbies of the client, the better the QOL. • It was concluded that intervening in leisure activities improved the QOL of the patient, and also created a positive cycle for the caregivers. • One of the ways to support QOL was to enable and expand hobby activities. • She was a person who participated in volunteer work and knitting circles at home, so it was good to enable her to do that. • I think that patients should have hobbies and other activities at the same time. • I think that providing activities based on hobbies and the like can be useful for QOL. • The approach to leisure activities and productive activities is also an approach to QOL. • OT is the only person who can intervene to make people feel that they can have a fulfilling life so that they can enjoy their favourite hobbies.
Good personal causation	Have an accurate perception of life and abilities	Rediscovering your life	• When I was practising taking the washing in and out of the washing machine on the ward, she pulled out the washing with her back to me and said, "This is how I used to live". • I was thinking about how I used to live my life, and how OT helps me to focus on that. • I thought it could help me to remember what I have been doing since I came back home, and what kind of life I have been leading. • In the end, it becomes "this is my life", and this process has a depth that supports QOL. • If you don't feel that you have got your life back, you should be happy with the hospital, you should be happy with this hospital.
		Being awareness as a sick client	• I think that we need to improve the quality of life of the sick people, even if they don't approve of the fact that they have a disease and it is natural that they can't do some things because of their disease. • Before we can move on to the next stage, we need to recognize that we have become ill and that there are parts of us that cannot be cured. • I think it's because he doesn't have the approval. I don't know who I can rely on, and I have to do it by myself, so I have to do it by myself . • First of all, it is important to accept the fact that we are approving you, and to make sure that you fulfil your role as a hospital. • I think that the sick should be sick because they are in a part of the hospital called the recovery rehabilitation ward. If we don't make them sick first, they won't be able to achieve what they want to achieve. • If you think that being independent as a sick person will improve your QOL, if you are not approved, your QOL will not improve in the long run.

Core category	Main category	Sub category	Code
Good personal causation	Have an accurate perception of life and abilities	Have a disability awareness due to stroke	• If you can't accept your disability, you can't be happy yet, or maybe you can't get the real QOL. • You have to understand your current situation, and you have to understand what will happen when you go home in a month. • It's not for us to teach them to understand their current situation, but for them to recognize that this is who they are and this is what they want to be. • I would like to make it important to create opportunities for the person to understand their own situation, their own existence, their own characteristics, and to express themselves. • I want them to be able to understand themselves, to be able to live with the disability, to think about their own health in order to take the next step. • The client has to be the sick person. It is only after that that the QOL of the next life can be achieved.
		Family understanding of disability	• It was more about being as involved as possible with the family. It was more about getting the family to understand the disability. • When it comes to quality of life, people who are easy to intervene with and people who are difficult to intervene with are the ones who can listen to their families. It is important to be able to listen to the family's perception. • When we were assessing the attention disorder of higher brain functions, we asked the family to see as much as possible. I would tell them that this is an attention disorder, and that it could affect their lives in this way.
	Have a sense of self-efficacy regarding their future life	Confidence in what they want to do	• From a comprehensive point of view, it is important to keep looking at the person and thinking about them, and not to forget their thoughts and feelings. • We use the MAL (Motor Activity Log). Well, the subjective confidence of the patient may be important. • I think QOL is the most important subjective QOL of the patient, and I think it is very necessary to do rehabilitation based on the patient's thoughts. • I think that in order to support QOL, we should not focus on subjectivity, such as "I feel like I can do it". • It is the subjectivity that is evaluated, such as the feeling that one can do something, or the feeling that one wants to do something.
		Awareness of what they feel they can do	• There is a relationship between self-efficacy and quality of life, and it can be linked to the development of occupational therapy to provide success experiences and to encourage the person to experience success in meaningful occupation. • An assessment method that reflects the feeling of being able to do something and the feeling of wanting to do something may be a QOL outcome in recovery. • If you can make people feel that they can do it, I think that is a wonderful perspective for occupational therapists in the recovery period. • In terms of QOL, I think that raising self-efficacy is one of the missions of OTs in the recovery phase. • How much the patient can do, and how satisfied they are with it.
Family happiness and good relationships	Good personal relationships	With family	• I think it is important to think about the relationship between the family and the patient, now and later. • If the mother is in hospital and there is a devoted daughter, when the daughter comes to visit the mother and daughter, it is important to have a friendly relationship with the mother and daughter so that they can meet and make small talk. • In the case of a severe patient, rather than thinking about the QOL of the patient, we think about the amount of care the family needs, and not only about the QOL of the patient, but also about the family. • I think the needs of the family and the needs of the patient are both important, so I like to provide QOL support that supports both. • We also checked with the father that the electric wheelchair would work well at home and that he would be able to get around. • I think a lot of people focus on whether they can do something with their family, so I thought it was very important. • I didn't want to bother my wife, so I practiced so that I could do it by myself. I think that was another way of supporting my QOL. • I think that supporting parent-child relationships, marital relationships and family connections can also be QOL support.
		With others	• What we need to focus on in the recovery period is social interaction with others. I think it is important to create social interaction after the patient returns home. • When I think about it in the recovery period, I also think that building relationships between therapists, nurses and other staff and clients is also a quality of life.
	A sense of happiness in the family	Family feeling secure and satisfied	• Isn't it important for recovery rehabilitation to make the family feel at ease? • I think that raising the satisfaction level of the family, as I did in the section on family satisfaction, is one form of QOL. • I don't know what the QOL of the patient is, but the family's QOL, the satisfaction of the family, can be improved, so we did transfer practice, family guidance, and wheelchair adjustment for about five months. • Regardless of what the patient thinks, it is the family that ultimately receives the treatment, so we have to make sure that we meet the family's needs. • The family should be able to feel at ease through the relationship. • For the families of patients who cannot talk about it, their trust in the hospital or rehabilitation will be determined by how the patient is treated.
		Carer's happiness	• If the patient is not happy, the caregivers will not be happy either. • If the patient is not happy, the caregivers are not happy either. • We paid attention to the family's sense of well-being, QOL, and the improvement of their quality of life. • The joy of the family may not be the same as the joy of the patient, but if we could support the joy of the family, it would be QOL support.

concerned primarily with the welfare, health, and well-being of their clients, they must use well-known measures associated with the broad concept of QOL [11] and that the widespread use of the term QOL is because there is general agreement regarding what it represents [19]. In other words, currently, there is no evidence showing that the stated and universally accepted aim of occupational therapy is improving and supporting clients' QOL. However, this may be a common assumption routinely found and reported.

Therefore, the concept of 'adaptation to meaningful occupation' as one of the occupational therapists' perceptions of QOL among stroke clients, which was identified in this study, can be considered synonymous with achieving the aims of occupational therapy, including the improvement of clients' QOL. This concept supports occupational therapists' perceptions that objectives of occupational therapy are closely related to QOL.

The second perception of QOL involves the core category 'good personal causation', which is generated from the following main categories: 'having an accurate perception of life and abilities' and 'having a sense of self-efficacy regarding future life'. The perception of ability and self-efficacy fall under the personal causation in the will, as described in the Model of Human Occupation [20]. The aftereffects of stroke are complex and include motor, sensory, and higher brain dysfunction. It is also argued that the negative consequences of illness create a perception that one is not in control [21]. On the other hand, those who think they can do well will seek opportunities, use feedback to modify their performance, and keep attempting to achieve their goals [22].

The results of this study indicate that occupational therapists perceive their clients' 'good personal causation' as satisfactory QOL. This may be because occupational therapists understand that even if a client suffers from various impairments owing to stroke, if they have a 'good personal causation', they will not become lethargic but will have a proper understanding of their current abilities and can challenge themselves through setting appropriate goals according to their abilities. Previous research has also shown that the ability to improve QOL depends on whether an individual can live the life they want while paying attention to their abilities [6, 8]; and the QOL of people with physical disabilities is not higher among those with minimal disability and not lower among those with complete paralysis [23, 24]. Some reports suggest that the disability status and QOL are not related. In other words, QOL among stroke clients, as perceived by occupational therapists, is not based on the actual degree of functional impairment or disability caused by stroke, thereby suggesting that the degree of personal causation attribution may be a crucial factor for determining clients' QOL.

The last core category: family happiness and good relationships is generated from the following main categories: good personal relationships and a sense of happiness in the family. It was established that occupational therapists perceived good personal relationships with family and caregivers and a sense of happiness among family and caregivers as stroke clients' QOL. Many previous studies on QOL and the relationships between family members and others have shown that QOL is influenced by the relationships between people and the help they receive as a result of these relationships[25,26]. In a study on QOL among clients, patient reports mentioned that family problems influence the perception of QOL. This is because occupational therapists know that QOL among stroke clients is closely related to the QOL of their family members. Therefore, focusing on the family's well-being may also be a vital factor affecting the enhancement of QOL among stroke clients. 'Family happiness and good relationships', one of the QOL concepts for stroke clients, can be generated through the interaction of good relationships between family and caregivers and the happiness of stroke clients and their family and caregivers.

The main reason for the identification of these three core categories may be that the main area of stroke involved by the study participants was the recovery phase. Recovery phase has an institutional function of restoring physical function, life skills and returning home [27]. However, stroke recovery is said to be a time when clients experience a separation of social roles and forms and switch to a new image of life, living with the disabilities caused by the effects of stroke [28, 29].

Skilled AOTs are likely to be highly aware of the importance of re-establishing social roles, disability perceptions and family presence necessary for reintegration back into the home by working deeply with stroke client during stroke recovery, and recognise that these concepts are closely related to the wellbeing and quality of life of the stroke client.

Therefore, the categories of 'adaptation to meaningful occupation', which focuses on re-establishing roles to improve stroke survivors' QOL, 'good personal causation', which indicates self-efficacy and self-perception of appropriate competence, and 'family happiness and good relationships', which indicates family relationships necessary for returning home, are considered to have been extracted.

Finally, we would like to discuss the differences between existing QOL measures and the QOL concepts extracted in this study. Typical QOL measures used by occupational therapists include the SF-36 and the WHOQOL-BREF [30]. However, the SF-36 does not

include content related to environmental and personal factors other than health and functioning [31], and the WHOQOL-BREF does not have enough items related to human environments and personal factors. Additionally, the Stroke-specific QOL scale has sub-items for vision, upper limb function, language function, mood, and energy, but it does not contain sufficient content related to the human, social, environmental, and personal factors.

There seems to be a significant difference between the results of this study and the QOL concepts of existing measures. The WHOQOL-BREF and the SF-36 are comprehensive QOL scales that are not limited to stroke. Comprehensive QOL scales are said to be superior in assessing general health status, mental status and comparison with healthy subjects. In other words, they do not address disease-specific aspects of stroke, which may be a reason for the differences between the results of this study and those of the present study.

In addition, the WHOQOL-BREF and SF-36 are scales developed by a wide range of subjects around the world, and cultural aspects of a limited number of subjects in a limited geographical area, as in this study, may have a significant impact on the results and be a factor in the differences in the concept of QOL.

However, our study aimed to identify concepts that were missing from traditional QOL indicators and had not been considered in the literature. In particular, we believe that the concept of QOL, which includes the philosophical background and identity of occupational therapy, is essential for the future development of occupational therapy.

Therefore, we believe that the novelty of the results obtained through this study involves the extraction of concepts that reflect the philosophy of occupational therapy, including ‘adaptation to meaningful occupation’, ‘good personal causation’, and ‘family happiness and good relationships’, which are not included in the existing QOL scales. The results of this study, combined with further research on the concept of QOL, as perceived by stroke clients, will contribute to the development of novel disease-specific QOL indicators among stroke clients and, ultimately, occupational therapy practices for improving QOL among stroke clients.

Limitations and directions for future research

This study has three limitations. First, the participants were occupational therapists, and the QOL among stroke clients cannot be determined by this alone. To clarify the concepts, future studies comparing and integrating stroke clients research participants are necessary. Additionally, further research based on the Consensus-based Standards for the selection of health Measurement Instruments (COSMIN) is necessary for future scale development. Second, this study clarified the perceptions of occupational therapists regarding the concept of QOL among stroke clients. The differences in QOL regarding other symptoms and diseases remain unclear. In future studies, comparisons with other diseases will be necessary. Finally, it is possible that social acceptance bias existed among some of the study participants. All participants were asked for their accurate and honest opinions prior to the interview, and sufficient member checking was conducted on their responses. However, it cannot be completely ruled out that some of the participants may have given answers that represented untrue intentions, but rather, those that were considered desirable by the public.

Conclusions

This study investigated occupational therapists’ perceptions of QOL among stroke clients. The results revealed that ‘adaptation to meaningful occupation’, ‘good personal causation’, and ‘family happiness and good relationships’ were the three major concepts contributing to QOL. These findings can be used by occupational therapy clinicians and researchers to address QOL among stroke clients and are vital for ensuring the development of QOL assessment scales and occupational therapy services.

Conflict of interest

There are no conflict of interest related issues to be disclosed in relation to this paper.

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■ORIGINAL ARTICLE

A Novel Developed Nine-Hole Pegboard to Assess Peg Travel and Reach Times

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Abstract: Objective: The aim of this study was to develop a personal computer (PC)-coupled nine-hole peg test (NHPT) incorporating an engineering device that could accurately measure the travel time of individual pegs and use it to provide standard data in healthy young women for future reference.
Methods: We produced a nine-hole pegboard consisting of a container with an accelerometer, a small photo reflector, and an amplifier. Four temporal variables were calculated using software developed by the researcher. NHPTs were performed by 37 healthy right-handed young women with dominant and non-dominant hands. The hand used, the distance from the container to the peg hole (index of difficulty; ID), task (container to the board and board to the container), and phase (peg movement time, reaching time) were used as independent variables.
Results: The developed pegboard was found to accurately measure the time in each of the assumed phases. The total performance time with the dominant hand was significantly shorter than that of the non-dominant hand ($P < 0.001$). Time to move the peg from the container to the board accounted for approximately 54% of the total performance time for both the left and right hands. The peg movement time increased performance time as the task difficulty increased ($P < 0.001$).
Conclusions: Our pegboard accurately measures movement times with individual pegs and the time to reach pegs without stopwatch assessments in young women. Baseline data on the right- and left-hand peg travel times and reach times for healthy young women were provided for future reference.

Keywords: nine-hole peg test, hand dexterity, rehabilitation, Fitts' law, functional assessment

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1. Introduction

The nine-hole peg test (NHPT) was developed in 1971, and its protocol, reliability, and validity were confirmed in 1985 [1, 2]. The National Institutes of Health Toolbox for Assessment of Neurological and Behavioral Function, a simple assessment tool for researchers and clinicians, was created in 2006 and recommended NHPT for assessing hand dexterity [3]. The NHPT consists of a container with nine pegs and a board with nine holes. The user must lift one peg at a time from the container, insert the peg into a hole in the board, and after all the pegs are inserted, return the pegs to the container one by one. The total time from the moment the finger touches a peg in the container to the moment that the last peg is moved back to the container is recorded.

The kinematic parameters measured by NHPT allow for the detection of early motor deficits, typical of some pathologies [4]. The NHPT has also been used in recent studies as an outcome measure for characterizing diseases, to determine the severity of disability and

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whether it can be self-managed, and to estimate the likelihood of improvements [5].

The advantages of the NHPT include simplicity, low cost, portability, short measurement time, and ease of application to all age groups. However, there are several disadvantages to the traditional testing method. First, although there have been attempts, the NHPT has not been technologically improved since 1971. Second, the test result is based solely on the total time, which cannot evaluate each patient's particular difficulty (e.g., in picking up the peg, transferring the peg, putting the peg in a hole, or putting a peg back in the container). Third, the difficulty of NHPT varies with the task (removing or inserting a peg) and distance (location of peg holes); thus, without evaluating the movement of individual pegs, the variation in the difficulty of NHPT is hard to evaluate in detail. The difficulty of the NHPT is determined by Fitts' law [6], which has been used as a quantitative definition of difficulty in various studies involving clinicians [7], healthy individuals [8], and two- and three-dimensional movements [9]. Fitts' law predicts that the operation time increases linearly with the task's index of difficulty (ID).

There were two aims in the present study; the first was to develop a new NHPT to accurately measure the travel time of individual pegs, and the second was to present future reference data in healthy adults using the newly developed NHPT. Regarding the development of new pegboards, we developed a method whereby an electro-optical device is fitted to detect the in and out movement of individual pegs, and a connected personal computer (PC) is used to acquire and analyze accurate time information. This method measures the time taken to move individual pegs, the time taken to reach the next peg to be moved, and the difference in distance to the position of the hole in the pegboard. Additionally, no measurements include the examiner's time measurement error, thus ensuring accurate data. Regarding the second aim, we provided detailed baseline data on peg movement times and reach times in healthy young women. Previous studies have reported gender differences in upper limb dexterity [2]. Therefore, in this study, subjects were limited to females to eliminate the influence of gender.

2. Methods

2.1. Participants

This study included 37 young, healthy female participants (mean age ± standard deviation [SD] = 24.6 ± 2.5 years old). The dominant hand was investigated using the Edinburgh Handedness Inventory [10]. All participants were determined to be right-handed (mean laterality quotient ± SD = 89.78 ± 10.36). No participants had a history of hand injuries. Each participant provided informed consent. This study was approved by the ethics committee at the Kawasaki University of Medical Welfare (No.17-104) and conformed to the Declaration of Helsinki.

2.2. Pegboard development

A wooden nine-hole pegboard box (length × width × height = 340 × 145 × 60 mm) with a round lightweight shallow plastic peg container (diameter = 105 mm) was built with reference to the size and depth of the holes and hole-to-hole distance of a commercially available Rolyan nine-hole pegboard (Model A8515, Sammons Preston Co., USA) (Fig. 1a). A miniature photo-reflector (RPR-220, Rohm Semiconductor Co., Japan) was fixed at the bottom of each hole to detect the light reflected by a small, lightweight wooden peg (weight = 0.5 g, diameter = 7 mm, length = 32 mm) (Fig. 1b). Self-built analog amplifiers for photo-reflector signal amplification were also placed inside the pegboard box (Fig. 1c). A miniature 3-D accelerometer (ADXL-335, Analog Device Co., USA) was attached to the back side of the container to detect the vibration caused by the participant touching a peg. The distances from the hole and container centers were 110 mm for the first column, 142 mm for the second, and 174 mm for the third. Electrical signals from the photo-reflector and the accelerometer were A/D-converted (250 Hz/channel) and stored on a PC.

2.3. Experimental procedures

The experiment was conducted in a quiet clinical room. Each participant was briefed about the experimental task to be performed after receiving a demonstration of the task by one of the researchers. The participant then sat on a chair, faced the test table on which the pegboard was placed, and performed practice trials until they felt comfortable performing the task. The first task was to move the pegs from the container, one by one, and place them into the holes on the board as quickly as possible ("Task A"). The second task was performed without pause, consisting of removing the pegs from the board, one by one, and returning them to the container as quickly as possible ("Task B") (Fig. 2). The experimenter said "start" to initiate the task. When using the right hand, the container was located on the right side of the board, while for left hand movements the container was located on the left side of the board. Pegs were always inserted and removed from the holes in the front line to the third line, from the first column to the third column for the right hand, and from the third column to the first column for the left hand. For the experimental data collection, each participant performed the task

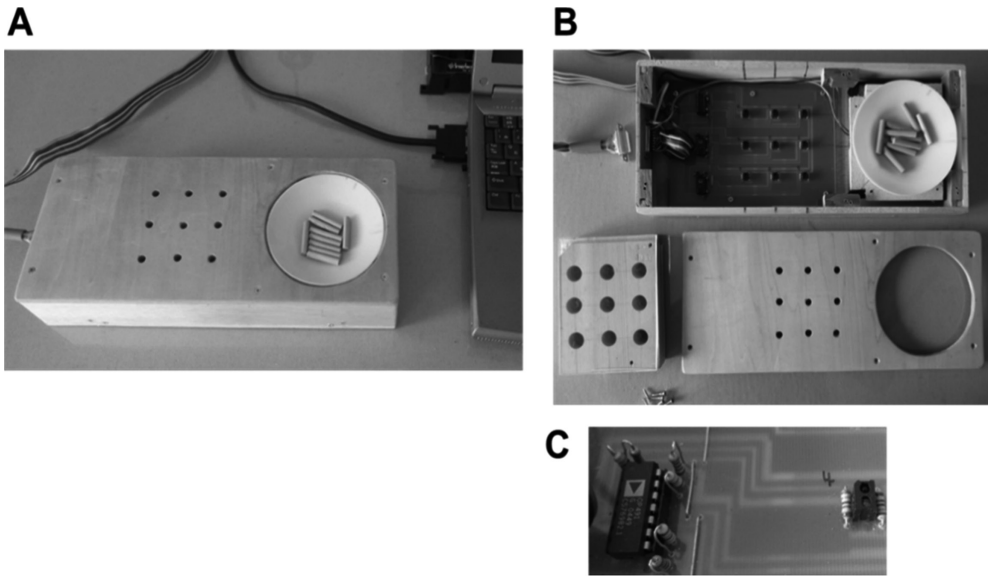

Fig. 1. PC-connected nine-hole pegboard.
A. A nine-hole pegboard with sensors was developed. B. The electrical circuits installed inside the pegboard C. One of the photo-reflectors and operational amplifiers.

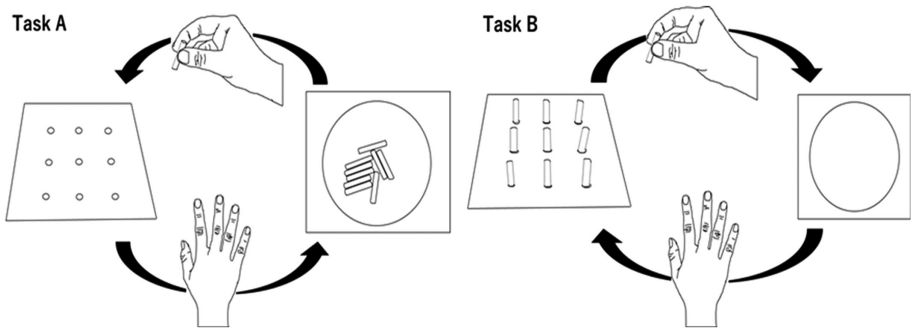

Fig. 2. Procedural operation.
Task A. The task is to take the peg from the container and put it in the hole, then reach for another peg in the container. Task B. The task is to return the peg inserted in the hole to the container and then reach the peg inserted in the hole.

twice for each hand. Adequate breaks were provided between trials to minimize fatigue. Failure to grasp a peg or dropping the peg in the middle of the task resulted in retesting.

2.4. Data analysis

A MATLAB (MathWorks, version 9.12)-based program was developed by the authors to determine the moments of accelerometer signal onset for finger-peg contact on the container and the peg drop in the container. The photo-reflectors onset and offset moments represented the insertion of a peg into the hole and removal of a peg from the board (Fig. 3). Another MATLAB program was used to compute four temporal variables for each of the nine pegs for the subsequent statistical analysis. The temporal variables included durations from the finger-peg contact to the hole insertion (Fig. 3a) and from the hole insertion to the next peg contact on the container (Fig. 3b) during Task A, as well as durations from the removal of the peg from the board to the container (Fig. 3c) and from the drop into the container to the removal of the next peg on the board (Fig. 3d) during Task B. Durations depicted in Figs. 3a and 3b were the durations needed to move the pegs, which we termed "*peg movement times*." The durations depicted in Figs. 3c and 3d involved the movement of the hand to reach the next peg to be moved, which we termed the "*reaching times*."

The total performance time was determined from the initial finger-peg contact moment to the final peg drop in the container moment. The total time in Tasks A and B was the sum of peg movement and reaching times for the nine pegs. The time for the inter-task interval was also computed by subtracting the total times of the

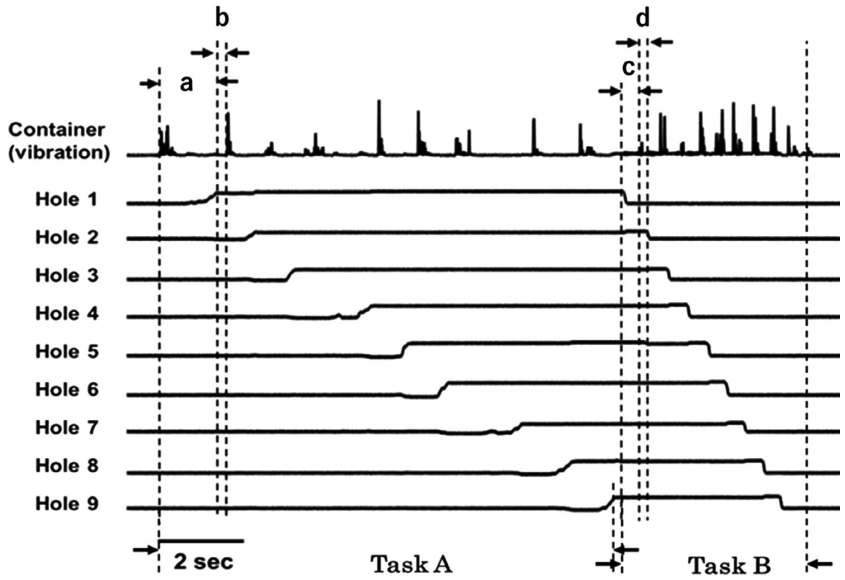

Fig. 3. Signal output from the sensor pegboard and the examined temporal variables.
a. Peg movement time during the container-to-board task; b. reaching time during the board-to-container task; c. peg movement time during the board-to-container task; d. reaching time during the container-to-board task.

container-to-board and board-to-container tasks from the total performance time.

2.5. Statistical analysis

Statistical analysis was performed with IBM SPSS (Statistical Packages for Social Sciences, 21.0) with a chosen significance level of 0.05. Depending on the purpose of the comparison, a paired samples t-test or two-way analysis of variance (ANOVA) with repeated measures was used. When performing the two-way repeated measures ANOVA, the independent variables used were the task (Tasks A and B), phase (peg movement and reaching times), hand used (right or left), and column (first, second, and third columns). Post hoc multiple comparisons were performed using a Bonferroni method when necessary.

2.6. Application of Fitts' law to the nine-hole pegboard performance

Fitts studied the relationship between the size of an object, the distance to a target, and its associated motion time from a tapping task with a metal stylus and expressed these relationships in the following equation:

$$MT = \mathrm{a} + \mathrm{b} \times \mathrm{ID}$$

Movement time (MT) is the movement time to the target, "a" and "b" are constants, and ID is the difficulty of the movement, which is expressed by the following equation:

$$ID = \log_2\left(\frac{2A}{W}\right)$$

where "A" is distance and "W" is width.

3. Results

3.1. Total performance time

The mean values of the total performance, peg movement, reaching, and inter-interval times for all participants for each hand and task are summarized in Table 1. The peg movement times for Task A accounted for 54.1% of the total performance time for the right hand and 55.2% of that of the left hand. For Task B, the peg movement times were 15% of the total performance time for the right hand and 14.7% of that for the left hand. The reaching and task interval times for both tasks were approximately 14% and 2% of the total performance time for both hands, respectively. The results of the paired t-test are also presented in Table 1. For both tasks, the total performance, peg movement, and reaching times were significantly lower with the right hand than with the left hand.

To investigate whether the differences in time for tasks were due to differences in the tasks performed (Task A or B) and phase (peg movement time, reaching time), we performed ANOVA of the two corresponding factors, with task and phase as independent variables and time as the dependent variable. There was an interaction of task × phase ($F(1, 72) = 3{,}572.984$, $P < 0.001$). There was a main effect in both task ($F(1, 72) = 4{,}227.638$,

Table 1 Mean total performance, peg movement, and reaching times for the Task A and Task B with right and left hand.

	Total perfomance time	Task A		Task B		Task interval time
		Peg movement time	Reaching time	Peg movement time	Reaching time	
right hand (sec)	15.78 (1.21)	8.53 (0.71)	2.31 (0.24)	2.37 (0.26)	2.22 (0.33)	0.35 (0.05)
left hand (sec)	17.48 (1.33)	9.65 (0.83)	2.51 (0.34)	2.56 (0.23)	2.39 (0.34)	0.37 (0.09)
t-test t-value	−8.15***	−7.52***	−4.45***	−5.65**	−2.98**	N.S

The values in parenthesis are the standard deviation. ** $p < 0.01$, *** $P < 0.001$.

$P < 0.001$) and phase ($F(1, 72) = 3{,}926.839$, $P < 0.001$). Peg movement time in Task A was approximately 3.6 times higher than that in Task B (9.1 vs. 2.5 s; $P < 0.001$). Reaching time in Task A was greater than that in Task B (2.41 vs. 2.31 s; $P = 0.013$). Peg movement time was greater than the reaching time for both Tasks A and B ($P < 0.001$).

3.2. Index of difficulty of the NHPT

The difficulty in Task A in a descending order of the distance between the column and the contender was as follows: first column ID, 7.6 bits; second column ID, 8.1 bits; and third column ID, 8.4 bits. In contrast, the difficulty in Task B was as follows: first column ID, 1.0 bits; second column ID, 1.5 bits; and third column ID, 1.8 bits.

3.3. Peg movement time in Task A

To investigate whether the differences in peg movement time in Task A were due to differences in the hand used (right or left) and distance (first, second, or third column), we performed an ANOVA of these two factors, with hand and distance as independent variables and time as the dependent variable. The results showed that there was no interaction of hand × distance ($F(2, 72) = 0.710$, $P = 0.495$), but the main effects of hand ($F(1, 36) = 53.063$, $P < 0.001$) and distance ($F(2, 72) = 87.597$, $P < 0.001$) were significant (Fig. 4). Task A took approximately 3.6-times longer than Task B. Multiple comparisons using the Bonferroni method showed that the first column was the faster and the third column the slowest. The left hand required more time than the right, and the third column required more time than the first.

3.4. Reaching time in Task A

There was no hand × distance interaction for the reaching time in Task A ($F(2, 72) = 1.015$, $P = 0.368$), but there were main effects of hand ($F(1, 36) = 11.967$, $P = 0.001$) and distance ($F(2, 72) = 12.505$, $P < 0.001$) (Fig. 5). The results of multiple comparisons using the Bonferroni method showed a significant difference between the mean times for the second and third columns for the right hand ($P = 0.011$). There was a significant difference between the mean times for the first and third columns for both left and right hands (right hand: $P = 0.001$, left hand: $P = 0.038$).

3.5. Peg movement time in Task B

Regarding peg movement times in Task B, there was an interaction of hand (right or left) × distance (first, second, or third column) ($F(2, 72) = 3.929$, $P = 0.021$). There was a main effect of hand ($F(1, 36) = 30.079$, $P < 0.001$) and distance ($F(2, 72) = 183.598$, $P < 0.001$) (Fig. 4). Multiple comparisons using the Bonferroni method showed the first column was the faster and the third the slowest.

3.6. Reaching time in Task B

There was no interaction between hand and distance ($F(2, 72) = 0.730$, $P = 0.485$). Further, there was no main effect of distance ($F(2, 72) = 1.868$, $P = 0.162$), although there was a main effect of hand ($F(1, 36) = 7.029$, $P = 0.012$) (Fig. 5).

4. Discussion

4.1. A newly developed NHPT

In the frequently used NHPTs, an examiner with a stopwatch signals the beginning of the test to the individual, starts the measurement by visually judging the start of the individual's movement, and stops it upon visual confirmation of the last peg being moved to the container. The measured results are always influenced by the examiner's judgment and stopwatch operation errors. Moreover, the only time information available from these tests is the total task execution time, and no detailed movement time information related to the manipulation of the pegs can be obtained. To overcome these challenges, we developed a prototype NHPT that can identify peg travel times using electro-optical technology. The results showed that the novel NHPT could measure the travel time of individual pegs between the container and the board and the peg arrival time of the hand in milliseconds. The importance of separating the peg transfer from the container to the board in the first half (Task A) and from the board to the container

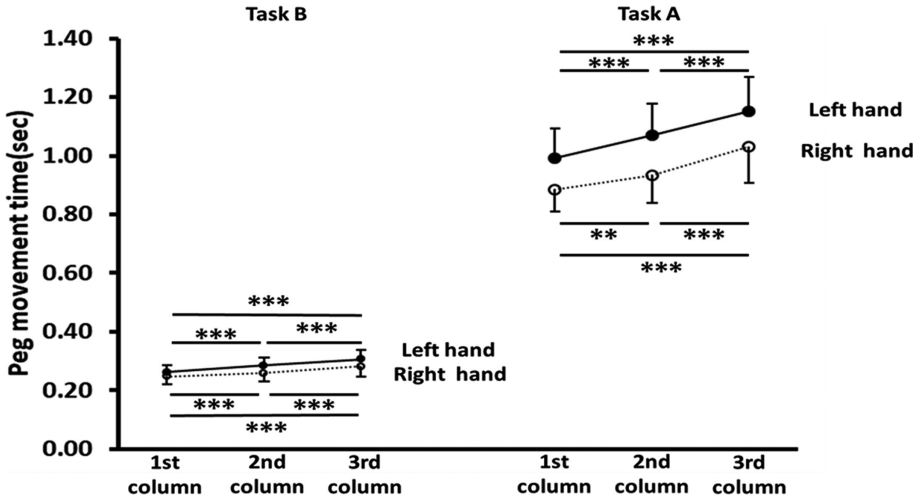

Fig. 4. Peg movement times for each distance with the right and left hands.
As the distance increased, it took longer to complete the task with both the left and right hands. ** $P < 0.01$, *** $P < 0.001$.

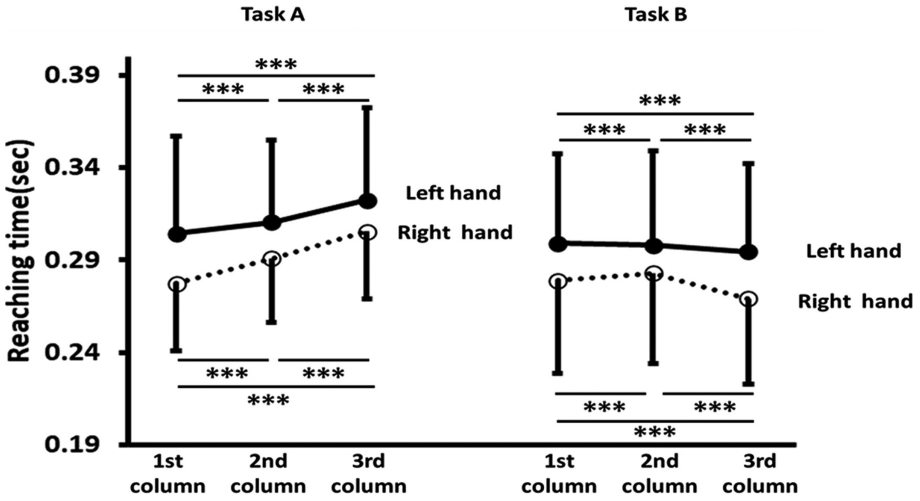

Fig. 5. Reaching time with the right and left hands.
The 1st column represents the holes close to the container, the 2nd column represents the holes in the middle of the pegboard, and the 3rd column represents the holes far from the container. In Task A, the reaching time increased as the distance increased. In Task B, reaching took more time at closer distances than at farther distances. *** $P < 0.001$.

in the second half (Task B) was also demonstrated. Furthermore, the differences between peg transfer time and hand reaching time to the peg were also clarified, allowing a more detailed assessment of the individual's dexterity function with more time variables. Incorporating a system for wireless data capture to mobile phones and software for an immediate evaluation of results can improve the usefulness of this new device.

4.2. Task differences

Regarding peg movement times, it became evident that the peg manipulation time became longer as ID increased in both Tasks A and B. The peg movement time of Task A accounted for approximately 55% of the total performance time with both the left and right hands, clearly showing that Task A required longer to move pegs than Task B. The IDs of the peg movement of Tasks A and B were 7.6–8.4 bits and 1.0–1.8 bits, respectively. The peg movement time in Task A was approximately 3.6 times longer than that in Task B. The peg movement time for both Tasks A and B tended to increase as the ID increased, which supported the results of previous studies [11]. The time required for the left and right hands increased as task difficulty increased, as indicated by the difference between the left and right hands (191 ms for Task B and 1,129 ms for Task A).

In Task A, the movement times became longer as the distances to the object increased. These results

supported a previous study on online feedback and trajectories in pointing tasks in which the time required for reaching increased as the distance to an object increased [12, 13]. However, in Task B, which showed no significant differences, there was a reverse trend in which the movement time was shorter for the third column than that for the first column. To clarify the cause of these results, we filmed several participants performing the test. Throwing the peg into the container was frequently observed as the peg movement distance became longer. This reversal may have occurred because the reaching distance became shorter than the actual distance because participants were throwing the peg.

Taken together, the NHPT is an evaluation method that includes two types of tasks that differ in difficulty: grasping and manipulating an object and reaching for it. The results for peg movement and reaching times in Tasks A and B suggested that the degree of difficulty of each task differs. Even for peg manipulation, inserting a peg in Task A and removing it in Task B have different characteristics. To perform the NHPT correctly, it may be necessary to instruct the participants to place the pegs in the container and prevent them from throwing the pegs during Task B.

The concept of task difficulty may help assess the upper extremity. In the context of specific upper extremity functional assessments, such as the NHPT, Purdue Pegboard Test [14], and O'Connor Finger Dexterity Test [15], the task difficulty differs owing to changes in the transmission distance. Nevertheless, the index for these assessments is the total time required to perform the task. We suppose that their task difficulty was quantified in the same way as in this study. In that case, it might be possible to identify patient problems, develop training content and new treatment methods, linking assessment to rehabilitation.

4.3. Baseline data

Detailed baseline data on the NHPT of 37 healthy young women were provided. Cross-group studies of dexterity using the pegboard test have often identified that women perform better than men [2]. A recent study has found that women are significantly more dexterous than men, even when hand size is considered [16]. Thus, in the present study, only women were included, considering the differences in dexterity between men and women. The total performance time was shorter for the dominant right hand (15.78 ± 1.21 s) than that for the nondominant left hand (17.48 ± 1.33 s), and significant differences in the interval time required to switch between tasks were found. The right hand had shorter execution times in Task A, Task B, and each of the four phases. The results of this study were consistent with previous studies [17], which showed that the dominant hand elaborates and shortens the motor time more than the nondominant hand.

4.4. Limitations

This study has some limitations. Healthy young right-handed women with their normative values were included, and data on men, healthy individuals of a wider age range, left-handed individuals, and patients with hand dexterity problems were not included, which is an issue that needs to be addressed in the future. Furthermore, the board was prototyped using a commercially available NHPT as a model, and the data obtained were analyzed using dedicated software developed by the researchers. For use in clinics and other facilities, it is necessary to develop general-purpose software that allows data to be easily processed and calculated on a PC or a mobile phone.

5. Summary and conclusions

This study introduced a newly developed PC-connected NHPT that automatically measures peg insertion and peg lifting, dividing it into two tasks and four phases. Moreover, detailed baseline data on peg movement times and reaching times were obtained in the left and right hands of 37 healthy young women, showing that a longer time was required for the left hand than for the right hand in all four phases and with the increasing ID of the NHPT.

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Disclosure statement

No potential conflicts of interest were reported by the authors.

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■ORIGINAL ARTICLE

Variation in Lifestyle and Readiness of Participants of a Return to Work Program According to Depressive State by a Mixed Design Method

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Abstract: Background: Mental health problems in the workplace are an important issue globally, and return-to-work (RTW) programs for people on sick leave because of mental health problems are being developed. However, participants' situations and states are various and there are few assessment tools.
Objectives: We aimed to reveal the clinical picture of participants of an RTW program according to depressive state with mixed method research to help occupational therapists plan client-centered rehabilitation programs.
Methods: We used a conversion mixed methods research design. We collected basic information and administered the Beck Depression Inventory (BDI) in the quantitative arm, and used written rehabilitation plans based on interviews conducted in the initial stage assessments of participants in an RTW program as the qualitative arm. Data from the quantitative arm were divided into three groups according to severity of depressive symptoms based on BDI cut-off points. Qualitative data were analyzed by creating codes and categories following the grounded theory approach. Both types of data were merged by calculating the frequencies of occurrence of codes for each depression severity group.
Results: Our results showed that participants' clinical pictures were different depending on their depressive state. Participants with a severe state had difficulty waking up early, disordered eating habits and appetite, and difficulty with selfdisclosure. Participants with a lighter depressive state had a stable lifestyle and were able to perform high-level cognitive activities like studying or exercise.
Conclusions: Our results will help occupational therapists assess participants in the initial stage RTW programs, and contribute to effective interventions.

Keywords: depression, return to work, assessment, mixed design

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Introduction

Mental health problems in the work place are one of the most important issues globally. For these problems, prolonged absence or separation from work is one of the issues that needs to be resolved [1]. Support and appropriate assessments for the people absence from work by mental health problems is one of the central role of occupational therapists.

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Various interventions have been conducted and reported on in the literature. For example, Nieuwenhuijsen et al. [2] reported that the combination of a work-directed intervention and clinical intervention reduced the number of sick leave days. Stronger evidence was also found for cognitive behavioral therapy-based stress management [3]. The effectiveness of occupational therapy for depressive symptoms is already supported by strong evidence, and various occupational therapy practices also have been shown to improve clients' daily lives and work performance, and increase participation in the workforce [4]. In return-to-work programs, occupational therapists reported possibility of playing a role with intervention focused on cognitive functions [5]

In Japan, similarly, absence from work and

retirement due to mental health problems have constituted a significant issue. The number of employees on administrative leave has increased rapidly, and the number of cases of mental health issues recognized as being work-related in 2019 was the highest ever. Investigations of employees who returned to work after leaving due to depression also showed that 47.1% of them took administrative leave again, and the second period of leave was 1.5 times longer than the first [6-8]. Moreover, Endo's report from an information technology company showed that there was a steep increase in recurrent rates the first two years after RTW [9]. To resolve this situation, in Japan, return-to-work (RTW) programs under the direction of psychiatric doctors in mental health clinics have been implemented since the 2000s, and were reported the effectiveness in depressive state, social anxiety and parasympathetic activity [10, 11]. Many occupational therapists have become involved in various programs and taken on the central role of conducting the programs. Support for RTW programs in Japanese society has since been growing [12]. However, the problems in daily living and concrete disabilities experienced by RTW users in Japan have not yet been clarified because there have been few reports on the matter.

In RTW programs in Japan, generally, various interventions based on group therapy are conducted, for example, cognitive behavioral therapy, psychoeducation, and assertive training [13]. In Japan, a psychiatrist or industrial doctor is responsible for the occupational therapists conducting RTW programs, and the entry qualification for RTW programs primarily consists of only the taking of a leave of absence from work at the point of starting the RTW program. As a result, the client's situations, with respect to things such as depressive state, period of leave, motivation, relationships with their co-workers and family, and activities outside of work, are varied. Initial assessments in RTW programs tend to be based on a medical model and, as mentioned above, are quite uniform, despite being graded according to the client's depressive state. In other words, the clinical picture in the initial stage of RTW is not evaluated thoroughly enough. Therefore, although occupational therapists' focus is client-centered, there tend to be few interventions in individualized settings [4]. This situation too might be caused by the structure of RTW programs in Japan, which are packaged, uniform, and group based; however, this is not an issue unique to Japan, and is one of the common challenges faced worldwide in the relatively new field of occupational therapy in RTW. For client-centered interventions in RTW, we first need to reveal the full variety of clinical pictures of clients in the initial stage of RTW.

On the other hand, we generally only have few and limited tools for initial assessments, such as the Beck Depression Inventory (BDI) [14], The Center for Epidemiologic Studies Depression Scale [15], or the Psychiatric Rework Readiness Scale (PRRS) [16]. Therefore, in order to develop more effective RTW interventions, we need further investigations to help assess clients based on evidence in the initial stage and to set attainable goals.

The purpose of this study was to clarify RTW program participants' clinical pictures in the initial stage according to their depressive state through mixed method research. The results are expected to enable occupational therapists to play an important role in planning precise RTW rehabilitation programs and allow for more effective client-centered interventions.

Materials/Subjects

We used a mixed method design for the purposes of this study, which aimed to clarify RTW program participants' clinical pictures in the initial stage according to their depressive state. We used interview data from staff to develop initial rehabilitation plans as qualitative data for grasping participants' clinical pictures. We also used BDI scores as quantitative data to assess participants' depressive state. BDI was the main assessment tool in previous studies, and thus enables us to compare our results with those of previous studies, and to verify the position of our results in this area. Therefore, we adopted BDI scores as quantitative data for producing a quantitative standard. After collecting both the qualitative and quantitative data, we merged them. This method enabled us to explore multiple perspectives based on both qualitative and quantitative factors, and reveal relationships spanning multiple research questions such as RTW participants' clinical pictures, depressive state, and readiness for work [17].

Participants in both the quantitative arm and qualitative arm

Participants were users of an RTW program. The RTW program was conducted at one clinic in Aichi Prefecture in Japan. The conditions for participation in this RTW program were absence from work due to mental health problems, depression, adjustment disorder, or bipolar disorder. The aim of the RTW program was to ensure a smooth return to work for RTW users by gradually increasing their level of activity aiming toward an eventual return to work. The program was conducted 5 days a week, and was combined with cognitive behavioral therapy, desk work, self-help

meetings, communication training, and exercise. Professional staff including occupational therapists assessed participants and conducted the RTW program based on the assessment. The general usage period of RTW programs in this institute was about 4 to 5 months. The contents of the RTW program conducted in this institute are standard in Japan, and the program is registered by the Japan Association of Rework for Depression [18], which plays a central role in public awareness in Japan.

The inclusion criteria for participants in this study were as follows: (a) started using the RTW program at the participating facility from 2017-2020, (b) absence from work at the start of the program, (c) diagnosis of major depression or an adjustment disorder according to the Diagnostic and Statistical Manual of Mental Disorders 5th edition (DSM-5), and (d) consented to participation in this study. The exclusion criteria were: (a) diagnosis of bipolar disorder or a developmental disorder according to the DSM-5 and (b) quitting work at the start of the program. We recruited the participants at the end of their RTW program taking into consideration their depressive state and mental health burden. We gave them information on our research and requested their participation and use of their data. All the participants provided written and verbal informed consent to participate. All procedures were approved by the Research Ethics Committee of the Graduate School of Medicine, Nagoya University, Japan (authorization number: 2018-0149) in 2018, and followed all ethical standards laid out in the Declaration of Helsinki.

Methods

Instruments

Background information and measurement: Quantitative arm

We collected the following data as background information: age, sex, years of education, number of leaves of absence from work, kind of work, work position, length of current service, and number of job changes. We also conducted the BDI, which is a self-administered questionnaire used to assess individuals' depressive state in the preceding 2 weeks. Higher scores indicate depressive symptoms as being more severe. The cut-off scores are as follows: 0-13 (minimal), 14-19 (mild), 20-28 (moderate), and 29-63 (severe). The validity and reliability of the Japanese version of the BDI have been confirmed [19]. The BDI assesses depressive state for preceding 2 weeks. Hence, in this study, in order to assess the depressive state on the starting day of the RTW program, participants answered the BDI between the first and 14th day of the RTW program.

Rehabilitation plan: Qualitative arm

We collected documents of rehabilitation plans written based on initial interviews for assessments and goal setting at the initial stage of the RTW program. In the documents, results of interviews included free-writing text, and we used that text data in this study. The initial interview was a semi-structured interview that lasted from 40 minutes to 1 hour, and was conducted during the same period as the BDI. Contents of interviews were constructed based on the participant's needs and assessment items were extracted from the PRRS [16]. The PRRS is an observational assessment for readiness of actual work in the last 2 weeks and consists of the following eight items: living condition, symptoms, basic social skills, support, relationship with the participant's company, work ability, readiness of actual work, and health management.

Data analyses

Data from the quantitative arm were divided into three groups according to severity of depressive symptoms based on the cut-off points of the BDI. Each background data item was compared among three groups: severe (BDI: 21-40), light (BDI: 11-20), and minimal (BDI: 0-10).

Data from the qualitative arm were analyzed in steps. Firstly, we conducted incident-by-incident initial coding following the Grounded Theory Approach [20] for one participant. After that, we conducted focus coding depending on the contents of the initial code. Finally, we divided the focus codes into categories.

After analyzing the data in both arms, we merged the quantitative data and qualitative data, and calculated the frequencies of occurrence of focus codes in the severe depression group based on BDI scores. Namely, we calculated the occurrence rate as follows in each depressive state group: number of initial codes in the same focus code in each group per number of participants included in each group. According to the occurrence rate, we reviewed the characteristics of the participants.

Results

Participants

94 individuals used an RTW program in this research period, and 27 participated in this research. 24 males and three females participated, and the average age was 40.7±9.95 years. Table 1 shows detailed sociodemographic data of the study participants.

Table 1 Demographics of participants

	All participants (n=27)	Severe group (n=8)	Light group (n=13)	Minimal group (n=6)	P value †
Average age, years (SD)	40.7 (9.95)	41.3 (8.73)	38.0 (10.7)	46.1 (8.86)	0.28
Average BDI(SD)	17.9 (9.53)	29.5 (5.26)	16.6 (3.12)	5.33 (1.21)	<.001 MG < LG < SG**
Sex (Male/Female)	24/3	7/1	11/2	6/0	0.61
Complication (with/without)	14/13	3/5	11/2	0/6	0.18
Number of leaves of absence,					0.07
1	14	1	9	4	
2	5	3	2	0	
3	6	2	2	2	
4	2	2	0	0	
Occupation,					0.36
Sales work	1	1	0	0	
Clerical work	8	2	5	1	
Engineering or technical work	13	4	5	4	
Medical work	2	0	2	0	
Public official	1	1	0	0	
Others	2	0	1	1	
Position					0.87
Higher than manager	11	3	5	3	
General	16	5	8	3	
Average years of incumbent employment (SD)	17.2 (10.8)	17.5 (3.5)	15.1 (11.4)	21.3 (11.3)	0.49
Number of job changes,					0.37
0	22	5	12	5	
1	2	1	1	0	
2	3	2	0	1	
Education level,					0.016
Less than high school	1	0	0	1	
High school graduate	12	3	9	0	
College graduate or more	14	5	4	5	

Note.MG = Minimal group, LG = Light group, SG = Severe group, SD = standard deviation, BDI: Beck Depression Inventory, IQR: interquartile range.9.53

†Scores between the three groups were compared using One way ANOVA and t-test for age, BDI, years of incumbent employment. Scores between the three groups were compared using Pearson's chi-square test for sex, complication, number of leaves of absence, occupation, position, number of jobs change and education level.

Quantitative arm

The mean BDI of all participants was 17.9±9.53. Participants were divided into three groups based on BDI score: minimal group (six participants), light group (13 participants), and severe group (eight participants). The mean BDI in each group was as follows: minimal group (5.33±1.21), light group (16.6±3.12), and severe group (29.5±5.26). Background information in each group is also shown in Table 1. In only education level, although it showed different trends between the minimal group and light group significantly, we were unable to conduct further analysis due to the limitation of the small number of participants. All other factors were not significantly different among the three groups.

Qualitative arm

We identified 570 initial codes based on our procedure, and after the next stage, we developed 124 focus codes. Finally, we created 13 categories. The names of the categories were as follows (the number

Table 2 Developed focus codes and categories

Category (number of focus codes-initial codes)	Examples of focus codes
Lifestyle (15-98)	Have three meals a day
	Going to bed later than usual on work days
	Drinking habit; once a day
Sleep (15-69)	Difficulty getting to sleep
	Have interrupted sleep
	Have hypersomnia
Taking medicine (3-28)	Missing doses
	Only take medicine as needed
Activity (12-66)	Housework
	Exercise
	Watching TV
People, interpersonal relations and social scenes that participants don't like (17-73)	People who put themselves under high pressure or are angry
	Shy of strangers
	Feeling others can't understand me
Psychiatric symptoms when in a bad condition (14-46)	Feeling something is wrong with mentality
	Being pessimistic
	Decreased concentration
Somatic symptoms when in a bad condition (14-33)	Headache
	Palpitation
	Abdominal pains/diarrhea
Current relationships with people at work (5-24)	Little contact with people at work
	Regularly contact with people at work
	Want to transfer
The relationships with family or doctor (2-3)	Wanting to transfer a different hospital
Purposes of RTW program (27-132)	Already decided the period of returning to work
	Participating in the program without absence
	Reinforcement of interpersonal skill
	Finding my own pace for life

RTW: return-to-work

of included focus codes-the number of included initial codes): Lifestyle (15-98), Sleep (15-69), Taking medicine (3-28), Activity (12-66), People, Interpersonal relations and social scenes that participants do not like (17-73), Psychiatric symptoms when in a bad condition (14-46), Somatic symptoms when in a bad condition (14-33), Current relationships with people at work (5-24), Relationships with family or doctor (2-3), and Purposes of the RTW program (27-132). Table 2 shows examples of the focus codes.

Merge of quantitative data and qualitative data

We extracted, in each group, focus codes with frequencies of occurrence of over 50%. We showed the frequencies Table 3.

As a result, the following five focus codes showed frequencies of over 50% in all groups: *Difficulty in getting to sleep*, *Housework*, *People who put themselves under high pressure or are angry*, *No missing doses*, and *Already having decided the period of returning to work*. In the severe group only, *Waking*

Table 3 Frequencies of occurrence of focus code

	Name of category	Name of focus code (number of included initial codes)	Number of included initial codes (Percentage of frequency :%)		
			Severe group (n=8)	Light group (n=13)	Minimal group (n=6)
All three groups in common	Sleep	Difficulty getting to sleep (18)	5 (62.5)	10 (76.9)	3 (50.0)
	Activity	Housework (20)	4 (50.0)	11 (84.6)	5 (83.3)
	People, interpersonal relations and social scenes that participants don't like	People who put themselves under high pressure or are angry (20)	6 (75.0)	10 (76.9)	4 (66.6)
	Taking medicine	No missing doses (23)	8 (100)	11 (84.6)	4 (66.6)
	Purposes of RTW program	Already having decided the period of returning to work (22)	6 (75.0)	11(84.6)	5 (83.3)
Only severe group	Lifestyle	Wake up later than you should for work (10)	4 (50.0)	4 (30.7)	2(33.3)
	Purposes of RTW program	Finding my own pace for life (9)	4 (50.0)	5 (38.4)	0 (0)
		Participating in the program without absence (10)	4 (50.0)	6 (46.1)	0 (0)
Severe group and light group	Life style	Skipping meals (11)	4 (50.0)	7 (53.8)	0 (0)
	People, interpersonal relations and social scenes that participants don't like	Shy of strangers (15)	4 (50.0)	9 (69.2)	2 (33.3)
Light group and minimal group	Lifestyle	Have an appetite (14)	3 (37.5)	7 (53.8)	4 (66.6)
		Have three meals a day (17)	3 (37.5)	8 (61.5)	6 (100)
Only minimal group	Psychiatric symptoms in bad condition	Feeling something is wrong with mentality (12)	2 (25.0)	6 (46.1)	4 (66.6)
	Activity	Exercise (10)	3 (37.5)	3 (23.0)	4 (66.6)
		Studying (5)	1 (12.5)	0 (0)	4 (66.6)
	Purposes of RTW program	Understanding the contents of the program (6)	3 (37.5)	0 (0)	3 (50.0)
		Reinforcement of interpersonal skills (8)	1 (12.5)	3 (23.0)	4 (66.6)
		Working as usual (7)	1 (12.5)	2 (15.3)	4 66.6)

up later than needed to for work, *Finding one's own pace for life*, and *Participating in the program without absences* showed frequencies of over 50%. Also, *Skipping meals* and *Shy of strangers* showed frequencies of over 50% in the severe group and the light group. On the other hand, in the light group and minimal group, *Having an appetite* and *Having three meals a day* had high frequency focus codes. Additionally, we revealed the following six focus codes as having over 50% frequency in the minimal group only: *Feeling there is something wrong with own mentality*, *Exercise*, *Studying*, *Understanding the contents of the program*, *Reinforcement of interpersonal skill*s, and *Working as usual*.

Discussion

The aim of this study was to reveal RTW participants' concrete clinical pictures in initial stage according to their depressive state. We focused on characteristic categories, and discussed our results from the following three points: variation in attitudes towards participation in the RTW program according to depressive state; clinical picture in daily life; and characteristics in interpersonal activities.

Variation in attitudes of participation in the RTW program according to depressive state

Already having decided the period of returning to work was revealed to have a high frequency in all groups, which showed that participants had high motivation for the RTW program. Additionally, in all groups, *No missing doses* showed a high frequency, which showed that participants had high treatment compliance. In Japan, generally, re-work programs are optional programs provided in addition to outpatient care; therefore, participants choosing to participate in an RTW program of their own volition suggests it is possible that they agree with their own diagnoses and thus take their medication as directed.

However, *Participating in the program without absence* and *Finding one's own pace for life* showed a high frequency in the severe group only. This result suggests that participants with a severe depressive state had little confidence about participating in the RTW program and being able to reconstruct their daily lives thorough the program. Therefore, based on those results, we focused on wake-up time as a factor causing absence in the program, and participants in the severe group, at high frequency, woke up later than usual (*Waking up later than needed to for work*). Previous studies reported that depression caused insomnia [21], and patients with depression tended to have difficulty waking up because of sleeping disorders or diurnal variation [22]. Similarly, in this study, participants with a severe depressive state seemed to show this code at a high frequency. On the other hand, our results showed *Difficulty in getting to sleep* was common in all stages of depression. A previous study showed continuity of this symptom [23] over all recovery stages of depression, and our results supported the results of this previous research. Therefore, our results suggested the necessity of focusing on regulation of participants with severe depressive state for participation in RTW programs. Occupational therapists, in other words, should pay attention to clients' wake-up time and promote regulation in their lives, in addition to interventions for continuous difficulties based on insomnia as generally seen in clients with depression. Actually, in some previous reports of rehabilitation for the clients with depression [24, 25], regulation of their life or time management was suggested as the first step of rehabilitation or occupational therapy.

Generally, is it recommended for clients to have achieved a certain recovery stage at the start of an RTW program because they are required to participate in activities through the program. Based on this, however, we suggest that occupational therapists should focus on participants in a severe depressive state who are experiencing difficulties that occur more easily in the initial recovery stage, and conduct appropriate interventions for them.

In the minimal group, additionally, in accordance with the purpose of the RTW program we revealed focus codes such as *Understanding the contents of the program* and *Reinforcement of interpersonal skills*, which were above simple participation, and constituted the more advanced purposes of the RTW program. Moreover, participants were able to notice their minor psychiatric symptoms (*Feeling there is something wrong with one's own mentality*). Occupational therapists tend to think that understanding of the purpose of the program and the participants' own states develops after the middle stage of the rehabilitation period, namely the stage when some recovery has been achieved; however, our results showed that participants with a very low depressive state could understand those purposes and understand themselves even in the initial stage of the RTW program. Such understanding can promote participants' motivation, and therefore, in order to put it to use in the RTW program, occupational therapists will need to select an appropriate intervention without being biased by the stage of the program.

Daily activities participants performed

When we focused on the participants' lifestyles, skipping meals was common in the severe and light groups. In addition, some participants in the light and minimal groups indicated they had an appetite and had three meals a day. This result indicates that participants' appetites in the initial stage of rehabilitation might be an indicator of depressive state. In the DSM-5 [26], decreased or increased appetite with significant weight loss are common symptoms of depression. Moreover, Papadimitriou [27] mentioned the co-occurrence of disturbed sleep and appetite loss, and some reports have suggested appetite and the sleep/wake cycle were the most sensitive biological rhythms. In this study, similarly, delayed wake-up time co-occurred with decreased appetite in the severe group. Occupational therapists tend to focus only on factors directly related to work performance; therefore, it is easy to overlook participants' appetite. However, these results suggest that the degree of a participant's appetite is an important indicator in RTW programs.

We also discussed the activities the participants performed. Housework was conducted by participants in all groups. Generally, housework includes activities that require high-level cognitive functions, like cooking or child-rearing. Otherwise, housework can also include easy and short-duration activities like taking out the garbage or simple cleaning. In other words, housework can be thought to require several kinds of cognitive functions. As such, most participants in different depressive states might be able to perform housework.

On the other hand, studying and exercise were characteristic activities in participants in the minimal group. Generally, studying is a desktop activity that requires high-level cognitive functions such as attention and memory. In our results, participants in the minimal group seemed to be able to perform activities like studying using cognitive functions that improved in accordance with their recovery from depressive symptoms. Previous studies suggested that impairment of attention, executive functioning, and verbal memory continued in patients after remission, and also that those cognitive dysfunctions were influenced by the remaining depressive symptoms [28, 29]. Additionally, the severity of cognitive functioning impairment was said to be one of the independent indicators of psychosocial aspects [30]; therefore, focusing on cognitive functioning through activities the participants performed was important from the viewpoint of the RTW program, in order to assess participants' state in the initial stage of rehabilitation.

Exercise was also one of the characteristic activities in the minimal group. Previous studies have also shown physical activity and depression to be consistently inversely associated [31]. Based on those reports, similarly, the amount of physical activity in participants in the minimal group seemed to be higher than those in other groups with a more severe depressive state. Focusing on participants' activities is essential in occupational therapy, and based on our results we believe that occupational therapists can investigate, as part of the initial assessment, whether clients perform activities requiring high-level cognitive functions or actions like exercise or desktop activities, as indicators.

Characteristics in interpersonal activities

In interpersonal activities, participants in all groups showed unpleasant feelings towards people who put themselves under high pressure or were angry. Many previous reports [32] mentioned high sensitivity for interpersonal factors in interpersonal conflicts in people with depression, and the Interpersonal Sensitivity Scale (IPSM) [33] was used in many of those reports. The IPSM consists of five underlying components: interpersonal awareness, separation anxiety, timidity, fragile inner self, and need for approval. Discussed from the viewpoint of those five components, unpleasant feelings towards individuals who put themselves under high pressure or are angry in our results seemed to be related to sensitivity of "interpersonal awareness" and "timidity". Further, participants in the severe group and light group mentioned they were "shy of strangers", potentially indicating a "fragile inner self" as described in the IPSM. Moreover, Luty et al. reported not only that the total IPSM score was strongly correlated with depressive state, but "fragile inner self" was also the only significantly correlated factor with depression in the five sub-axes in the IPSM [34]. From these considerations, it can be said that interpersonal problems revealed in this study were expressed at the appropriate point, indicating high interpersonal sensitivity in those with depression.

Clinical Implications

We revealed a variety of depressive states and clinical pictures among users in the initial stage of an RTW. Sleeping disorders and degree of appetite are appropriate considerations for the assessment of RTW users' state. Moreover, the contents of the activities they performed were varied, and might have changed according to depressive state. As a clinical implication, carefully listening to information about users' daily lives based on the specialty of occupational therapists is suggested to be important. These points

are self-evident for occupational therapists; however, RTW programs tend to follow a medical model, and we cannot deny that we tend to overlook these aspects in our practice. We believe that we should develop our interventions based on those results. In this study, we did not collect detailed data regarding participants' occupations in the interviews, such as information about the meaning of their occupation, because we focused on users' clinical pictures in the initial stage of the RTW program, in which their condition is usually severe and it is difficult for them to develop rapport with others. If we conduct those assessments in the middle stage of the RTW, interventions could potentially be more effective and client-centered.

Limitations

First, we should note that our results are based on data from only one clinic. There is thus the possibility of bias in both participants and staff participating in our research. Additionally, participants were skewed toward being male. Therefore, it might be difficult to generalize our results, although they did reveal important perspectives. In order to generalize and make our results relevant to clinical practice, we need to conduct further research in the future.

Second, qualitative data were collected from interviews based on the PRRS. The PRRS is an assessment specific to RTW, and it was matched with the participants and purpose of this study. However, by using the PRRS, we could not focus on other characteristics or clinical pictures not included in it. In a future study, to compensate for this problem, we need to acquire more information about participants through observation or unstructured interviews.

Third, we set depressive state (as determined by BDI score) as a factor influencing participants' lifestyles and clinical pictures, and divided qualitative data based on BDI score. However, factors besides depressive state can influence sick leave, including developmental disorders, economic state, and sex [35]. Moreover, the degree to which these factors influence the clinical picture is unclear. In order to clarify this, we hope to analyze qualitative data based on other aspects. It is also important to clarify the degree to which those factors influence participants' daily lives.

Summary and Conclusions

We investigated the clinical pictures of participants of an RTW program according to depressive state in a cross-sectional study with a mixed method design. Our results showed that participants' clinical pictures differed substantially depending on their depressive states. Participants with a severe state had difficulty waking up early, had disordered eating habits and appetites, and they seemed to be unable to use the RTW program properly. Additionally, they tended to feel difficulty with self-disclosure. On the other hand, participants with a lighter depressive state had stable lifestyles, and they could perform high-level cognitive activities like studying or exercise. They also could use the RTW program and understand its contents.

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Declaration of Conflicting Interests

The authors confirm that there is no conflict of interest.

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■ORIGINAL ARTICLE

The Effects of Cognitive Rehabilitation Targeting Frontal Lobe Executive Function in Mild Cognitive Impairment

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Abstract: Background: Mild Cognitive Impairment (MCI) are known to revert to normal cognition, so early intervention during the MCI stage is required. MCI is reported to be associated with a reduction in frontal lobe volume, blood flow, and metabolism; dysfunction of the frontal lobes has also been reported to increase the risk of progressing to dementia. This study verifies the effects of cognitive rehabilitation targeting frontal lobe executive function in MCI.
Method: MCI patients aged over 65 were divided into a group taking part in the Frontal/Executive Program (FEP Group), and the Control Group. Ten FEP Group patients took part in the FEP, and nine Control Group patients took part in the Group Exercise Program, 22 times each. Cognitive function was evaluated with MoCA-J, BACS-J, and WCST.
Results: The FEP Group showed significant improvements over the Control Group in verbal memory, working memory, executive function, conversion of sets, and persistent wrong answers. A dramatic effect was also seen in the FEP Group before and after intervention in verbal memory, working memory, verbal fluency, executive function, conversion of sets, and persistent wrong answers. These effects on verbal memory, verbal fluency, and conversion of sets were maintained for a period of three months. In addition, 60.0% of the patients in the FEP Group reverted to and maintained normal cognition for three months.
Conclusion: Improvements were seen in the target function due to cognitive rehabilitation targeting frontal lobe executive function. A high rate of reversion was also seen from MCI to normal cognition.

Keywords: cognitive rehabilitation, dementia, executive function, frontal lobe, mild cognitive impairment

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Introduction

Mild Cognitive Impairment (MCI) is a condition mid-way between normal cognitive changes caused by aging and dementia. The patients are in a state in which, despite a decline in cognitive functions, their daily life activities are successfully maintained. MCI cannot be considered as necessarily being the first manifestation of an underlying neurodegenerative process, as it can be caused by transient and reversible conditions (e.g. nutritional deficits, affective disorders, cerebrovascular events, physical frailty, sleep disorders, and social issues). Therefore, MCI is an unstable and fluctuating condition, with subjects actually experiencing a reversion to normal cognition over time. While between 20 and 25% MCI patients reverts to normal cognition [1, 2], the rate of MCI progressing to dementia has been reported to be between 10 and 32.5% annually [3–5]. Early detection and early intervention in the MCI stage are therefore important.

Researchers have reported that MCI is caused by a reduction in the volume of the subregional basal forebrain's cholinergic system, and a reduction in the volume of gray matter in the frontal and temporal lobes [6, 7]. In MCI, similar to the lowered perfusion seen in

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mild Alzheimer's dementia (AD), blood flow decreases in various areas of the brain, such as the medial temporal lobe and the temporal/parietal cortices, posterior cingulate cortex, and the anterior prefrontal cortex [8–10]. In addition, 79% of multiple-domain MCI are reported to show decreased frontal metabolism in combination [11]. Amnestic MCI multiple domains have a high risk of progressing to AD. This risk is reported to be especially high if psychomotor speed and executive functions have declined [12]. We also know that MCI in individuals whose cortex in the prefrontal, temporal, and parietal regions is thin are at high risk of progressing to dementia, and that both amnesia MCI and non-amnesia MCI cases have a high risk of progressing to dementia if they are accompanied by frontal executive dysfunction [13, 14]. It can be said, therefore, that, a reduction in frontal lobe gray matter and blood flow, as well as frontal lobe dysfunction, are characteristic of MCI, and that such dysfunction elevates the risk of MCI progressing to dementia.

Based on the neurological findings described above, pharmacotherapy and non-pharmacotherapies is used. For example, among non-pharmacotherapies in interventions using aerobic exercise, functional improvements are reported in general cognition, working or immediate memory, language ability, multitasking, cognitive flexibility, information processing speed, and selective attention [15, 16]. Studies investigating the effects of cognitive rehabilitation using computer programs has reported functional improvements in language learning, memory, focused attention, processing speed, and conversion of attention [17, 18]. Interventional studies that combined aerobic exercise and cognitive rehabilitation, meanwhile, have reported improvements in working memory, executive function, Mini-Mental State Examination scores, and logical memory, as well as reduced atrophy of the left medial temporal lobe [19, 20].

As seen from the above, the risk of transition to dementia is high when dysfunction of the frontal lobe is present in MCI, therefore improvement of dysfunction of the frontal lobe and prevention of functional decline are important therapeutic targets. Prompted by the lack of conclusive results of interventions that directly target dysfunction of the frontal lobes, which are seen in a majority of MCI cases, we carried out this study to investigate whether there are improvements in MCI's cognitive impairment as a result of cognitive rehabilitation that targets the frontal lobe executive functions and to identify conversion rates of MCI to dementia and reversion rates to normal cognition.

Methods

Subjects

We used community bulletin boards at three sites in Hidaka-cho, Hokkaido, to display a leaflet that described the significance and purpose of this study, the content of the program to be implemented, and conditions for participation. People aged 65 and older with concerns about their cognitive function were stated to be eligible for participation. We also called for participation in the study by distributing similar leaflets at a nursing care prevention class held at one location in the town. We explained the content and purpose of the study orally, and obtained the participants' consent. In a private room, a therapist individually performed the Japanese-language edition of the Montreal Cognitive Assessment (MoCA-J) [21] on the 23 individuals who had been recruited as described above. Of these, 19 who were suspected of having MCI based on MoCA-J were used as the subjects of this study after eliminating 4 individuals with normal cognition (MoCA-J $\geq$ 26). Next, the 19 individuals who were adopted as the study's subjects took part in base point evaluation, and 10 subjects who requested to participate in the cognitive remediation program. were assigned to the FEP Group (four males, six females, mean age: 79.5 $\pm$ 5.5 years), and the remaining nine to the Control Group (one male, eight females, mean age: 76.3 $\pm$ 5.4 years) (Fig. 1). All study participants (23 subjects) provided informed consent, and this study was carried out on receiving approval by the A University Graduate School of Clinical Psychology Research Ethical Committee.

Content of the intervention

Frontal/Executive Program

The subjects in the FEP Group took part in a one-hour per session cognitive function improvement therapy once or twice a week for a total of 22 sessions. The cognitive function improvement therapy used a Frontal/Executive Program (FEP) [22] that was formulated by focusing on the frontal lobe/executive function, and implemented on a one-on-one basis with an occupational therapists or nurses inside a quiet, private room. An FEP normally comprises 44 sessions. For this study, however, we used a program that consisted of 22 sessions, An FEP normally comprises 44 sessions. For this study, however, we used a program that consisted of 22 sessions, with the number of sessions in each module halved in the first half, in consideration of the subject's physical fitness. The FEP comprises three modules: Cognitive Flexibility, Working Memory, and Planning. Cognitive flexibility module is intended to enhance flexibility in attention and cognition. Working memory module aims

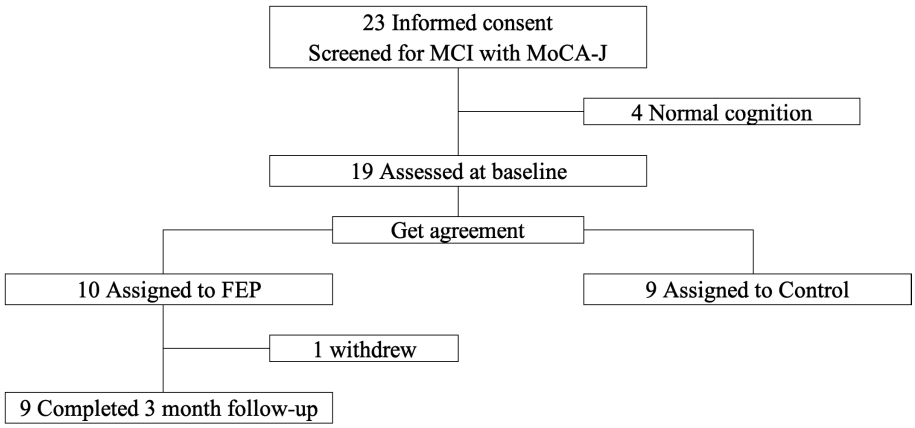

Fig. 1. Subject flow diagram from initial contact through study completion.

at manipulating maximum of 8 sets of information. The task focuses on attention, sequence, multiple tasks, and working memory. Planning module is intended to attention skills, organizing information, applying reasoning, setting lower goals, sequence, working memory, and controlling processes required to work on multitasks within same modality or between modalities. The content of the tasks becomes more complex as the program progresses.

Physical exercise

The subjects in the Control Group took part in the Group Exercise Program once or twice a week for a total of 22 sessions. Group exercises were carried out targeting 25 to 30 participants and were led by one occupational therapist and one caregiver for two hours each time inside an area spacious enough to allow the participants to move around without constraint. The Group Exercise Program featured strength training such as bending and stretching the lower and upper limbs, as well as rotating the trunk, using Theraband training tubes for 1 hour, and aerobic exercises such as boxercise for 1 hour.

Treatment fidelity

The implementers of FEP were certified nurses or occupational therapists. They confirmed the implementation methods prior to starting each session, and compared/checked the content at least once a month. The Group Exercise Program was provided by the same occupational therapist and caregiver each time.

Evaluations

The following cognitive functions were evaluated at the base point and the end point and, for the FEP Group, at the follow-up point, three months after the end of the intervention.

MoCA-J [21] is a cognitive screening test for detecting MCI, consisting of visuospatial/executive function, naming, memory, attention, language, abstraction, delayed recall, and orientation. A score of 26 points on the MoCA-J out of a perfect score of 30 points was made the cutoff point. Our study employed this test to diagnose MCI and evaluate the rate of reversion to normal cognition.

The Brief Assessment of Cognition in Schizophrenia, Japanese version (BACS-J) [23], is a scale for assessing cognitive function. It consists of a test that evaluates six subscales: verbal memory, working memory, motor function, attention and information processing speed, verbal fluency, and executive function. Our study used as a reference the average values of healthy males or females aged 70–79 [24]. We made our assessments using Z-values, whereby the score is linearly converted such that the average and SD become 0 and 1, respectively.

Wisconsin Card Sorting Test (WCST) [25] is a test of abstract behavior and "set shifting." Our study assessed three items: The number of categories that had been achieved, the number of perseverative errors of Milner (PEM), and the number of perseverative errors of Nelson (PEN). The number of categories achieved indicates the number of categories answered correctly for six consecutive questions. The scores ranged from 0 to 7, with larger numbers indicating better results.

Statistical analysis

A total of 19 subjects, ten in the FEP Group and nine in the Control Group, were targets of analysis. A χ^2-test was performed for sex and a non-paired *t*-test for age, the number of years of education received, and MoCA-J. Likewise, a non-paired *t*-test was performed on a two-group comparison of pre-intervention cognitive function and on a comparison of various functional

evaluations between before and after the interventions. To investigate the efficacy of FEP and continuation of the effects in the FEP Group, we performed the Holm method three times in nine FEP Group subjects: before intervention, after intervention, and as a follow-up. We used JASP 0.11.1.0 for statistical analysis, and set the level of significance at 5%. GPower 3.1 was used to analyze statistical power.

Results

Subjects' demographic information

Table 1 shows the demographic information of the subjects in each group. No significant inter-group differences were seen in the subjects' age (P = .282), number of years of education received (P = .44), percentage of males (P = .153), and MoCA-J scores (P = .236).

Comparison of base point cognitive function between the two groups

Table 2 shows the cognitive function at the base point of the 19 subjects in the FEP and Control Group in this study. The Control Group had significantly higher scores in the BACS-J's Composite Score (P = .01) and Verbal Memory (P = .049), and in the WCST's Categories (P = .033).

Table 1. Clinical characteristics of participants at Base point.

	FEP group(n=10)		Control group(n=9)		P
	Mean	SD	Mean	SD	
Age	79.5	5.5	76.3	5.4	0.282
Years of education	10.3	3.1	11.3	3.0	0.44
Gender(%male)	40.0		11.1		0.153
MoCA-J	22.6	2.2	23.8	1.1	0.236

The significance level of 5%

The average and SD of age at base point, the number of years of education received, and MoCA-J of the FEP Group and the Control Group. For statistical analysis, a x^2-test was performed for sex and a non-paired t-test for age, the number of years of education received, and MoCA-J.

Comparison of changes in cognitive functions before and after intervention

Table 3 compares the changes in cognitive function in the two groups before and after intervention. With BACS-J, the FEP Group showed a more significant improvement than the Control Group in Composite Score (P < .001) and Verbal Memory (P = .02), Digit Sequencing (P = .024), and the Tower of London (P = .005), and, with WCST, in Categories (P = .002) and PEN (P = .03). In other words, in these subordinate test items, the FEP Group showed a larger increase in scores after intervention and greater changes than the Control Group.

Comparison of the effect size of the FEP Group at three times

Table 4 shows the results on BACS-J and WCST of the nine subjects in the FEP Group at three time points, namely, base point, end point, and follow-up. As a result of comparing base point and end point, the end point was significantly higher and a larger effect size was observed with BACS-J's composite score (P <. 001; d = 2.28), Verbal memory (P = .009; d = 1.30), Verbal fluency (P = .028; d = 1.13), WCST's category (P = .002; d = 1.79), and PEN (P = .037; d = 1.07). In addition, no significant difference was found as a result of multiple comparison, but a large effect size was observed before and after the intervention with BACS-J's Digit Sequencing (P = .060; d = .97) and Tower of London (P = .078; d = .91). As a result of comparing base point and follow-up, the follow-up was significantly higher and a larger effect size was observed with BACS-J's compos-

Table 2. Cognitive function at Base point.

	FEP group(n=10)		Control group(n=9)		P
	Mean	SD	Mean	SD	
BACS-J(Z-score)[a]					
Composite Score	-1.87	1.05	-0.07	1.47	0.01*
Verbal Memory	-1.39	0.58	-0.09	1.55	0.049*
Digit Sequencing	-1.28	0.73	-0.35	1.36	0.177
Token Motor Task	0.56	1.04	0.52	0.78	0.806
Verbal Fluency	-1.40	0.69	-0.73	0.89	0.102
Symbol Coding	-1.15	1.36	-0.35	1.68	0.315
Tower of London	-0.50	2.01	0.01	0.77	0.435
WCST					
Categories	3.10	1.29	4.33	0.87	0.033*
PEM	1.30	1.25	1.44	1.13	0.800
PEN	5.80	4.08	3.67	2.18	0.132

*The significance level of 5%

Results of cognitive function assessments (BACS-J and WCST) at base point for the FEP Group (n=10) and the Control Group (n=9). A non-paired t-test was performed to determine any statistically significant differences between the two groups.

Table 3. Change of cognitive function Base point and End point.

		FEP group(n=10)			Control group(n=9)			P
		Basepoint	Endpoint	Difference	Basepoint	Endpoint	Difference	
BACS-J(Z-score)								
Composite Score	Mean	-1.87	-0.112	1.753	-0.07	-0.01	0.061	<0.001*
	SD	1.05	1.135		1.47	1.48		
Verbal Memory	Mean	-1.39	0.05	1.438	-0.09	0.40	0.485	0.02*
	SD	0.58	1.186		1.55	1.66		
Digit Sequencing	Mean	-1.28	-0.22	1.058	-0.35	-0.41	-0.060	0.024*
	SD	0.73	0.87		1.36	0.72		
Token Motor Task	Mean	0.56	1.29	0.733	0.52	0.36	-0.158	0.054
	SD	1.04	0.93		0.78	0.39		
Verbal Fluency	Mean	-1.40	-0.85	0.554	-0.73	-0.45	0.282	0.513
	SD	0.69	0.55		0.89	1.05		
Symbol Coding	Mean	-1.15	-0.69	0.458	-0.35	-0.27	0.079	0.251
	SD	1.36	1.24		1.68	1.79		
Tower of London	Mean	-0.50	0.97	1.466	0.34	-0.05	-0.384	0.005*
	SD	2.01	1.10		0.77	0.75		
WCST								
Categories	Mean	3.10	5.00	1.900	4.33	4.89	0.556	0.002*
	SD	1.29	1.05		0.87	1.05		
PEM	Mean	1.30	0.50	-0.800	1.44	0.78	-0.666	0.706
	SD	1.25	0.71		1.13	0.97		
PEN	Mean	5.80	1.40	-4.400	3.67	2.22	-1.445	0.03*
	SD	4.08	1.58		2.18	1.72		

*The significance level of 5%

Results and differences in cognitive function assessments (BACS-J and WCST)before and after intervention between the FEP Group (n=10) and the Control Group (n=9). A non-paired *t*-test was performed to determine any statistically significant differences between the two groups.

ite score (P = .005; d = 1.44), Verbal Memory (P = .009; d = 1.39) and WCST's category (P = .016; d = 1.17). In addition, no significant difference was found as a result of multiple comparison, but a large effect size was observed base point and follow-up with BACS-J's Verbal Fluency (P = .086; d = .80).

Implementing FEP yielded a large effect size in verbal memory, working memory, verbal fluency, executive function, conversion of sets, and persistent wrong answers. With verbal memory, verbal fluency, and conversion of sets, moreover, the effects lasted for three months.

The rate of reversion to normal cognition in the FEP Group

Of the 19 MCI patients who were subjects in this study, six in the FEP Group (ten subjects) and two in the Control Group (nine subjects) reverted from MCI to normal cognition (MoCA-J ≥ 26). In short, reversion from MCI to normal cognition occurred in 60.0% of the subjects in the FEP Group, and 22.2% in the Control Group. At the follow-up, moreover, of the six subjects in the FEP Group who had reverted to normal cognition at the end point, one had dropped out and five had maintained normal cognition (Fig. 2).

Discussion

The first purpose of this study was to verify the effects of cognitive rehabilitation targeting frontal lobe executive dysfunction, which can increase the risk of progressing to dementia, especially in individuals with MCI. We used a program that activates the frontal lobes/executive function in stages and in a comprehensive manner. The results showed more significant improvements in verbal memory, working memory, executive function, conversion of sets, and persistent wrong answers in the FEP Group than Control Group, which received motor interventions instead (Table 3). In our study, the subjects in the Control Group also showed improvements on several subscales of the BACS-J. On the other hand, the results suggest that the group undergoing cognitive rehabilitation focusing on frontal executive function showed even greater cognitive function improvement effects than did the Control Group, which engaged in aerobic exercise. Two points may be considered regarding the cause of improved cognitive function through FEP. First is verbalization, which is a requirement in the FEP. FEP requires participants to repeatedly verbalize their understanding of a task and their plans/strategies to tackle it. This might have led to the improvement of functions such as verbal

Table 4. Change of cognitive function at Base point, End point and Follow-up.

				95% CI of Mean				
			Mean Difference	Lower	Upper	SE	Cohen's d	p_{holm}
BACS-J(Z-score)								
Composite Score	Base	End	1.74	0.97	2.50	0.25	2.28**	< .001*
	Base	Follow	1.47	0.45	2.50	0.34	1.44**	0.005*
	End	Follow	-0.26	-1.21	0.68	0.31	-0.28	0.424
Verbal Memory	Base	End	1.32	0.30	2.34	0.34	1.30**	0.009*
	Base	Follow	1.52	0.42	2.63	0.37	1.39**	0.009*
	End	Follow	0.20	-0.25	0.66	0.15	0.45	0.215
Digit Sequencing	Base	End	0.99	-0.04	2.01	0.34	0.97**	0.060
	Base	Follow	0.37	-0.31	1.04	0.22	0.55	0.276
	End	Follow	-0.62	-1.75	0.51	0.38	-0.55	0.276
Token Motor Task	Base	End	0.68	-0.42	1.77	0.36	0.62	0.199
	Base	Follow	0.48	-0.17	1.14	0.22	0.74	0.169
	End	Follow	-0.19	-1.03	0.64	0.28	-0.23	0.507
Verbal Fluency	Base	End	0.60	0.07	1.14	0.18	1.13**	0.028*
	Base	Follow	0.50	-0.13	1.13	0.21	0.8**	0.086
	End	Follow	-0.11	-0.54	0.33	0.15	-0.24	0.491
Symbol Coding	Base	End	0.49	-0.21	1.19	0.23	0.70	0.203
	Base	Follow	0.12	-0.72	0.95	0.28	0.14	0.686
	End	Follow	-0.38	-1.17	0.42	0.26	-0.47	0.386
Tower of London	Base	End	1.53	-0.16	3.22	0.56	0.91**	0.078
	Base	Follow	1.50	-1.15	4.14	0.88	0.57	0.252
	End	Follow	-0.03	-1.65	1.59	0.54	-0.02	0.958
WCST								
Categories	Base	End	1.89	0.83	2.95	0.35	1.79**	0.002*
	Base	Follow	1.56	0.22	2.90	0.44	1.17**	0.016*
	End	Follow	-0.33	-1.34	0.67	0.33	-0.33	0.347
PEM	Base	End	-1.00	-2.67	0.67	0.55	0.60	0.324
	Base	Follow	-0.78	-2.35	0.79	0.52	0.50	0.348
	End	Follow	0.22	-1.09	1.53	0.43	-0.17	0.622
PEN	Base	End	-4.78	-9.27	-0.29	1.49	1.07**	0.037*
	Base	Follow	-3.44	-8.16	1.27	1.56	0.73	0.118
	End	Follow	1.33	-0.61	3.28	0.65	-0.69	0.118

*The significance level of 5% **Cohen's d＞0.8

Effect sizes before and after the intervention and at follow-up in the FEP Group (n=9). The Hold method was performed to determine statistically significant differences between the two groups.

memory and fluency, as well as the improvement of executive function in the form of establishing strategic thought processes. The second factor is that in addition to cognitive flexibility modules that target subordinate cognitive areas module sessions in the FEP are designed to improve the two cognitive areas of working memory and planning. In other words, improvements in working memory and executive function may have occurred through emphasis on frontal lobe functions related to working memory and executive function, and because of the relationships with the subscales of cognitive function assessments that were conducted on this occasion. On the other hand, there is a possibility of ceiling effects in the Control Group's results because the Control Group had significantly higher scores than the FEP Group at the base point on Multiple sub items. Moreover, instead of randomly dividing the participants into two groups, in the study design we included in the FEP Group individuals who had provided consent for intervention. This resulted in differences in the subjects' treatment motivations between the two groups, so the possibility of greater effects in the FEP Group cannot be dismissed.

Second, comparison of the FEP Group between before and after the intervention found a large effect size in verbal memory, working memory, verbal fluency, executive function, conversion of sets, and persistent wrong answers. Improvement effects had also continued, even at the follow-up point three months after the end of intervention in verbal memory, verbal fluency, and conversion of sets (Table 4). It appears possible

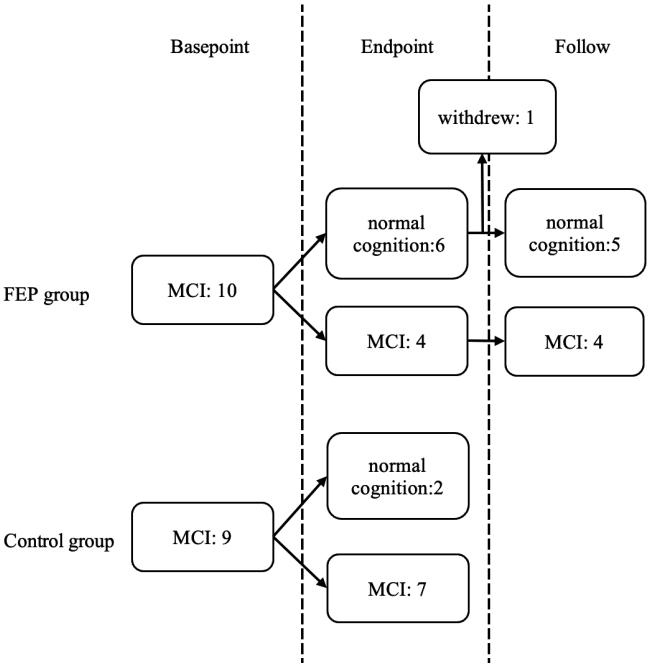

Fig. 2. Cognitive function at Base point, End point and Follow-up.
Changes in MCI to normal cognition in the FEP Group and the Control Group at three time points: base point, end point, and follow-up.

that, through interventions that targeted the frontal lobe, the subjects experienced increased motivation through activation of the frontal area and acquired a sense of achievement and confidence in having completed the program, which in turn helped increase the volume of activity in their daily lives. Studies have reported that increases in daily activity lower the risk of progressing to dementia [26]; in our study also, it is likely that cognitive function was maintained, not only due to the effects of cognitive rehabilitation itself but also to the resultant increase in daily activity. Our study only evaluated cognitive function; thus, mental functions including will/motivation as well as life functions such as activity volume remain a matter of speculation. In the future, therefore, there is a need to evaluate not only the aspects of cognitive function but also those related to mental and life functions.

The second purpose of our study was to identify conversion rates of MCI to dementia and reversion rates to normal cognition. In this study, no progression from MCI to dementia was seen in either group. Reversion from MCI to normal cognition occurred in 60.0% of the subjects in the FEP Group, and 22.2% in the Control Group (Fig. 2). Previous studies reported that one out of four or five MCI subjects reverts to normal cognition [1, 2]. The Control Group rate of reversion to normal cognition by motor intervention alone was not high, no progression to dementia was seen, indicating that the subjects in aerobic exercise able to maintain their functions. On the other hand, in the FEP Group, suggesting that the interventions made in this study had caused the MCI patients to revert to normal cognition. In the follow-up to the FEP Group, suggest that all the individuals had maintained normal cognition (Fig. 2), and that the effects of the interventions in this study were retained for three months. In other words, the effects of cognitive rehabilitation that targeted frontal lobe executive function which appear to confer a high risk of MCI progressing to dementia, had greater potential to raise the rate of reversion to normal cognition and contribute to a reduced risk of progressing to dementia than aerobic exercise. Thus, there is a need to investigate the continuity of even longer-term effects of interventions while taking into consideration the natural decline in cognitive function due to aging.

In this study, by conducting cognitive rehabilitation that targeted the frontal executive function, we saw improvements in verbal memory, working memory, verbal fluidity, and executive functions. The rate of reversion from MCI to normal cognition, moreover, was a high 60%, and normal cognition was maintained for three months. In the future, while it is hoped that the program can be applied to MCI patients who show a decline in frontal executive function, there is a need to establish a randomized, double-blind framework and interventional designs to investigate the effects of long-term interventions that take into consideration the natural decline in cognitive function that is caused by aging.

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Effects of Functional Electrical Stimulation on Attentional Function: A Study on Healthy Young Participants

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Abstract: Background: Functional electrical stimulation (FES) improves unilateral spatial neglect (USN). However, only few studies have reported on the relationship between FES and cognitive function. Therefore, this study aimed to investigate the effects of FES on attentional function in healthy participants using the Posner task, which is generally used to assess patients with USN.
Methods: In this interventional study, we conducted experiments on healthy participants to obtain fundamental knowledge before investigating effective ways of adapting FES to patients with USN as our final purpose. A total of 28 right-handed healthy young participants were assigned to the online-effect group or after-effect group and underwent FES simultaneously with or immediately before the Posner task, respectively. FES was applied to the extensor muscles of the left forearm to induce involuntary movement.
Results: A significant difference was observed in the effects of FES in the Posner task between the online-effect group or after-effect group in the left-valid conditions (online-effect, 26.7 ms delay; after-effect, -0.4 ms [reduction]; $p = 0.01$). No interaction was noted between the groups and the type of target of the Posner task presentation condition. The effects of FES differed between the online- and after-effect condition groups.
Conclusion: Performing the attention task after FES may enhance attention compared with performing the task with FES simultaneously.

Keywords: Functional electrical stimulation, attention, Posner task, unilateral spatial neglect

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1. Introduction

Unilateral spatial neglect (USN) is a common disorder that occurs after stroke and is defined as the failure to orient to, respond to, or detect stimulation on the affected side [1]. Left USN, which occurs after right-hemisphere damage, is more frequent (43%) than right USN (19%), which occurs after left-hemisphere damage [2–4]. Therefore, the right hemisphere, particularly the frontal and parietal lobes, may be involved in the amelioration of USN symptoms. Patients with USN encounter numerous problems in their daily living, such as missing food and meeting with crashes during walking. This is because USN prevents the detection of objects on their desk and in their way [5]. Several interventions to improve USN, including visual scanning training, prism adaptation, and limb activation, have been reported previously [6].

Robertson and North [7] reported that the active movement of the paretic limb in the neglected space significantly improves the symptoms of neglect on letter cancelation and reading tests. They concluded that only the active movement of the affected limb in the affected space improves USN. However, Làdavas et al. [8] demonstrated that even involuntary limb

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movement on the affected side improves USN based on results of a naming test, in which a patient is required to name all the projected target stimuli (i.e., line drawings of objects). Moreover, involuntary limb activation is considered beneficial because it can be used regardless of the severity of motor paralysis.

Functional electrical stimulation (FES) is used to induce involuntary limb movements. FES is a rehabilitation technique in which high-frequency electrical pulses are administered to the nerves or directly to the muscle belly for inducing muscle contraction and improving motor function in the paralyzed limb after a central nervous system injury, such as stroke [9]. Moreover, Eskes et al. [10] reported that visual scanning tasks (i.e., reading letters and numbers) performed simultaneously with FES-induced involuntary wrist extension improves USN. Some previous studies on FES intervention for USN have reported on the effects of this intervention on attentional function upon conducting attention tasks simultaneously with FES [10,11,12], whereas others have reported on these effects on attentional function after FES [13]. However, to the best of our knowledge, no studies have directly compared the online-effect and after-effect. Comparing the online- and after-effect of FES may provide insights into effective intervention methods for USN. For example, if the online-effect is operational, researchers should implement a combination of attentional function training or activities of daily living (ADL) movements and FES. If the after-effect is operational, researchers should recommend introducing ADL movement training after FES.

Paper-and-pencil tests help in effective identification of various USN pathologies; however, the results may incorrectly reflect the behavior of patients with USN in daily activities. This finding appears to be partially attributed to diverse symptoms, such as "internal representation" of space, "spatial attention," and "spatial frame of reference," in patients with USN [14]. For example, patients should switch their attention instantly during movement to avoid people or objects. Paper-and-pencil tests cannot assess this behavioral trait, thus necessitating a method to evaluate the reaction time (RT) of patients with USN to switch their attention instantly.

The Posner task is a computerized method that helps evaluate spatial attention by measuring the RT (in ms) [14]. In a previous study, participants were instructed to press the response key swiftly after a target appeared on the computer screen. The following two types of targets appeared: 1) targets that appeared on the side indicated by a cue (valid condition) and 2) targets that appeared on the opposite side (invalid condition). The valid condition is associated with voluntary attention, and the invalid condition is associated with the reorientation of attention [15].

USN can occur in the horizontal (left-right) and vertical (upper-lower) spaces [16,17]. However, the conventional "paper and pencil tests" for USN and the Posner task are unsuitable for detecting vertical neglect. Therefore, Osaki et al. [18] developed a modified Posner task, wherein the target presentation time was extended, and the target was presented at four locations (upper left, lower left, upper right, and lower right). The modified Posner task was used for patients with USN; the RT to target the left side was significantly more than that required to target the right side under invalid conditions [18]. Reorientation of attention is necessary to react to unpredictable movements, such as the sudden appearance of a person crossing the street while walking. The modified Posner task can be used to evaluate this type of reorientation.

Furthermore, Osaki et al. [19] performed a modified Posner task in patients with USN, those with right-hemisphere injury without USN, and healthy older participants to evaluate attentional functions, including left/right and vertical directions. They observed no significant difference in the RT between the upper left and lower left visual fields in the desk task in patients with USN, whereas the RT was delayed more in the lower left visual field than that in the upper left visual field in the modified Posner task. The present study was conducted in healthy young participants, aiming to implement the intervention in patients with USN in the future. Based on previous results [19], attentional function should be evaluated in the four quadrants of left, right, upper, and lower visual fields while applying the modified Posner task to patients with USN.

Researchers have published several reports of interventions on attentional function in healthy participants as the basis for USN intervention [20–22]. In these reports, leftward visual search was increased in healthy participants after general USN interventions, such as prism adaptation and visual search. However, this effect was observed for goal-directed attention, and the effect on stimulus-driven attention, which is important for USN improvement, is unknown. Furthermore, no reports are available on the effects of electrical stimulation on stimulus-induced attention in healthy participants.

We hypothesized that FES of the left upper limb facilitates brain activity in the right hemisphere and improves responses to the left space. Therefore, before applying FES to patients with USN, we aimed to determine whether (1) FES affects stimulus-driven

attention and (2) attention tasks are more effective when performed simultaneously with FES or after FES in healthy participants. Our findings will be applied to the rehabilitation of patients with USN in the future.

2. Materials and Subjects

2.1. Participants

In this interventional study, 28 right-handed young and healthy individuals without neurological or medical history were included (12 men and 16 women: mean age, 24.9 ± 4.5 years). Sample sizes were calculated using G*Power 3.1 [23] for the test family (F-test) and analysis of variance (ANOVA) (repeated measures; intermediate interactions). Based on an a priori power analysis performed with G*Power, Cohen's d [24], we assumed a moderate effect size (f=0.25), 5% significance level (α=0.05), 80% statistical power (1-β), 2 group (between) x 4 position (within) interaction, 0.50 correlation among repeated measures, and 1.00 nonsphericity correction. The sample size was 12 dropouts per group (24 total). This number was set to 12 persons per group to account for unexpected dropouts. We set the number of participants to 14 per group.

The study procedures were performed in accordance with the ethical standards of the Declaration of Helsinki, and all participants provided written informed consent to participate. The study protocol was approved by the Ethics Committee of Tokyo Metropolitan University (approval number: 19094, approval date: February 14, 2020) and Kansai University of Health Sciences (approval number: 19-56, approval date: June 19, 2020).

3. Methods

3.1. Modified Posner task

The modified Posner task (Figure 1) was used to examine the effects of FES on attentional function [12]. The task was displayed on a 15.6-inch monitor (120-Hz refresh rate) using a computer (MSI GL65-9SD-046JP, New Taipei, Taiwan). Behavioral responses were elicited using a numeric keypad (ELECOM TK-TCM011, Osaka, Japan) connected to the computer. We used the stimulation presentation software SuperLab 5.0 (Cedrus Corporation, San Pedro, USA) to create a modified Posner task. A cross fixed at the center (fixed viewpoint) and a frame of four squares arranged left to right along the horizontal meridian were presented on the monitor. Each square was presented at a visual position of 4.3° from a fixed viewpoint. The diameter of each square was within a visual angle of 1°, and a circular target appeared at the center of the square. The diameter of each target had a visual angle of 0.3°.

After 500 ms at the beginning, an arrow cue indicating left or right appeared at the fixation point for 2,000 ms. Subsequently, after a delay of 1,000–2,000 ms, a target (circle) appeared in one of the four frames (upper left, lower left, upper right, and lower right) for 3,000 ms. Each session comprised 60 trials. The target appeared at the location indicated by the cue in 80% (48 trials) of the trials (valid condition) and on the opposite side in 20% (12 trials) of the trials (invalid condition). We instructed the participants to detect the target rapidly and press the key with their right hands. The RT of the key and the accuracy of the keypress timing were recorded.

3.2. Apparatus

The IVES+® (OG Giken Co., Ltd., Okayama,

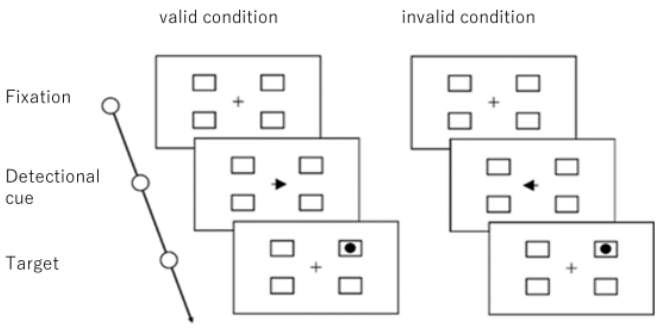

Fig. 1. The modified Posner task
In valid the condition, the target appears at the indicated position. In the invalid condition, the target appears on the opposite side.

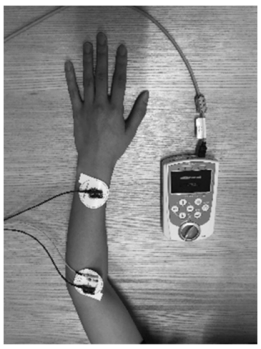

Fig. 2. Functional electrical stimulation apparatus (The IVES+® [OG Giken Co., Ltd.]). Stimulation electrodes are attached to the extensor muscles of the left forearm.

Japan) was used as the FES device (Figure 2). Stimulation electrodes were attached to the extensor muscles of the left forearm with gel conductors, and the left wrist was moved passively with the programming set for 5-s stimulation and alternative resting. Stimulation was performed for 6 min. The stimulation pulse frequency was 40 Hz, pulse width was 50 μs, and stimulation intensity was set to a level that caused muscle contraction.

3.3. Procedures

Figure 3 depicts the measurement protocol for the online- and after-effect conditions.

Twenty-eight participants were assigned randomly to the online- and after-effect condition groups (14 participants in each).

3.3.1. Online-effect condition

The online-effect condition included the Posner task that lasted for 6 min and a rest period that lasted for 3 min. Fourteen participants were randomly assigned to perform the tasks in either of the following two orders:

(A) Posner task with FES, rest, Posner task with sham control, rest, Posner task with sham control, rest, and Posner task with FES.

(B) Posner task with sham control, rest, Posner task with FES, rest, Posner task with FES, rest, and Posner task with sham control.

The entire test, including the rest period, lasted for approximately 35 min.

3.3.2. After-effect condition

The after-effect condition comprised 6 min each of the pre-FES Posner task, FES or sham control, and post-FES Posner task. Fourteen participants were assigned randomly to perform in either of the following two orders:

(A) Posner task before FES, FES, Posner task after FES, rest, Posner task before sham control, sham control, and Posner task after sham control.

(B) Posner task before sham control, sham control, Posner task after sham control, rest,

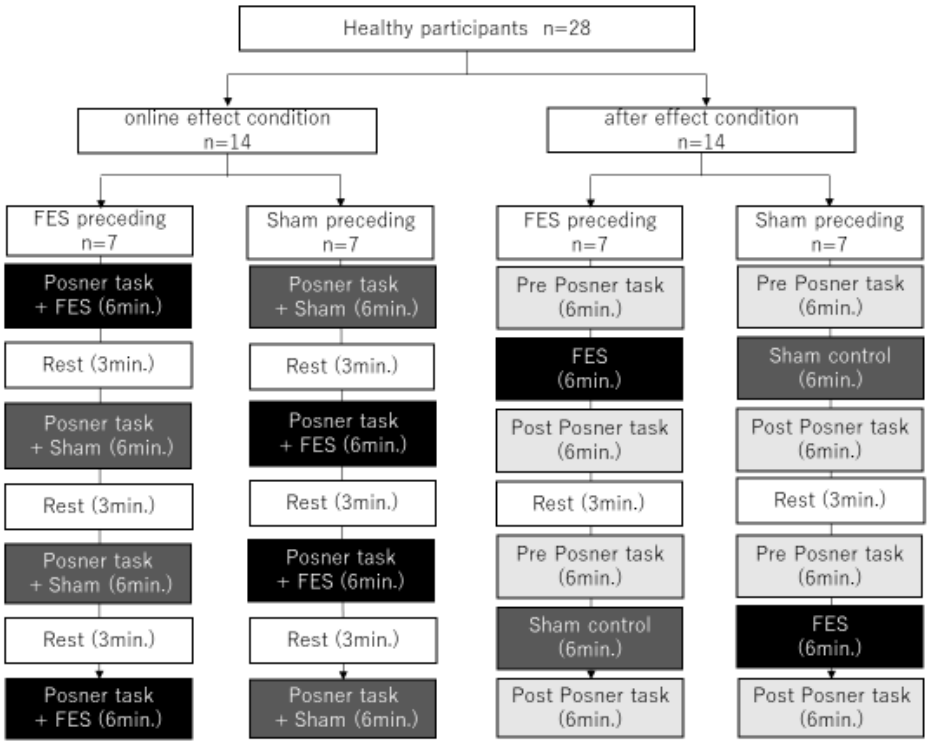

Fig. 3. Measurement protocol.
The two columns on the left show the measurement protocol for the online-effect condition consisting of the Posner task that lasted for 6 min and the rest condition that lasted for 3 min in each set. Participants are randomly assigned to perform the tasks in either of the two orders.
The two columns on the right show the measurement protocol for the after-effect condition consisting of 6 min of the pre-FES Posner task, 6 min of FES or sham control, and 6 min of the post-FES Posner task in each set. Fourteen participants are randomly assigned to perform the tasks in either of the two orders.

Posner task before FES, FES, and Posner task after FES.

The entire test, including 3 min of rest, lasted for approximately 40 min.

3.4. Statistical analysis

For the modified Posner task, we analyzed the amount of change in RT for the four conditions as follows: (a) Lt-invalid condition, the target appeared on the left side and a cue was demonstrated for the right side in the invalid condition; (b) Lt-valid, the target appeared on the right side and a cue was demonstrated for the right in the valid condition; (c) Rt-invalid, the target appeared on the right side and a cue was demonstrated for the left in the invalid condition; and (d) Rt-valid, the target appeared on the right side and a cue was demonstrated for the right in the valid condition.

The Shapiro–Wilk test indicated consistent data with a normal distribution. The formula for calculating the amount of change in RT was as follows: online-effect condition = RT with FES – RT with sham control; after-effect condition = RT post-FES – RT pre-FES.

Two-way mixed ANOVA with online- and after-effect conditions as between-subject factors and target condition (Lt-invalid, Lt-valid, Rt-invalid, Rt-valid) as the within-subject factor was used to analyze the modified Posner task performance.

Post-hoc tests with Bonferroni correction were used for multiple comparisons between the groups (p=0.05/2=0.025) and within each group (p=0.05/4=0.012). IBM SPSS Statistics ver. 25 (IBM Corp., Armonk, NY, USA) was used for the statistical analysis.

4. Results

Table 1 and Figures 4 and 5 summarize the modified Posner task RT results. Figure 6 depicts the amount of change in RT.

Regarding the amount of change in RT of the modified Posner task, ANOVA demonstrated a main effect for the groups (online- and after-effect conditions) ($F(1, 222) = 3.3$, $p<0.05$) and condition (target conditions) ($F(3, 220) = 6.2$, $p<0.05$). Significant interactions were absent. Post-hoc analyses demonstrated the following differences in the tasks with the Lt-valid conditions (online-effect, 26.7 ms longer; after-effect, -0.4 ms [reduction]; p=0.01).

In tasks with the Lt-invalid conditions, the difference in the amount of change in the RT tended to be greater in the after-effect condition group (online-effect, 8.1 ms longer; after-effect, -13.1 ms [reduction]; p=0.05). Furthermore, in tasks with the Rt-valid condition, the difference in the amount of change in the RT tended to be greater in the after-effect condition group (online-effect, 19.6 ms longer, after-effect, -1.4 ms [reduction]; p=0.06).

Regarding the target presentation conditions, the Lt-valid condition tasks in the online-effect condition group demonstrated a significantly greater amount of change in the RT than those in the Lt- and Rt-invalid condition tasks (p=0.01).

5. Discussion

We investigated the effects of involuntary limb activation by FES on attentional function using the Posner task. The effects of FES differed between the online-effect and after-effect condition groups. In addition, the effects of FES differed between the Posner tasks with invalid and valid conditions.

Table 1 Reaction time of the modified Posner task (ms)

	Online-effect condition		After-effect condition	
	Sham M (SD)	FES M (SD)	Post-Sham M (SD)	Post-FES M (SD)
Lt-target				
invalid	368.5 (60.0)	376.5 (63.0)	360.9 (70.5)	357.6 (54.4)
valid	350.0 (52.1)	377.0 (62.1)	332.3 (35.8)	348.6 (43.4)
Rt-target				
invalid	372.5 (65.3)	377.4 (55.4)	366.8 (69.8)	365.0 (47.9)
valid	352.7 (50.7)	372.3 (48.3)	335.8 (45.2)	347.1 (34.7)

FES: functional electrical stimulation, Lt-target: Target appeared in the left space, Rt-target: Target appeared in the right space, invalid: targets appeared on the opposite side that was indicated by a cue, and valid: targets appeared on the side that was indicated by a cue valid condition for target presentation in the left space.

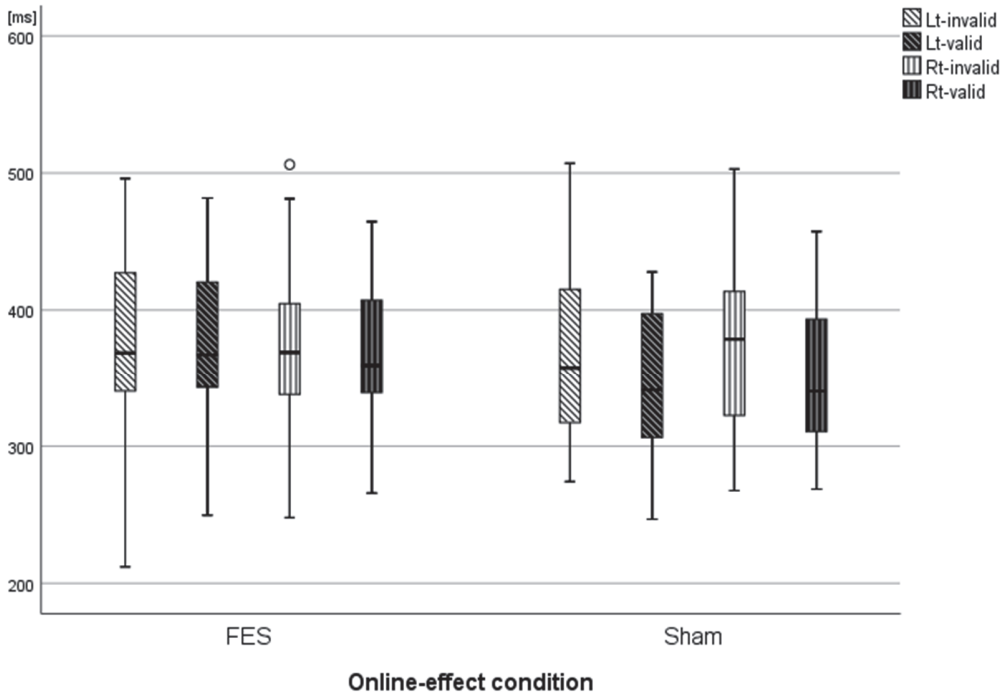

Fig. 4. Reaction time of modified Posner task on online-effect condition (ms)
Lt-invalid: invalid condition for target presentation in left space, Lt-valid: valid condition for target presentation in left space, Rt-invalid: invalid condition for target presentation in right space, Rt-valid: valid condition for target presentation in left space. ◦ : outlier.

5.1. Differences between online- and after-effect conditions

The RT was delayed in the online-effect condition group. Therefore, the FES-induced brain activity may have interfered with the brain activity attributed to the task performance. Regarding the interference of brain activity, dual-task interference occurs when two tasks are performed simultaneously, resulting in increased errors and delayed RTs in one or both tasks [25–27]. In the online-effect condition, FES increased the amount of external stimulation, which required more processing resources to pay attention to and respond to the target. In practice, several participants reported that their attention turned to the FES and left upper limb, suggesting dual-task interference between FES and task performance.

In contrast, the RTs tended to reduce in the Lt-invalid condition tasks in the after-effect condition. A previous study on healthy individuals reported that unilateral sensory stimulation acts on the spatial representations and shifts the self-centered coordinate system to the stimulated side [28]. In addition, FES of the extensor muscles of the left forearm in patients with USN reduces severe USN symptoms, and the effect continues 6 months post-intervention. Furthermore, FES could activate the intrinsic receptive sensory map in the right parietal lobe [11]. Thus, FES for the left upper limb resulted in brain activity in the somatosensory region of the right hemisphere. FES may have improved the spatial representations on the left side of the brain, resulting in a tendency to reduce the RT in the Lt-invalid condition.

5.2. Differences between the target-present conditions

The online-effect condition group, wherein the Posner task was performed simultaneously with FES, demonstrated a greater change in the RT in valid condition tasks than in invalid condition tasks.

Previous studies that compared invalid and valid conditions in the Posner task reported on longer RT in the invalid condition tasks than in the valid condition tasks performed by healthy individuals and patients with USN [29,30]. In the valid condition, attention is focused on the target, which can be predicted (voluntary attention). Moreover, responses are faster in the valid condition than in the invalid condition [31,32]. In the invalid condition, the focus of attention needs to be shifted away from the location predicted by the cue to a new location (attentional shift). Difficulties in shifting attention persist even in patients without clinical signs of USN [33,34]. In a previous study wherein tDCS was performed on right-handed healthy participants in the parietal region, the response was signifi-

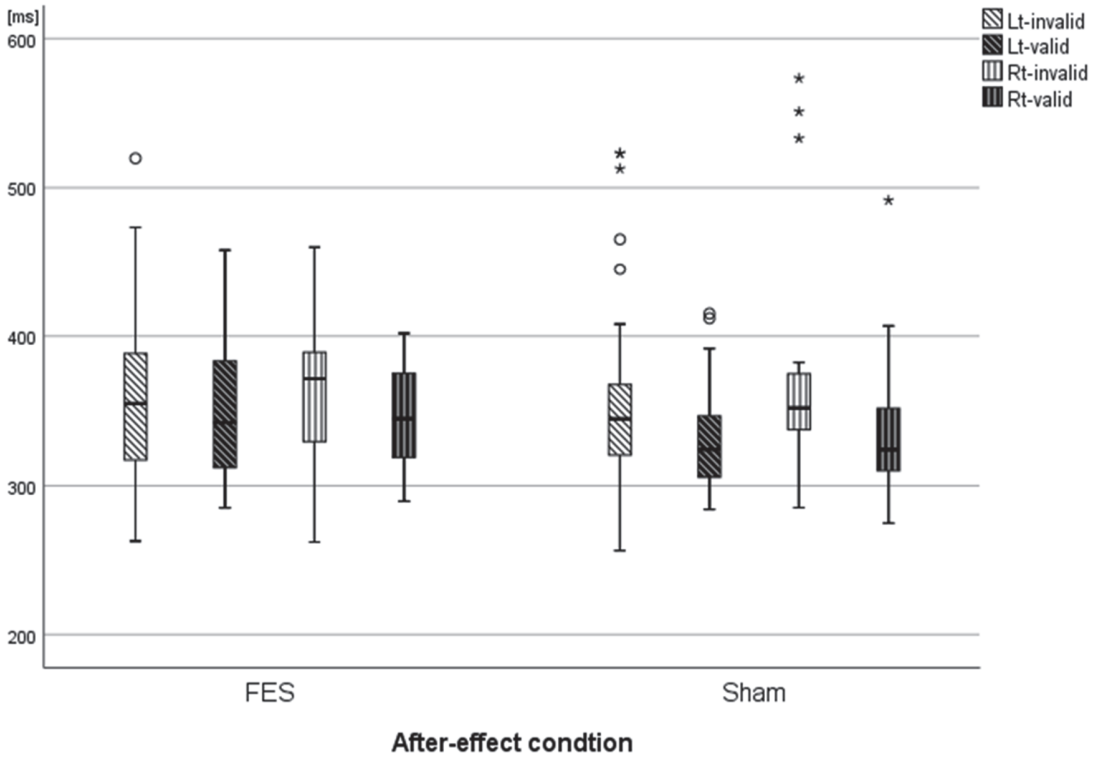

Fig. 5. Reaction time of modified Posner task on after-effect condition (ms)
Lt-invalid: invalid condition for target presentation in left space, Lt-valid: valid condition for target presentation in left space, Rt-invalid: invalid condition for target presentation in right space, Rt-valid: valid condition for target presentation in left space. ◦, ★: outlier.

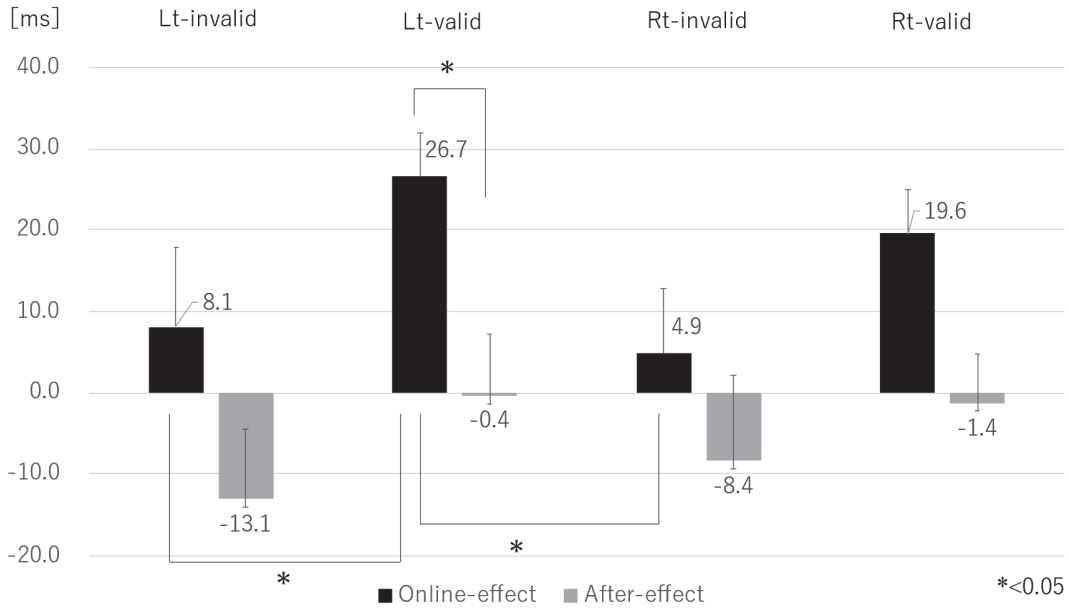

Fig. 6. Amount of change of average RT.
Lt-invalid: invalid condition for target presentation in left space, Lt-valid: valid condition for target presentation in left space, Rt-invalid: invalid condition for target presentation in right space, Rt-valid: valid condition for target presentation in left space.

cantly faster in the valid condition than in the invalid condition. Nonetheless, no effect of tDCS implementation was noted [35]. Contralateral parietal tDCS may have facilitated hemispheric perceptual bias, without significant differences. However, our results demonstrated that the longer RT attributed more to FES in the valid condition than in the invalid condition in the online-effect condition group. This finding indicates a ceiling effect because invalid conditions, which require more attentional resources than valid conditions, had a more severe task difficulty and slower RT before FES.

In the after-effect condition group, the RT demonstrated a marginal change in the valid conditions and tended to reduce in the invalid conditions.

Invalid conditions are reportedly associated with the reorientation of attention [15]. Corbetta and Shulman [36] suggested that voluntary attention was related to the dorsal pathway in the bilateral hemispheres, and the reorientation of attention was related to the ventral pathway that is dominant in the right hemisphere. However, Corbetta and Shulman [36] only included patients with USN, whereas we included healthy participants; therefore, it is difficult to compare the two studies directly. However, FES of the left upper limb activates the intrinsic receptive sensory map of the right parietal lobe [13], suggesting that it activated the ventral pathway of the attentional network, resulting in a tendency to reduce the RT under the invalid condition rather than the valid condition.

Upon focusing attention to the unaffected side in patients with USN, it is difficult to shift the attention to the affected side [37]. In the Posner task, patients with USN show a greater delay in RTs under the invalid condition than that under the valid condition [27]. FES may be considered a more effective intervention for patients with USN if FES of the left upper limb can activate the reorientation of attention in the ventral pathway in the right hemisphere.

5.3. Limitations

This interventional study was based on healthy individuals; future studies should consider enrolling patients with USN. Furthermore, we examined the effects of FES based on the results of the Posner task; however, we did not examine the patients' brain activity, which should be evaluated in future studies.

The setting of the modified Posner task was according to previous studies [18,19], and a 1,000–2,000 ms delay occurs between the cue and the target appearance. We selected this long timing because we ultimately intended to apply the intervention to patients with USN; however, the time is sufficiently long to trigger some inhibition of return in healthy young participants.

6. Conclusions

We examined the effects of limb activation by FES on attentional function. The effects of FES differed in the RT in the Posner task between the online- and after-effect condition groups, indicating that FES of the left upper limb could affect the invalid condition involving the reorientation of attention. Thus, involuntary upper limb activation by FES may be an effective intervention to manage USN.

Funding

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Tokyo Metropolitan University (approval number: 19094) and Kansai University of Health Sciences (approval number: 19-56).

Informed Consent Statement

Informed consent was obtained from all participants involved in the study.

Acknowledgements

We acknowledge the cooperation of all the participants in the study.

Conflicts of Interest

The authors declare no conflict of interest.

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■ORIGINAL ARTICLE

Surveys of the Efficacy, Technical Difficulty, Ethics, and Dissemination of Splint/Orthosis Fabrication Using Thermoplastic Splint Sheets

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Abstract: Objective: For splints/orthoses fabricated by therapists during hand therapy to be recognized as a novel specialized medical technology, we demonstrated their ease of dissemination, ethics, safety, and effectiveness. We also investigated the technical difficulty and dissemination of splints/orthoses in a first study on the current situation of splint/orthoses fabrication using thermoplastic splinting sheets, and evaluated the effectiveness, safety, and ethics of splinting sheets in a second study.
Methodology: In the first study, we investigated the name of the target diagnosis, purpose of fabrication, time of fabrication, joints involved, presence or absence of component connections, and fabrication time. In the second study, we investigated basic attributes, explanations and consent, prescriptions, difficulties, and efficacy indicators. The participants were 49 therapists from 46 institutions who completed the academic society-approved seminars in the first and second studies.
Results: The subjects were 31 out of the 49 therapists (response rate: 67.4%), and the target splints were 547. The splints/orthoses were used in daily clinical practice after surgery or immediately after injury, and various splints/orthoses were fabrication according to a specific purpose, even during treatment. Moreover, regarding the difficulty level, the splints/orthoses could be fabrication in a relatively short time by a advanced hand therapist. For instance, 260 (48%) were produced within 20 minutes.
Conclusion: The safety and ethics of the splint/orthoses showed high values, but further objective indicators and subjective data indexing of efficacy are required.

Keywords: splint/orthosis, technical difficulty, dissemination, ethics, effectiveness

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1. Introduction

A splint/orthosis is an extremely effective therapeutic tool for correcting problems of bones/joints or the neuromuscular systems. A splint/orthosis has been used to solve problems that affect functional prognosis, based on close collaboration between doctors and therapists [1-3]. Therefore, it is important for therapists who fully understand the goals and content of therapy to provide treatment promptly according to the timeline of therapy. The main advantage of splints/orthoses fabricated by therapists is that they are available on time in clinical settings. Most splints/orthoses are thermoplastic splint sheets with plastic properties that soften at low temperatures and can be molded directly to the patient's upper limb. Various innovations have been made according to this application [4,5].

An analysis of the actual use of splints/orthoses and orthotics by certified hand therapists in the United States and Canada [6-8] showed that those fabricated by certified hand therapists are a common and important part of the practice of hand therapy [9-12]; thus, they are emphasized in clinical practice, research, and

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training. Additionally, the Centers for Medicare and Medicaid Services, the primary entity that manages the public health insurance system in the United States, covers splints/orthoses and orthotics fabricated by occupational therapists and physical therapists as specialized medical technology.

In Japan, the certified hand therapist system launched in 2009 includes a training system aimed at improving the specialized knowledge and practical abilities of hand therapy practitioners, developing and expanding therapeutic techniques, and improving educational and research standards related to hand surgery. Qualification as a certified hand therapist requires 6,400 minutes of training and other credits, followed by passing a certification examination. Part of the examination consists of splint training, which includes a basic hand splint seminar (720 minutes) and advanced hand splint seminar (720 minutes), totaling 1,440 minutes or 23% of the entire curriculum. This training is backed by specialized knowledge and skills, is promoted to eliminate disparities among therapists and facilities, and plays a major role in improving the skills, environments, and other aspects of splint fabrication. However, despite the maturing conditions surrounding therapeutic splint fabrication, assessments of splint and orthotics fabrication by occupational therapists and physical therapists as a specialized medical technology are not yet fully established in Japan's medical fee structure for health insurance.

Japan's Advanced Medical Care Program aims to make promising medical technologies available to patients through coverage by the National Health Insurance. For splints/orthoses fabricated by therapists during hand therapy to be recognized as novel specialized medical technology, it is essential to describe the level of technical difficulty involved and demonstrate its ease of dissemination, ethics, safety, and effectiveness [13]. Hence, fact-finding surveys regarding splint fabrication are extremely important.

Herein, we conducted two fact-finding surveys on the fabrication of splints/orthoses using thermoplastic splint/orthosis sheets to obtain basic data for setting new medical fees. We aimed to investigate the actual situation of splint fabrication and the technical difficulty and ease of dissemination of splints/orthoses and evaluate the ethics, safety, and effectiveness of splints/orthoses.

2. Methods

2.1. Ethics statement

This study was commissioned by the Japan Hand Therapy Society (JHTS). The surveys were conducted after the respondents were given sufficient explanations and provided informed consent. This study was approved by Tokyo Kasei University Ethics Committee (approval no.: SKE2020-70; year: 2020), and all participants provided written informed consent. The study was conducted in accordance with the principles of the Declaration of Helsinki. The participants were assigned arbitrary subject numbers so that no individual could be identified. The document listing matched participants with their corresponding subject numbers was stored on a password-protected USB drive that remained locked in the principal investigator's laboratory. The data analysis file was stored on a different password-protected USB drive locked in the principal investigator's laboratory.

2.2. Survey 1

The purpose of the first study was to investigate the technical difficulty and ease of dissemination of splints/orthoses. This survey targeted 49 therapists from 46 facilities who had completed the advanced splint/orthosis seminar part of the Japan Hand Therapy Society's certified hand therapist training curriculum from fiscal years 2013 to 2018.

The survey was conducted by emailing therapists a questionnaire about their basic attributes and practice of splint fabrication. The email also included an explanation of the survey, and we considered that informed consent was obtained if they responded. The survey period lasted 2 months, from September 1, 2019 to October 31, 2019.

The survey items were as follows: a) subjects' basic attributes, b) diagnostic classifications that the fabricated splint/orthosis was used for, c) the purpose of fabrication, d) fabrication timing, e) joints involved (size), f) presence or absence of component connections, g) fabrication time, and h) material size. The details of these items are listed in Tables 1 and 2.

2.3. Survey 2

The purpose of the second study was to investigate the ethics, safety, and effectiveness of splints/orthoses. The subjects and methods were the same as those for survey 1, and the survey period lasted 2 months, from October 1, 2020, to November 30, 2020.

The survey items were as follows: a) subjects' basic attributes, b) the presence or absence of informed consent, c) presence or absence of a splint prescription from a doctor and the prescribing doctor, d) trouble while wearing the splint and its content and remedies, and e) presence or absence of splint effectiveness indicators and their content. The details of these items are listed in Tables 1 and 2.

Table 1 Survey details

	Survey 1	Survey 2
Purpose	To investigate the technical difficulty and ease of dissemination of splints/orthoses	To investigate the effectiveness, safety, and ethics of splints/orthoses
Facility and subjects	49 therapists from 46 facilities	49 therapists from 46 facilities
Investigation period	September 2019 to October 2019: 2 months	October 2020 to November 2020: 2 months
Number of target splints/orthoses	547	937

Table 2 Items and content of Survey 1 and 2

Survey 1		Survey 2	
Item	Content	Item	Content
a. Subjects' basic attributes	Age, years of experience as a hand therapist, affiliation	a. Subjects' basic attributes	Age, years of experience as a hand therapist, affiliation
b. Diagnosis classifications	Bone/joint diseases, neuromotor diseases, amputations/complex injuries, and others	b. Informed consent	Explanation from a doctor or therapist (Y/N)
c. Purpose of fabrication	Immobilization/rest/support, extension/correction, tendon excursion/restriction, functional compensation/training, other	c. Splint prescription	Splint prescription from a doctor (Y/N), prescribing doctor
d. Timing of fabrication	Within 1 week, 1–4 weeks, 5–12 weeks, more than 12 weeks post injury or surgery, unknown	d. Difficulties	Trouble while the wearing splint, methods of addressing it
e. Joints involved	Finger, thumb, wrist, forearm, elbow, shoulder, non-classified joint (duplicate responses allowed)	e. Effectiveness indicators	Splint effectiveness indicators (Y/N), content
f. Components (Y/N)	Elastic or nonelastic component connections (Y/N)		
g. Fabrication time	10–40 min (10-minute increments), more than 40 min		
h. Material size	Size (when the commercial size approximately 24×18 inches is taken as 1)		

Y, yes; N, no

2.4. Statistical analysis

Descriptive statistics were used to summarize the survey data in Excel 2019 (Microsoft Corp.). The subjects of this study were 49 people from 46 facilities who completed all the Hand Therapist Training Curriculum Hand Split Advanced Seminars conducted by academic societies from 2013 to 2018 without performing detection ability analysis. Data pertaining to three cases and five facilities were missing and had to be obtained by contacting each patient individually by email.

3. Results

The proportion of participants was different in each study, as described below.

3.1. Survey 1

Consent and responses were obtained from 31 of the 49 therapists (response rate: 67.4%), and 547 splints/orthoses were fabricated during the survey period.

Table 3 Therapist demographics

	Survey 1	Survey 2
Recovery rate, number of respondents	67.4%, 31	42.9%, 21
Basic attributes		
Age	30s, 71%; 40s, 23%; 20s, 6%	30s, 63%; 40s, 33%; 20s, 4%
Years of experience	5–10 years, 76%; 11–15 years, 24%	5–10 years, 37%; 11–15 years, 59%
Affiliation	General hospital, 68%; special function hospital, 22%; clinic 10%	General hospital, 78%; special function hospital, 19; clinic, 4%

Table 4 Indications for splints/orthoses

	Survey 1	Survey 2
Target disease		
Bone/joint diseases	86%	72%
Neurological/motor diseases	7%	18%
Amputations/complex injuries	4%	8%
Other diseases	3%	2%
Target purpose		
Immobilization/rest/support	64%	63%
Correction	20%	20%
Excursion/restriction	9%	9%
Compensation/training	7%	8%

Table 5 Characteristics of splint procedures

	Survey 1, % (quantity)	Survey 2, % (quantity)
Fabrication timing		
Within 1 week	40% (220)	36% (333)
1–4 weeks	26% (142)	34% (351)
5–12 weeks	16% (89)	19% (180)
12 weeks or later	12% (68)	8% (70)
Fabrication time		
10 min or less	40% (107)	28% (258)
10–20 min	48% (153)	47% (441)
20–30 min	6% (35)	17% (159)
30–40 min	6% (32)	6% (54)
40 min or later	0% (2)	2% (25)

3.1.1. Participants' basic attributes

Overall, 71% of therapists were in their 30s, 23% in their 40s, and 6% in their 20s (Table 3). Their years of clinical experience were 5–10 years (76%) and 11–15 years (24%). Their affiliations were general hospitals (68%), advanced treatment hospitals (22%), and clinics (10%).

3.1.2. Target diseases for splints/orthoses

Bone/joint diseases accounted for 86% of splints/orthoses, neurological/motor diseases for 7%, amputations/complex injuries for 4%, and other diseases for 3% (Table 4).

3.1.3. Purpose of splint fabrication

Immobilization/rest/support was the purpose for splint fabrication in 64% of splints/orthoses, correction in 20%, excursion/restriction in 9%, and functional compensation/training in 7% (Table 4).

Fabrication timing: Most splints/orthoses were fabricated within 1 week post surgery or injury in 40% (220) of splints/orthoses, followed by 1–4 weeks in 26% (142), 5–12 weeks in 16% (89), 12 weeks or later in 12% (68), and unknown in 6% (28) (Table 5).

3.1.4. Joints involved

The most common joints involved were the fingers in 275 splints/orthoses, followed by joints from the fingers/thumbs to the wrist in 115, wrist only in 73, thumbs in 53, and elbows in 19.

3.1.5. Component connections

Most splints/orthoses had no component connections (81%, 445 splints/orthoses).

3.1.6. Fabrication time

Fabrication took 10–20 minutes in 48% (153) of splints/orthoses, 10 minutes or less in 40% (107), 20–30 minutes in 6% (35), and 30–40 minutes in 6% (34).

3.1.7. Material size

The size of the material was 1/10 in 60% (329) of splints/orthoses, 1/6 in 24% (134), and 1/8 in 13% (73) (1 sheet size, 460 × 610 mm).

3.2. Survey 2

Consent and responses were received from 21 of 49 participants (response rate: 42.9%). During the survey period, 937 splints/orthoses were fabricated.

3.2.1. Participants' basic attributes

The attributes of the therapists were similar to those of the therapists who responded to survey 2 (Table 3). Overall, 63% of therapists were in their 30s, 33% were in their 40s, and 4% were in their 20s. Their years of clinical experience were 5–10 years (37%) and 11–15 years (59%). Their affiliations were general hospitals (78%), advanced treatment hospitals (19%), and clinics (4%).

3.2.2. Explanation and consent

Informed consent was obtained for splint fabrication in 892 out of 937 splints/orthoses (95%). The following is the purpose of the physician prescription instructions for the 892 approved splints/orthoses: immobilization/rest/support, 99%; correction, 100%; excursion/restriction, 58%; and compensation/training, 97% (Table 6).

Table 6 Splint/orthosis indications and physician prescription information in Survey 2

	Percentage of splints/orthoses
Target purpose	
Immobilization/rest/support	99%
Correction	100%
Excursion/restriction	58%
Compensation/training	97%

3.2.3. Presence or absence of a splint prescription from a doctor and the prescribing doctor

Prescriptions were provided for 77% of splints/orthoses. There were differences in the presence or absence of a prescription depending on the purpose: immobilization (88%), prevention (78%), compensation (57%), and extension (49%). The prescribing doctor was a hand surgeon or an orthopedic surgeon (81%).

3.2.4. Trouble while wearing the splints/orthosis

Problems with wearing the splint/orthosis were observed in 7% of splints/orthoses (70). Table 7 shows a breakdown of the data.

4. Discussion and implications

According to the membership statistics of the Japanese Association of Occupational Therapists, 75% of registered occupational therapists are in their 20s and 30s, and 72% work at general hospitals. Additionally, the number of therapists who treat orthopedic diseases including trauma is 14%, which is second only to cerebrovascular diseases [14]. This study will help determine the direction and content of occupational therapy splints in the future.

We will first discuss the technical difficulty and ease of dissemination based on the results of the survery 1. Regarding technical difficulty, when the purpose of fabrication was immobilization/rest/support, the splint was a so-called static splint that functions to immobilize the joint. Fabrication of such splint took approximately 20 minutes or less for fingers and 40 minutes or less when including the wrist. We believe this is because the therapists acquired the skills to fabricate a basic static splint in approximately 20 minutes through the splint-related seminars provided by the JHTS. For purposes other than immobilization/rest/support, mobilization splints/orthoses that supply some forms of movement are used, and they are often attached the elastic or nonelastic component to a static

Table 7 Troubles while wearing the splints/orthoses by the purpose of the splint/orthosis

	Fixation	Extension	Compensation	Prevention
Issue involving fitting	68%(32)	50%(2)	100%(9)	
Damage, deterioration	9%(4)	50%(2)		37.5%(3)
Skin issues	17%(8)			37.5%(3)
Angle adjustment	6%(3)			25%(2)
Total	100%(47)	100%(4)	100%(9)	100%(8)

% (quantity)

splint. Although fabrication of this kind of splint only made up about 10% of splints/orthoses, this showed that even more complex splints/orthoses are sometimes fabricated in daily clinical practice. We are convinced that it's crucial to train therapists who can safely and effectively apply forces to joints based on fundamental knowledge of physiology as well as mechanics and physics. Expanding the training of advanced therapists in the educational curriculum of the JHTS will ensure that the technical difficulty of splints/orthoses fabrication will be relatively low and that many patients will be able to use this technique.

Regarding ease of dissemination, most splints/orthoses (220) were fabricated within the first week in terms of the timing of fabrication and the most common purpose was immobilization/rest/support (171 splints/orthoses). These also included a complex splint that had connecting parts to supply early movement after surgery to repair the finger flexor muscles and tendons. These results indicate that a splint/orthosis is a medical technology that can be fully utilized even when risks need to be managed, including addressing acute inflammatory symptoms, such as post-injury or postoperative pain, dealing with wound status, and being careful about contraindications. Concerning the timing of fabrication by purpose, the most common time was within 4 weeks for the purpose of immobilization/rest/support; after 5 weeks onward, the purpose was for extension/correction, and after 12 weeks, there were various purposes. So that it was showed that splint/orthosis is a medical technology that can be adapted to the course of treatment.

Next, we discuss ethics, safety, and showed orthosis effectiveness of splints/orthoses based on the results of survey 2.

Concerning ethics, informed consent for splint fabrication was obtained for 892 of 937 splints/orthoses, with consent obtained in 95% overall. However, for fabrication purposes, consent was obtained for only 57% (35 of 81) of splints/orthoses for compensation/training. Overall, there were prescriptions for splints/orthoses in 77% of splints/orthoses. These results indicate that the use of a splint/orthosis for immobilization and excursion tended to be prescribed at the start of rehabilitation, while prescriptions, explanations, and informed consent for splint/orthosis adapted to the course of treatment were not sufficient.

Regarding safety, trouble while wearing a splint was observed in 7% of all splints/orthoses. These can be classified as trouble related to fitting, splint damage and deterioration, skin issues, and adjustments to the outrigger angle. These results indicate that the incidence of trouble was low and that the characteristics of thermoplastic splint/orthosis sheets promptly adupted the patients' situations. However, it was also found that mild skin problems, which could be a significant risk factor, were difficult to avoid completely and require countermeasures, such as post-fabrication evaluations and supervisory reports.

Concerning effectiveness, objective or subjective indicators were used in 74% of all splints/orthoses. Objective indicators could be classified as range of motion, imaging and clinical findings, inflammatory findings, and activities of daily living. Subjective indicators could be classified as pain, quality of life, and other narrative data. The use of effectiveness indicators in splints/orthoses for immobilization was low (60%). In studies on the effects of splint/orthosis for various diseases, pain and disease-specific scales were often used as subjective assessments [15-17], although few used the amount of time until surgery [18, 19].

This study has some limitations. First, the therapists were experts who were attending seminars offered by the Japan Hand Therapy Society. Second, the survey periods of the first and second studies were limited to 2 months. Important issues going forward are the need to summarize the various effectiveness indicators for different purposes, coherence in the selection of objective indicators, and creation of indicators of subjective data for individualized responses.

5. Conclusions

We conducted fact-finding surveys regarding splint fabrication with 49 therapists who had completed the certified hand therapist training curriculum of the JHTS and discussed the technical difficulty, ease of dissemination, ethics, safety, and effectiveness of splints/orthoses based on the survey results. In the future, we would like to further increase the number of subjects and the survey period. We also hope to add to the literature on splint effectiveness to standardize effective splint types and effectiveness indicators.

Declaration of conflicting interests

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Effectiveness of Self-help Device in Closing Zippers Using a Single Hand in Patients with Hemiplegia: A Retrospective Observational Study

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Abstract: Purpose: For patients forced to use only one hand, closing a zipper is challenging. Therefore, we developed a self-help device that uses a string and clothespins; the device stretches the zipper, allowing the individual to close it easily with one hand. We aimed to 1) demonstrate the effectiveness of this device by comparing the zipper closing motion when the device is used ("usage motion") with that when it is not used ("non-usage motion") and 2) determine whether difficulty level changes when using either the left or right hand.
Methods: This study included 38 patients with hemiplegia. Participants were asked to close the zipper with one hand after being instructed on how to perform the usage and non-usage motions. Next, we judged whether the participants could perform the movements, and measured the time taken to close the zipper using video.
Results: All participants could close the zipper using the usage motion; however, time taken to close the zipper was significantly shorter when the device was used than when it was not. On comparing the zipper closing time between the left and right hand for the usage motion, no significant differences were noted.
Conclusion: Experimental results suggest that device-based zipper closure is an efficient method for patients with hemiplegia. Furthermore, we demonstrated that a self-help device, combining inexpensive everyday items, could enable patients with hemiplegia to successfully dress themselves without difficulty.

Keywords: zipper, hemiplegia, self-help device, dressing

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Introduction

Separating zippers, comprising a chain, insertion pin, retainer box, slider, and pull tab, are used for jackets and coats [1]. Zippers with a right-hand-side insertion pin ("right-insertion zipper") are commonly used in Europe and Asia, whereas those with a left-hand-side insertion pin ("left-insertion zipper") are commonly used in the United States [2]. Right-insertion zippers are fixed by holding the slider and retainer box in close contact using the left hand, the insertion pin is inserted with the right hand, and the pull tab of the slider is pulled with the left hand while pulling the hem to prevent the insertion pin from slipping out of the retainer box [3]. The procedure is flipped for the left-insertion zipper [4]. In either case, closing the zipper with one hand ("closing motion") is extremely difficult. Therefore, zipper closing is difficult for patients with hemiplegia or individuals with diseases or injuries that limits them to using a single hand [5].

Some patients with hemiplegia use a self-help

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device to facilitate the closing motion. However, self-help devices for right-insertion zipper [6,7] and left-insertion zipper [5] closing motions only provide an explanation for the procedure using either the right or left hand, with no reports on the procedure for the other hand; furthermore, their effectiveness is unknown. We developed a self-help device for left- or right-handed use.

This study aimed to demonstrate the effectiveness of this device by comparing the closing motion when the device was used ("usage motion") or not used ("non-usage motion") in patients with hemiplegia. We further explored differences in difficulty levels between the left and right hand.

Methods

Participants

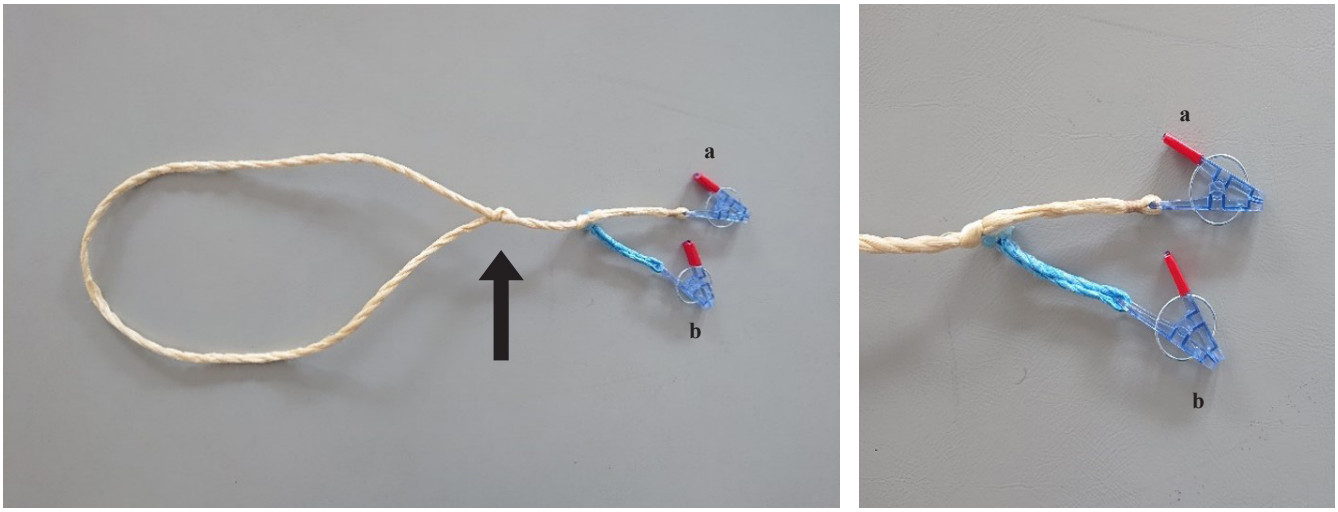
We recruited 38 hemiplegic stroke patients (19 males, 19 females; nine right hemiplegic males, nine right hemiplegic females; 10 left hemiplegic males, 10 left hemiplegic females) who regularly attended daytime nursing care facilities. All participants were in the chronic phase, at least one year after stroke onset. Of the 38 patients, 17 suffered cerebral infarction and 21 suffered cerebral hemorrhage. The mean age of the participants was 72 ± 10 years (range, 48–90 years). The participation criteria for this study were (1) unilateral motor paralysis, (2) a lack of functional impairment, which would interfere with daily life, manifesting in the upper limbs, fingers, or lower limbs on non-paralyzed side, (3) an absence of higher brain dysfunction, (4) a revised Hasegawa Simplified Intelligence Scale score that was within the normal range of 21 or more [8], (5) the ability to stably maintain a sitting position.

Ethics

This study was approved by the Institutional Review Board of the A Hospital (approval date: March 28, 2020) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

Equipment

The device is shown in Figure 1. The self-help tool studied here has the same chain tension mechanism as several existing self-help tools [5-7]. However, the existing self-help tools pull only on the hem of the insertion pin's side to apply the tension required to close the chain. In contrast, the studied self-help tool applies tension on the chain by pulling the hem on both the slider side and the insertion pin side. Pulling on both sides makes the tension on both the left and right chains more even, making it easier to raise the slider and close the zipper. Additionally, the string of the clothes pin that holds the insertion pin side is made 10 mm shorter than the string of clothespin a that



Full image Enlarged image of clothespin part

Fig. 1. Device structure
The string is polypropylene, and one end of the string is divided into two, as shown by "a" and "b," and clothespins are attached at each end of the string. Clothespin string "a" is 10 mm longer than clothespin string "b." The string is connected to one handle of the clothespin. The opposite end of the string is made into a loop so that it can be hooked on the leg. This device was used for experiments; the part indicated by an arrow was made into an adjustable grip hitch to allow the total length to be adjusted in the range of 600–800 mm.

holds the slider side, making it difficult to remove the insertion pin from the slider.

Experiments were conducted in a sitting position, and the height of the seat surface was set so that the hip and knee joints were at 90°. The device was hooked onto the leg in that position, and the length of the string was adjusted to allow the tip of the clothes-pin to reach the trochanter major. The jacket used for the experiment was a zip-up hoodie or tracksuit, owned by the patients. The jackets had insertion pin on the right and were made in Japan.

The closing motion was captured using web camera (c920r; Logicool Co Ltd., Lausanne) from two directions (non-paralyzed side and front side), and the images were uploaded at 30 frames/s in myoVIDEO (NORAXON USA Inc, Scottsdale) and simultaneously recorded and analyzed.

Closing Motion Procedure

Figure 2 shows the procedure of the closing operation for use and non-use where:

(a) depicts the usage motion, with the procedure

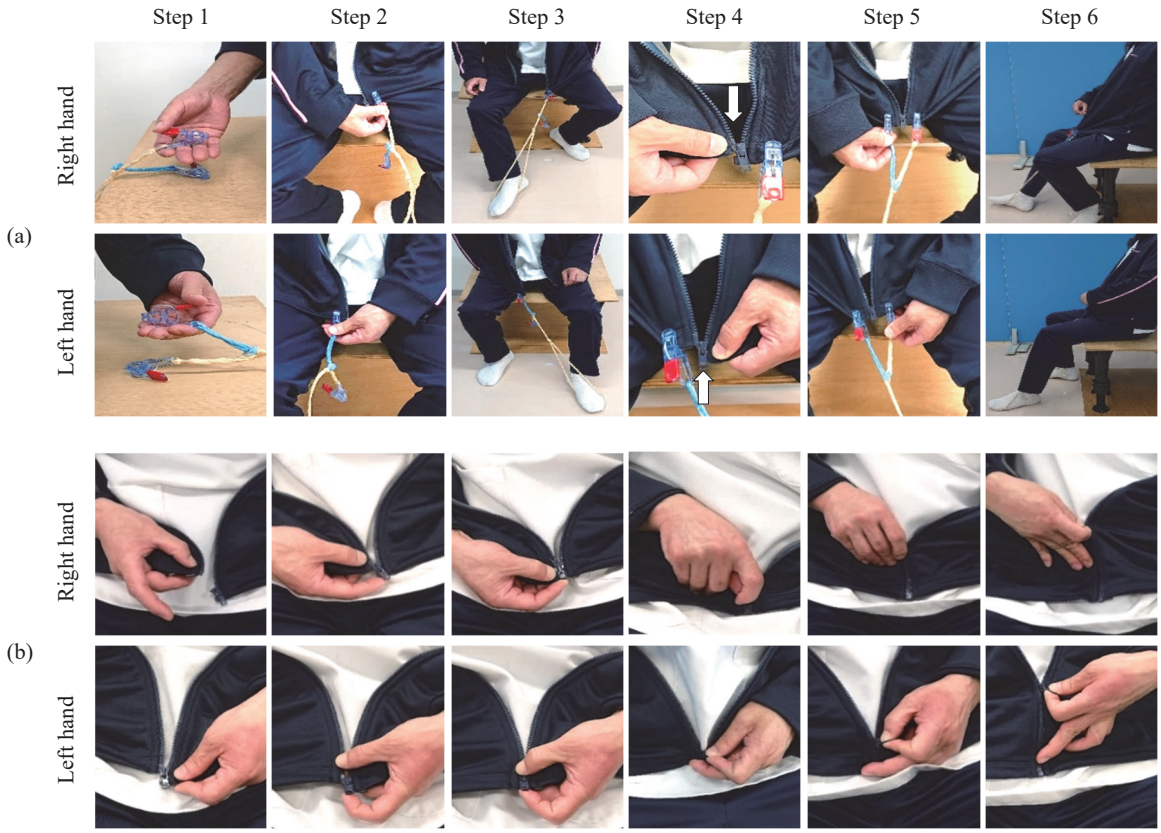


Fig. 2. Procedure for closing motion

(a) Usage motion procedure

The procedure for the right hand (upper row) is to hold the clothespins shown in Fig. 1a, pinch the hem around the box (Steps 1 and 2), put the loop on the right leg, extend the leg, insert the insertion pin (Steps 3 and 4), pinch the hem near the insertion pin with clothespins in Fig. 1b (Step 5), and tilt the trunk backwards, extend the right leg to the left side, and raise the pull tab (Step 6). The procedure for the left hand (lower row) is to hold the clothespins shown in Fig. 1b, pinch the hem around the insertion pin (Steps 1 and 2), put the loop on the left leg, extend the leg, insert the insertion pin (Steps 3 and 4), pinch the hem near the box with the clothespins in Fig. 1a (Step 5), tilt the trunk backwards, extend the left leg to the left side, and raise the pull tab (Step 6).

(b) Non-usage procedure

The procedure for the right hand (upper row) is to pinch the insertion pin with the thumb and middle finger, press the bottom of the box with the index finger (Steps 1 and 2), insert the insertion pin (Step 3), and raise the pull tab with the thumb and index finger while pressing the jacket with the middle and ring fingers. The raising is undertaken repeatedly to the desired position (Steps 4–6). The procedure for the left hand (lower row) is to insert the insertion pin slightly into the slider (Step 1), press the bottom of the box with the index finger, hold the insertion pin with the thumb and middle finger (Step 2), and insert the insertion pin (Step 3). (Steps 4–6) are the same as with the right hand.

for the right hand shown in the upper row, and the procedure for the left hand shown in the lower row; (b) depicts the non-usage motion, with the procedure for the right hand shown in the upper row, and the procedure for the left hand shown in the lower row.

Procedure

We explained the usage and non-usage motions to the participants, who then practiced the activities until satisfaction. Next, they were asked to close the zipper of their jacket using the non-paralyzed hand. The end position of the slider was decided by the patients, but the same position was used for the usage and non-usage motions.

After the experiment, we judged whether each participant could perform the closing motion. Next, we measured the time taken to close the zipper ("closing time") from the captured video footage.

Analysis

Success or failure of the closing motion.

The ability to perform the closing motion using the usage and non-usage motions was assessed. It was considered a success when a patient could close the zipper up to the target height and a failure if not.

Closing time.

The setting time, pulling time, and total time (sum of setting time and pulling time) were compared between the usage and non-usage motions. The setting time for the usage motion was from (Step 1)–(Step 5) in Fig. 2(a), and the pulling time was the time required for (Step 6). The setting time for the non-usage motion was the time required for (Step 1)–(Step 3), and the pulling time was the time required for (Step 4)–(Step 6) in Fig. 2(b). Statistical analysis used the Wilcoxon signed rank test, and the significance level was set to less than 5%. Participants who failed to perform either or both the usage and non-usage motions were excluded from the comparison.

Additionally, the setting, pulling, and total times of the usage motion were compared between patients with left hemiplegia and those with right hemiplegia. Statistical analysis included the Mann–Whitney U test, and the significance level was set to less than 5%. All statistical analyses were performed using IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY).

Results

Success or failure of the closing motion

All participants successfully performed the usage motion. However, only 18 participants successfully performed the non-usage motion, and 20 participants, who failed, were unable to conduct the setting motion. (Table 1)

Closing times

The closing times were compared between the usage and non-usage motions in 18 participants. For

Table 1 Success or failure of closing motion and comparison of closing time

	Usage motion	Non-usage motion	p value
Success or failure of closing motion			
Success	38	18	
Failure	0	20	
Closing time (seconds) n=18			
Setting time	30.1 (24.1-38.4)	51.6 (23.1-74.3)	.028
Pulling time	3.0 (2.0-3.9)	19.0 (11.0-40.0)	.001
Total time	33.2 (27.1-42.1)	80.6 (43.7-107.8)	.001

Closing times of comparison subjects are shown with median values (interquartile ranges).

Table 2 Comparison of closing times of patients with left and right hemiplegia in usage motion

	Patient with left hemiplegia n=20	Patient with right hemiplegia n=18	p value
Closing time (seconds)			
Setting time	35.2 (29.3-41.0)	43.2 (29.7-60.9)	.196
Pulling time	3.0 (2.0-5.4)	3.4 (2.0-5.7)	.74
Total time	40.5 (31.5-45.2)	48.5 (31.7-63.5)	.228

Closing times of all participants are shown with median values (interquartile ranges).

usage motion, setting ($p < 0.05$), pulling ($p < 0.01$), and total time ($p < 0.01$) were significantly shorter than for non-usage motion (Table 1).

On comparing the closing times for usage motion between patients with left- and right-sided hemiplegia, no significant differences were noted (Table 2).

Discussion

The results of this study suggest that the device may help both right-sided and left-sided hemiplegic patients to close zippers in a practical manner. All participants who failed the non-usage motion were unable to perform the setting motion. The setting motion in the non-usage motion involves inserting the insertion pin while pressing the bottom of the box with the index finger; this requires performing the two motions of fixing and inserting with one hand at the same time. In the usage motion, the device substitutes for fixing the box with the right hand and fixing the insertion pin with the left hand (Fig. 2(a). [Step 3]). Therefore, the involvement of the hand in the setting motion of the usage motion was only required for inserting the insertion pin, which led to the success of all the participants. Furthermore, a comparison of the setting time between the usage and non-usage motions showed that the non-usage motion was significantly longer than the usage motion, indicating the difficulty of the process [9]. In other words, the fact that the duration of the usage motion is short suggests that the difficulty of the setting motion was lower than that of the non-usage motion.

When conducting the pulling action in the non-usage motion, irrespective of the hand used, the movement involves pressing the jacket to the body with the middle and ring fingers, while pulling the pull tab with the thumb and index finger. These steps must be repeated multiple times to pull the zipper to the neck. For the usage motion, however, the hems on both the insertion pin and retainer box sides are pinched, the leg is stretched, and the trunk is leaned back to make the chain taut in a straight line; this facilitates pulling the pull tab [10]. Furthermore, the string that is connected to clothespin, which pinches the insertion pin side, is 10 mm shorter than the string connected to clothespin, which pinches the retainer box side (Figure 1). This makes the insertion pin side pull more tightly when the leg is stretched, making it more difficult for the insertion pin to come out of the slider and retainer box. This mechanism remains same for either hand (left or right) used. As the chain is made sufficiently taut to make it difficult to pull the insertion pin out, the pull tab can be pulled up to the neck in one movement. The usage motion does not involve the repetitive actions observed in the non-usage motion, thereby, significantly reducing pulling time.

There was no significant difference in closing time between the left- and right-handed groups. Major differences in difficulty would have been apparent through differences in activity time [9]. Thus, the lack of a difference in closing times suggests that the device was not associated with differences in difficulty levels with left- vs. right-hand.

Limitations and future directions

Our participants were limited to patients with chronic hemiplegia who could attend daycare facilities. Furthermore, we did not include patients with hemiplegia with severe higher brain dysfunction; thus, effectiveness of the device in such cases is unclear. The device may also be effective for patients who are forced to use only one hand due to orthopedic disease. It can be effectively used for left-insertion jackets, which are mainly worn in the United States, if the left and right procedures are reversed. Future studies should confirm the usefulness of this device in patients with severe higher brain dysfunction and those with orthopedic diseases, as well as with left-insertion jackets.

Summary and conclusions

We asked patients with hemiplegia to conduct a zipper closing motion with and without the use of self-help device. For usage motion, all participants successfully conducted the closing motion; however, over 50 % of the participants could close the zip using the non-usage motion. The usage motion also resulted in a significant decrease in the closing time, demonstrating the practical nature of the device. There was also no significant difference in closing times between patients with left- vs. right-sided hemiplegia. In conclusion, a self-help device for patients with hemiplegia which combined inexpensive everyday items could enable them to more easily dress themselves.

Conflict of Interest

There are no conflicts of interest to declare.

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■ORIGINAL ARTICLE

Observational Rating Scale of Attention Function is Associated with Independence in Activities of Daily Living

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Abstract: Introduction: Stroke rehabilitation that considers attention deficits and effectively improves activities of daily living (ADL) requires sufficient evaluation of attention functions. Attention function evaluations are generally performed using neuropsychological tests in patients with stroke. However, such tests become unviable for patients with acute stroke due to fatigue-related unstable general conditions and cannot determine how attention deficits affect ADL. Hence, developing an appropriate observational rating scale is crucial. Therefore, we investigated the factors related to independence in ADL in patients with acute stroke and the usefulness of the Moss Attention Rating Scale (MARS) score in predicting independence in ADL.
Methods: In this cross-sectional single-center study, we included 154 patients admitted to Acute Hospital, Japan for stroke treatment between April 2016 and April 2020 who consented to participate. The primary outcome was the motor functional independence measure (m-FIM) score. The secondary outcome measures were the Glasgow Coma Scale score, Brunnstrom recovery stage, grip strength, one-leg standing time (1LST), Mini-Mental State Examination-Japanese score, Visual Cancellation Task score, Symbol Digit Modalities Test score, and MARS score.
Results: The 1LST and MARS scores were associated with independence in ADL. The cutoff values were 2.99 seconds for 1LST (average), 89 points for MARS total score, and 58.87 points for MARS logit score.
Discussion: The MARS score and 1LST might be useful indices for predicting independence in ADL. Thus, behavioral assessments might be appropriately performed by implementing these indices to determine the degree of ADL independence in patients with stroke, and thereby establishing targeted rehabilitation strategies.

Keywords: stroke, attention, cognitive dysfunction, behavior rating scale, activities of daily living

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Introduction

Cognitive impairment is very common after stroke. Approximately 80% of patients with stroke were reported to experience cognitive impairment [1]. In addition, approximately 40% of patients still have cognitive impairments 3 months after stroke. [2]. Patients with stroke with cognitive impairment often require occupational therapy. Spaccavento et al. [3] reported that approximately 80% of patients with acute stroke had attention deficits. Attention is the basis of other cognitive functions, and its deficits interfere with daily and social lives [4, 5]. Therefore, stroke rehabilitation that considers attention deficits and effectively improves activities of daily living (ADL) requires sufficient evaluation of attention functions.

Attention function evaluations are generally performed using neuropsychological tests in patients with stroke [6]. However, in the acute phase, many patients

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might not be able to undergo neuropsychological testing due to their unstable general condition resulting from fatigue. In addition, these neuropsychological tests cannot determine the effect of attention deficits on ADL in these patients; hence, an observational rating scale is important for evaluating attention deficits in patients with acute stroke.

Observational rating scales of attention include the 14-item Ponsford and Kinsella's Attention Rating Scale [7], the 6-item Behavioral Assessment of Attentional Disturbance [8], and the 22-item Moss Attention Rating Scale (MARS) [9, 10]. These scales have the advantage of being widely applicable to observational evaluation and the convenience of directly relating to problems in ADL. Among observational rating scales of attention, the MARS has the potential to assess attention function in a more multifaceted way than other observational rating scales, due to the large number and segmentation of assessment items. However, the precise correlation between the MARS score and ADL remains unclear. In addition, the optimal MARS cutoff score for predicting independent ADL is yet to be established.

Thus, this study aimed to identify the factors related to independent ADL in patients with acute stroke and the validity of using the MARS score to evaluate them. We also aimed to determine the optimal cutoff value of the MARS score that is indicative of independent ADL.

Methods

Study design and participants

This cross-sectional, single-center study was conducted at our hospital. The study was approved by the hospital's ethics committee and was conducted according to the tenets of the Declaration of Helsinki. Written informed consent was obtained from all patients.

The participants were patients who were admitted between April 2016 and April 2020 for the treatment of stroke and underwent rehabilitation. The inclusion criteria were as follows: occupational therapy started within 1 week of stroke onset, ability to perform various assessments such as neuropsychological testing, adults 20 years of age or older, and consent obtained. The exclusion criteria were as follows: admission more than 1 week after stroke onset, severe respiratory or cardiovascular diseases, orthopedic diseases such as fracture or amputation, apraxia, previous diagnosis of dementia, and inability to provide consent.

Outcome measures and assessments

The tests were evaluated by an occupational therapist with at least five years of experience who was familiar with these evaluation methods. All outcome measures were assessed within 1 week before discharge. The primary outcome measure was the motor functional independence measure (m-FIM) score. In addition, the FIM score was defined as ADL performance. The secondary outcome measures comprised evaluation of clinical characteristics, neurologic tests, and neuropsychologic tests.

Clinical characteristics, including sex, age, diagnosis, lesion, date of stroke onset, presence or absence of surgery, dominant hand, and discharge destination, were also evaluated. Neurologic tests included the Glasgow Coma Scale (GCS), Brunnstrom recovery stage (BRS), grip strength, and one-leg standing time (1LST). Grip strength was measured once on each side, and the average was calculated. 1LST was performed to assess balance capacity. The dominant hand for eating and grooming was also assessed. Neuropsychological tests included the Mini-Mental State Examination-Japanese (MMSE-J) [11], Visual Cancellation Task (VCT) [12], and Symbol Digit Modalities Test (SDMT) [12]. Presence of attention deficits, aphasia, and unilateral spatial neglect (USN) were also assessed.

VCT and SDMT were selected because they are relatively easy to perform even in the acute stage of stroke and can assess selective attention (basic attention) and divided attention (complex attention). Attention deficit was defined as VCT results within the chronological mean-standard deviation or achieving an SDMT score below the chronological cutoff. Presence of aphasia was determined using the standard language test. The presence or absence of apraxia and USN was determined by observing ADL, checking finger imitation, using tools when symptoms were suspected, and conducting line cancellation. The MARS was used as an observational rating scale.

Functional independence measure (FIM)

ADL independence was defined as independence in activities including self-care and outdoor walking. The participants were divided into two groups according to previous research: those with an m-FIM score of ≥ 85 (the independent ADL group) and those with an m-FIM score of < 85 (the dependent ADL group) [13]. The reason for selecting the level of ADL independence was that a high level of ADL was judged to be necessary in anticipation of social life.

The m-FIM consists of 13 items, each scored on a scale of 1 to 7. The total m-FIM score ranges from 13 to 91, with higher scores indicating greater independence in ADL. Scoring was based on observation and evaluation of actual movement situations.

Visual Cancellation Task (VCT)

The VCT [12], which is a neuropsychological test, was used for assessing visual selective attention in three modalities: shape, number, and cursive Japanese syllabaries. Four relatively simple tasks were evaluated according to the time required for completion, percentage of correct answers, and percentage of hit rate.

Symbol Digit Modalities Test (SDMT)

The SDMT [12] was utilized to assess divided attention and conversion abilities. The test lasts for only 90 s, during which specific symbols and corresponding numbers are filled in. The results are expressed as percentage of achievement, ranging from 0% to 100%.

Moss Attention Rating Scale (MARS)

The MARS was translated into Japanese by Sawamura et al. in 2012 [14]. It consists of 22 items, and each is scored from 1 to 5: 1, definitely false; 2, false for the most part; 3, sometimes true, sometimes false; 4, true for the most part; and 5, definitely true. The total MARS score is calculated as the sum of scores of 22 items that ranges from 22 to 110, with higher scores indicating better attention. In addition, there are scores for three-factor subitems: restlessness/distractibility, 5; initiation, 3; and consistent/sustained, 3. The MARS total score was converted to a logit score, an interval scale. MARS total and logit scores were used in this study. MARS total and logit scores were extracted as factors related to ADL independence, and when calculating the cutoff values, we checked for any discrepancy between the two scores.

Statistical analysis

The normality test for continuous variables was performed using the Shapiro-Wilk test. The unpaired t-test, Mann–Whitney U test, and χ^2 test were used for assessing differences between the two groups based on the degree of independence in ADL. Univariate logistic regression analysis was performed with the FIM motor item as the objective variable, and explanatory variables with a P value of < 0.2 were extracted. Spearman's rank correlation coefficient was calculated considering the multicollinearity of the extracted factors, and factors with $|\rho| \geq 0.7$ were excluded from the analysis. Multiple logistic regression analysis (backward elimination) was performed using the significant factors from the univariate logistic regression analysis and Spearman's rank correlation coefficient as explanatory variables. Multiple logistic regression analysis created models using MARS total and logit scores. The R^2 and χ^2 tests, corrected Akaike information criterion (AICc), and Bayesian information criterion (BIC) were used to evaluate the goodness of fit of each model. Significant factors in the multiple logistic regression analysis were analyzed using the receiver operating characteristic (ROC) curve to calculate their cutoff value, sensitivity, specificity, area under the curve (AUC), positive predictive value, positive likelihood ratio, and accuracy. Regarding the cutoff value [15], we adopted a value that minimizes (1-sensitivity) + (1-specificity) [2]. The criteria for determining the AUC of the ROC curve were as follows: AUC = 0.9–1.0, high accuracy; 0.7–0.9, moderate accuracy; and 0.5–0.7, low accuracy [16]. All statistical analyses were performed using the JMP Pro 15 software (SAS Institute Inc. Japan). The explanatory variables used in the multiple logistic regression analysis were explanatory variables × 10 cases, as previously described [17]. Statistical significance was set at a P value of < 0.05.

Results

In total, 154 patients with an average age of 73.0 years were evaluated. Among them, 86 (55.8%) and 68 (44.2%) were men and women, respectively. The clinical characteristics and neurologic and neuropsychological test results of the patients are shown in Table 1. Overall, 109, 19, and 26 patients were diagnosed with cerebral infarction, intracerebral hemorrhage, and subarachnoid hemorrhage (SAH), respectively. The independent ADL group included 94 patients with an average age of 71.0 years: 54 (57.4%) men and 40 (42.6%) women. The dependent ADL group comprised 60 patients with an average age of 78.0 years: 32 men (53.3%) and 28 women (46.7%).

With respect to clinical characteristics, there were significant between-group differences in the date of the last evaluation, age (Mann–Whitney U test, $P < 0.05$), lesion, and discharge destination (χ^2 test, $P < 0.05$). Neurologic and neuropsychological tests showed significant differences in grip strength and GCS, 1LST, MMSE-J, VCT, SDMT, and MARS scores (Mann–Whitney U test, $P < 0.05$). There were also significant differences in the presence or absence of motor paralysis, attention deficit, and USN (χ^2 test, $P < 0.05$).

The possible explanatory variables were age, GCS, grip strength on the side used for performing ADL, 1LST, MMSE-J, VCT (shape), SDMT, presence of USN, MARS total score, and MARS logit score. Multicollinearity was confirmed for MMSE-J, SDMT, MARS total score, and MARS logit score. In the multiple logistic regression analysis, the objective variables were motor FIM (0, greater than 85; 1, less than 85) and variables in Model 1 (explanatory variables; GCS, grip on the side of ADL use, 1LST [average], VCT [shape1], presence of USN, MARS total score) and Model 2 (ex-

Table 1 Patient Clinical Characteristics, Neurologic and Neuropsychologic examinations.

	All (n = 154)	independent group (n = 94)	dependent group (n = 60)	*P* value
sex* male/femle	86/68	54/40	32/28	0.62
first evaluation date	4.0 (2.0–6.8)	3.5 (2.0–5.0)	4.0 (2.0–7.0)	0.17
last evaluation date	17.0 (10.0–26.0)	15.5 (10.0–22.0)	20.0 (12.0–30.3)	< 0.01
discharge Day	19.0 (13.0–26.0)	18.0 (11.3–24.0)	22.5 (15.8–34.0)	< 0.01
age	73.0 (62.3–79.0)	71.0 (57.0–77.0)	78.0 (68.8–83.0)	< 0.01
diagnosis* CI	109	69	40	
ICH	19	10	9	0.45
SAH	26	15	11	
surgery* presence/absence	36/118	18/76	18/42	0.14
lesion* right/left/both	67/58/29	41/38/15	26/20/14	0.87
front/back/both	111/34/ 9	63/27/ 4	48/ 7/ 5	0.03
dominant hand* right/left	152/2	93/1	59/1	0.75
destination* home/transfer	95/59	78/16	17/43	< 0.01
GCS	15.0 (14.0–15.0)	15.0 (15.0–15.0)	14.0 (14.0–15.0)	< 0.01
motor paralysis*	63 (40.9%)	29 (30.9%)	34 (56.7%)	< 0.01
paralytic side* right/left	27/36	14/15	13/21	0.34
BRS [arm] I/II/III/IV/V/VI	0/11/5/0/5/38	0/0/0/0/1/25	0/11/5/0/4/13	
[finger] I/II/III/IV/V/VI	1/13/2/2/2/38	0/0/0/0/0/26	1/13/2/2/2/12	
[leg] I/II/III/IV/V/VI	0/ 3/5/4/2/48	0/0/0/0/0/28	0/ 3/5/4/2/20	
Grip [right]	22.0 (15.8–29.0)	26.0 (19.1–32.3)	14.9 (4.5–22.0)	< 0.01
[left]	20.0 (12.0–28.0)	23.0 (17.0–31.3)	10.6 (2.0–20.0)	< 0.01
[average]	20.1 (14.4–28.0)	24.1 (19.0–31.7)	12.0 (7.1–19.0)	< 0.01
[ADL use side]	22.6 (16.0–29.0)	26.0 (19.5–32.3)	16.8 (10.0–22.9)	< 0.01
1LST [right]	4.8 (0.0–17.5)	9.9 (3.7–30.0)	0.0 (0.0–2.3)	< 0.01
[left]	4.2 (0.0–15.8)	9.3 (3.4–30.0)	0.0 (0.0–2.5)	< 0.01
[average]	5.1 (0.0–16.8)	10.9 (4.5–29.7)	0.0 (0.0–2.6)	< 0.01
Motor FIM	88.0 (65.5–91.0)	91.0 (89.0–91.0)	55.5 (22.8–70.3)	< 0.01
Cognitive FIM	33.0 (27.0–35.0)	35.0 (33.0–35.0)	24.0 (15.0–28.3)	< 0.01
Total FIM	120.0 (90.3–125)	125.0 (121.0–126.0)	81.0 (41.0–97.3)	< 0.01
Aphasia*	27 (17.5%)	14 (14.9%)	13 (21.7%)	0.28
MMSE-J	26.0 (22.0–28.8)	28.0 (25.3–29.0)	21.0 (16.8–25.0)	< 0.01
USN*	15 (9.7%)	2 (2.1%)	13 (21.7%)	< 0.01
Attention deficit*	111 (72.1%)	53 (56.4%)	58 (96.7%)	< 0.01
VCT [shape 1] time	60.0 (49.4–84.9)	54.3 (45.8–67.5)	90.4 (71.7–137.8)	< 0.01
correct answers	98.2 (96.4–100.0)	98.3 (98.2–100.0)	98.2 (91.2–100.0)	< 0.01
hit rate	100.0 (100.0–100.0)	100.0 (100.0–100.0)	100.0 (98.2–100.0)	< 0.01
VCT [shape 2] time	67.9 (53.2–98.3)	63.1 (50.1–78.0)	109.7 (87.5–145.3)	< 0.01
correct answers	100.0 (98.2–100.0)	100.0 (98.2–100.0)	98.2 (96.6–100.0)	0.02
hit rate	100.0 (100.0–100.0)	100.0 (100.0–100.0)	100.0 (97.0–100.0)	< 0.01
VCT [number] time	111.9 (91.2–141.3)	99.9 (87.6–129.9)	152.4 (134.2–185.2)	< 0.01
correct answers	99.1 (98.2–100.0)	100.0 (98.2–100)	98.7 (96.0–99.1)	< 0.01
hit rate	100.0 (100.0–100.0)	100.0 (100.0–100.0)	100.0 (100.0–100.0)	0.02
VCT [pseudonym] time	142.4 (111.3–173.2)	131.5 (108.1–161.3)	176.6 (152.4–237.6)	< 0.01
correct answers	96.4 (91.2–98.2)	96.4 (92.5–98.7)	92.9 (84.2–98.2)	0.02
hit rate	100.0 (100.0–100.0)	100.0 (100.0–100.0)	100.0 (99.1–100.0)	0.04
SDMT achievement rate	31.8 (21.8–42.7)	36.3 (27.7–45.0)	19.0 (12.7–26.4)	< 0.01
MARS total score	92.5 (78.3–106.0)	104.5 (94.0–108.0)	70.0 (55.8–81.3)	< 0.01
logit score	61.4 (54.3–76.2)	72.3 (62.4–82.7)	51.0 (45.5–55.6)	< 0.01
Restlessness/Distractibility	4.6 (4.2–5.0)	5.0 (4.7–5.0)	4.0 (3.0–4.4)	< 0.01
Initiation	4.6 (3.4–5.0)	5.0 (4.6–5.0)	3.0 (2.3–4.0)	< 0.01
Consistent/Sustained	4.0 (3.0–4.6)	4.6 (4.3–5.0)	3.0 (2.6–3.6)	< 0.01

Median (Quartile range)
Mann-Whitney U test, * χ^2 test
$P < 0.05$
CI: cerebral infarction, CH: cerebral hemorrhage, SAH: subarachnoid hemorrhage, GCS: Glasgow Coma Scale, ADL: Activities of Daily Living, BRS: Brunnstrom motor Recovery Stage, 1LST: one-leg standing time, FIM: Functional Independence Measure, USN: unilateral spatial neglect, MMSE-J: Mini Mental State Examination-Japanese, VCT: Visual Cancellation Task, SDMT: Symbol Digit Modalities Test, MARS: Moss Attention Rating Scale

planatory variables; GCS, grip, 1LST [average], VCT [shape1], presence of USN, and MARS logit score). In addition, each model was adjusted for age. The results of multiple logistic regression analyses are presented in Table 2. The two models were well fitted with a coefficient of determination (R^2) > 0.6 and χ^2 test of $P < 0.05$. AICc was 73.03 in model 1 and 74.40 in model 2, and BIC was 84.92 in model 1 and 86.28 in model 2. 1LST (average) (odds ratio [OR]: 1.13, $P = 0.03$) and MARS total score (OR: 1.22, $P < 0.01$) in Model 1 and 1LST (average) (OR: 1.14, $P = 0.02$) and MARS logit score (OR: 1.39, $P < 0.01$) in Model 2 were identified as factors related to independent ADL.

Table 2 Results of Multiple Logistic Regression Analysis for the Prediction of ADL independence in the Derivation Sample.

Explanatory variable	β	SE	*P* value	Odds ratio	95%CI
Model 1					
1LST [Average]	0.12	0.06	0.03	1.13	1.03–1.30
MARS total score	0.20	0.04	< 0.01	1.22	1.14–1.34
Model 2					
1LST [Average]	0.13	0.06	0.02	1.14	1.03–1.30
MARS logit score	0.33	0.07	< 0.01	1.39	1.23–1.64

Objective variable: motor FIM (0: ≥ 85, 1: < 85)
Explanatory variables:
Model 1; GCS, grip on the side of ADL use, 1LST [Average], VCT [shape 1], presence of USN, MARS total score
Model 2; GCS, grip on the side of ADL use, 1LST [Average], VCT [shape 1], presence of USN, MARS logit score
adjustment variable: age
Model χ^2 test: Model 1; $p < 0.05$, Model 2; $p < 0.05$
R^2: Model 1; 0.69, Model 2; 0.68
AICc: Model 1; 73.03, Model 2; 74.40
BIC: Model 1; 84.92, Model 2; 86.28
1LST: one-leg standing time, MARS: Moss Attention Rating Scale, FIM: Functional Independence Measure, GCS: Glasgow Coma Scale, ADL: Activities of Daily Living, VCT: Visual Cancellation Task, USN: unilateral spatial neglect

Figure 1 shows the ROC curves for the 1LST (average), MARS total score, and MARS logit score. The optimal cutoff values were 2.99 s for 1LST (average) (sensitivity: 0.830, specificity: 0.767, AUC: 0.867), 89 points for MARS total score (sensitivity: 0.872, specificity: 0.917, AUC: 0.965), and 58.87 points for MARS logit score (sensitivity: 0.883, specificity: 0.917, AUC: 0.967). When the MARS logit score was converted to the total score, it was 88 points [18].

From each model, the MARS total score and logit score were extracted as factors related to ADL independence. The cutoff values for the MARS total score and the logit score showed little divergence.

Discussion

The influencing factors for independence in ADL after acute stroke are yet to be clarified. The current study identified 1LST and MARS scores as factors associated with independence in ADL among patients with acute stroke. The optimal cutoff values were 2.99 s for

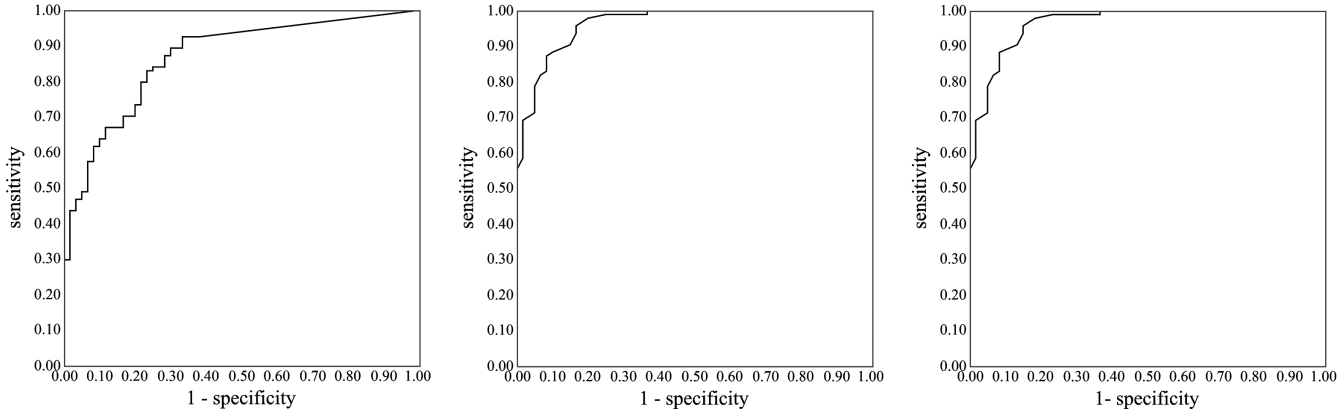

Fig. 1. ROC curves for factors related to ADL independence.
Abbreviations: 1LST, one-leg standing time; ADL, activities of daily living; AUC, area under the curve; MARS, Moss Attention Rating Scale; ROC, receiver operating characteristic.

1LST, 89 points for MARS total score, and 58.87 points for MARS logit score. There were significant differences between the independent ADL and dependent ADL groups with respect to the date of the last evaluation, age, lesion, and discharge destination. The significant differences in these factors could be related to stroke severity. There were more patients in the dependent group who were indicated for rehabilitation after surgery for cerebral hemorrhage or SAH. Neurologic tests showed significant between-group differences in GCS scores, presence of paralysis, grip strength, and 1LST.

A ceiling effect was considered to be present in GCS, suggesting that the current study was biased toward mild cases. This is supported by the BRS bias, which was mildly biased in the independent ADL group. Statistical analysis could not be performed due to the insufficient number of cases in each stage of the BRS. Therefore, in this study, the presence of paralysis was only considered to be related to the degree of independence in ADL. Neuropsychological tests showed significant differences in all items, except for presence of aphasia, suggesting that attention deficit was involved in the degree of independence in ADL. Comparisons of the clinical characteristics, neurologic tests, and neuropsychological tests between the two groups showed significant differences in many items. This suggests that a wide variety of assessments might be needed to examine independence in ADL in patients with acute stroke.

The MMSE-J showed multicollinearity with VCT, SDMT, and MARS, indicating that it was a multidimensional assessment of cognitive function and may be related to different attentional functions. The multicollinearity between SDMT and MARS could be attributed to distributive attention being a higher attention function among all functions, which controls other attentional functions [19]. In addition, divided attention functions are often required in ADLs [20]. Therefore, there might be an association between SDMT and MARS, which assesses attention function from multiple perspectives. In multiple logistic regression analysis, 1LST and MARS were identified as significant factors in both Models 1 and 2. This suggests that MARS could be an indicator of independence in ADL and might be a useful evaluation method for rehabilitation in patients with acute stroke.

Many factors such as equilibrium, muscle, osteoarticular, sensory, and cognitive functions have been shown to be related to balance ability [21]. This study evaluated patients with impaired physical and cognitive functions after stroke. Therefore, identification of the association of 1LST with independence in ADL might be considered a reasonable result. Age, sex, level of consciousness (GCS), paralyzed side, muscle strength, balance, cognitive functions (attention function and USN), and pre-onset ADL were also reported to be related to independence in ADL after acute stroke. In the current study, balance (1LST) and MARS score, which indicates attention function, were identified as related to independence in ADL. These findings are consistent with those in previous studies, supporting the validity of these findings [22–24].

The cutoff values of 1LST, MARS total score, and MARS logit score, which were identified as influencing factors for independence in ADL in multiple logistic regression analysis, were calculated using the ROC curve. The AUC of 1LST (average) was 0.867, indicating its moderate accuracy, while that of MARS was > 0.900, indicating high accuracy. This indicated that the MARS score was superior to the 1LST for identifying independence in ADL. Furthermore, it showed that an observational rating scale was also useful for evaluating rehabilitation in patients with acute stroke.

This study had several limitations. First, the relationship between degree of independence in ADL and changes in the MARS score could not be evaluated owing to the cross-sectional study design. Second, the study sample size was small because the assessment was conducted in a single center, and the study populations appear to be dominated by patients with mild stroke, possibly limiting the generalizability of the study findings. Lastly, neuropsychological tests were limited in this study, and intelligence and executive functions were insufficiently evaluated. Future longitudinal studies are needed to clarify the relationship between degree of independence in ADL and changes in MARS score. Serial case studies and multicenter studies with neuropsychological tests to evaluate intelligence and executive functions and multifaceted evaluations are also needed.

Conclusions

The MARS score, an observational rating scale of attention function, and balance were associated with independence in ADL in patients with acute stroke. Thus, the MARS might be a useful tool for behavioral assessments to determine the degree of independence in ADL in this patient population.

Cut-off values for MARS scores that result in ADL independence were identified. The cutoff values for the MARS total score and the logit score showed little divergence. The MARS total score required for ADL independence is 88 or higher.

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Conflict of Interest

None.

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■ORIGINAL ARTICLE

Measurement of Arm Mass Putting Arm on The Platform Scale in a Sitting Position and Analyzing Based on a Theoretical Model

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Abstract: Background: A simple method for measuring arm mass in clinical practice would be useful for medical records and experimental approaches; however, which but there is no popular measurement method.
Objective: To develop a simple, accurate, and reliable method for approximating arm masses.
Methods: A theoretical model for estimating the mass of the lower and upper arms was proposed. The validity of the model was confirmed via 34 measurements on a steel model in each of the nine upper arm abduction positions using one-sample *t*-tests. The reproducibility of the method was investigated by performing repeat measurements for 29 participants and was confirmed using paired *t*-tests.
Results: One-sample *t*-tests showed no significant differences ($p < 0.05$) in the mean of the nine upper arm abduction positions investigated during the model validation. Regarding reproducibility, the paired *t*-tests showed no significant differences ($p < 0.05$), and the 95% confidence intervals were corroborated by previous reports. Interpretation of intra-class correlation (ICC) was difficult because of inappropriate application.
Limitations: The reproducibility of the suggested method should be verified using an appropriate statistical method.
Conclusions: Because of insufficient reproducibility, supplemental method is required, such as the adjusted backrest fitting better for all subject, and assessor must try to achieve reproducibility when the therapists use this method in clinical practice.

Keywords: estimated arm mass, clinical use, validation and reproducibility

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Introduction

Somatometry is a branch of anthropometry that involves measuring the weight and dimensions of various body parts, including the limbs. Therapists can obtain useful information via somatometry. For example, Sasaki et al. [1] performed a dynamic joint torque calculation during the line-drawing task based on the arm mass measurement. They showed that simple instructions on strengths or weaknesses were insufficient. However, it is difficult to find a practical and accurate mass measurement method that can be used by therapists.

Various measurement procedures have been proposed for this purpose. Direct methods that use either dead or living specimens are not applicable to subject evaluations. Indirect methods include mathematical models [2], nuclear magnetic resonance imaging [3], water displacement [4], and center-of-mass measurements [5]. Several studies on mass measurements have developed mathematical models to examine physical and internal mass ratios using force plates, which are large, expensive, and challenging to operate [6]; thus, these methods are not suitable for routine use in clinical practice. In addition, crucial information regarding the arm mass and the corresponding measurement method are not included in the human characteristic databases of physical measurements [7]. These methods are proposed without defining the upper and lower arm, test-retest reproducibility, and reliability.

There is no mass measurement method for clinical use. Hence, we must define it. A simple and easy approach to minimize a patient's stress during measurement

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is to sit the person on a chair before a table and put his arm on two box scales placed on the desk. However, it is sometimes difficult to accommodate the patient in the same position because of pain, contracture, and other reasons. Therefore, a revised method to estimate the results of mass measurement will also be necessary.

To address this issue, we proposed a simple method based on a theoretical model that can be used by therapists and confirmed its validity and reproducibility.

The study was approved by the Ethical Committee of Yamagata Prefectural University of Health Sciences (0908-13), and conducted in accordance with the Helsinki Declaration.

Materials and Methods

Evaluation of Posture

Participants placed their arms on a desk-mounted platform scale while adopting a seated posture, and the upper arm was positioned according to the scapular plane, preventing substantial weight from being applied to the scale. The lower arms were positioned according to the middle supination and pronation digits; this position allows leeway in the range of motion of each joint and enables the movement or position that minimizes the loading on the joint to be investigated.

Scapular plane elevation elevates the humerus in the scapular plane and has been applied for the management of rotator cuff problems [8] and rehabilitation [9, 10].

The pressure between the scapula and humerus at each angle of the scapular plane elevation is not linear [11], and the evaluation angle must be constant for reliability.

Humeral elevation is also associated with scapulohumeral rhythm, and the scapulohumeral and scapulothoracic joints move at a ratio of 2:1 [12]. However, this ratio is not constant [13]; thus, to minimize the measurement error, the shoulder abduction angle should be constant.

These findings were suggested by the active movements, measurements were performed in a static position to prevent scapulohumeral rhythm, and internal/external rotation angles were consistent although some participants reported difficulty in relaxing their muscles.

Therefore, measurements were performed with participants sitting on a chair with their shoulder abducted and elevated at 45°, the elbow rotated internally at a flexion angle of 90°, the wrist in a neutral position, and the fingers flexed (Fig. 1).

Simplified model

Joint movement around the center of gravity point is muscle-based, and as the muscle mass and morphology are not uniform between individual participants, identifying the center of gravity in individuals can be difficult. To simplify the center of gravity determination process, the upper and lower arms were considered as two rigid bodies, with the mass of the hand included in the lower arm region. Therefore, the effects of muscle tone and joint geometry for a complete ball and socket joint were not incorporated into the mathematical model.

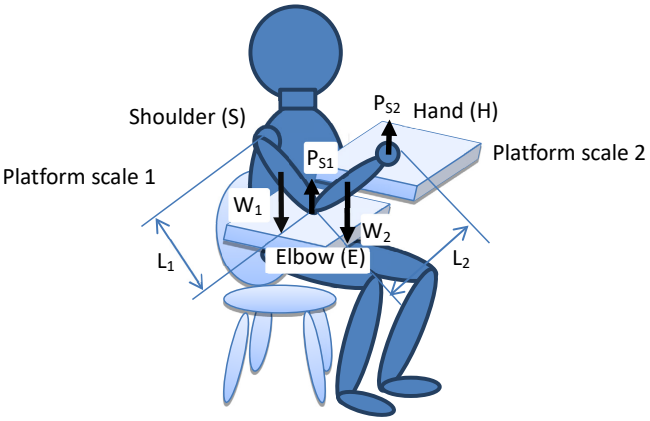

Fig. 1. Schematic of the measurement setup. L_1 denotes the distance from the acromion to the olecranon; W_1 denotes the upper arm mass (the upper arm center of mass is defined as $L_1/2$); L_2 denotes the length of the lower arm from the olecranon to the two distal interphalangeal joints of the index finger (with the hand in a gripping position); W_2 denotes the lower arm mass (the lower arm center of mass is defined as $L_2/2$). Platform scales 1 and 2 were placed under the elbow and hand, respectively, corresponding to the recorded measurements P_{S1} and P_{S2}.

Measurement materials

To perform measurements, two platform scales (1 and 2) were placed such that their inter-center distance was equivalent to the lower arm length of the participant being measured. Additionally, spacers (i.e., 1 ¥ coins) were placed on each platform scale, on top of which wooden boards were placed. After the spacers and boards were placed on the platforms, they were reset to 0 g before the participant placed their arms on the boards (Fig. 1).

Once the balance reading had stabilized and muscle relaxation had been confirmed, the shoulder elevation angle was measured, and the masses recorded by platform scales 1 and 2 were noted. The inclination of the upper arm was measured using an inclinometer (DL-155V, STS Corporation, Nagoya, Japan).

Arm mass calculation

Figure 2a shows the mechanical relationship between the upper and lower arms in a horizontal position.

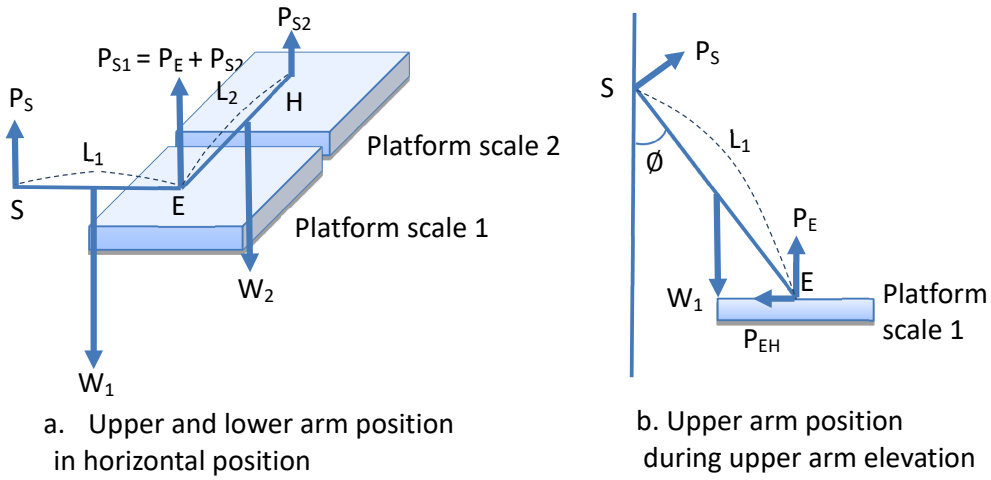

Fig. 2. Mechanical relationships at the time of measurement. The upper arm mass (W_1) and lower arm mass (W_2) were estimated using the upper arm length (L_1, shoulder [S] to elbow [E]) and lower arm length (L_2, elbow [E] to hand [H]), respectively. (a) The values measured by platform scale 1 (P_{S1}) are equivalent to the combined forces of the upper arm (P_E) and the lower arm (P_{S2}). (b) PS denotes the force exerted by the body perpendicular to the upper arm model vector, SE, while Ø denotes the upper arm elevation angle relative to normal.

The lower arm region (EH) ran from the elbow (E) to the hand (H), which were placed on platform scales 1 and 2, respectively. Assuming that the lower arm region (EH) is detached from the upper arm when placed on the platform scales, its mass according to its center of gravity can be approximated as

$$P_{S2} = \frac{W_2}{2} \tag{1}$$

The force exerted on platform scale 1, where the elbow was placed, comprises the forces exerted by the masses of the upper and lower arms, and is expressed as follows:

$$P_{S1} = P_E + (W_2 - P_{S2}) \tag{2}$$

Because $P_E = W_1/2$ and $P_{S2} = W_2/2$, when the upper and lower arms are horizontal, Eq. (2) can be rewritten as

$$P_{S1} = P_E + P_{S2} = \frac{W_1}{2} + \frac{W_2}{2}$$

Therefore, the upper arm mass W_1 can be derived by the following equation:

$$W_1 = 2(P_{S1} - P_{S2}) \tag{3}$$

Because maintaining the upper and lower arms in a horizontal position is difficult in clinical practice, measurements performed with the shoulder in an elevated position were considered. The mechanical relationship for the upper arm when positioned at a shoulder elevation angle of Ø is shown in Fig. 2b. The shoulder (S) experiences a force perpendicular to the upper arm vector, SE, which is countered by the force exerted by the scapula, P_S. The counterforce exerted on the upper arm mass is denoted by P_E, whereas P_{EH} is the force exerted horizontally on platform scale 1 by the dead weight of the elbow. As the forces perpendicular to the ground cancel each other, we can write:

$$P_S \sin Ø + P_E - W_1 = 0 \tag{4}$$

Considering the moment at the elbow (E) when a rigid body with one fixed point is balanced, the sum of the counterclockwise moments at the fixed point is equivalent to the clockwise moment and can be expressed as follows:

$$\left(\frac{L_1}{2}\right) W_1 \sin Ø = (L_1) P_S \tag{5}$$

Then, substituting Eq. (4) into Eq. (5) yields:

$$\left(\frac{2}{\sin Ø} - \sin Ø\right) P_S = P_E$$

Considering $(2/\sin Ø - \sin Ø) = k$, this can be simplified to:

$$P_E = kP_S \tag{6}$$

Additionally, assuming that the lower arm has a uniform mass, the counterforce exerted on the upper arm can be expressed as:

$$P_E = P_{S1} - P_{S2} \tag{7}$$

Specific post-measurement calculation procedure

The coefficient, k, was calculated from the elevation

angle, Ø. The lower arm mass, P_{S2}, was derived using Eq. (1), while the upper arm mass, P_E, was derived using P_{S1} and P_{S2} from Eq. (7). Next, P_S was derived using the P_E from Eq. (6). Finally, the upper arm mass, W_1, was derived using the values for P_E and P_S from Eq. (4).

Verification of theoretical validity and reproducibility

Because the effects of soft tissues cannot be excluded in living organisms, an experiment was conducted to verify the theoretical validity of the mathematical model using a steel model. Repeated measurements were performed to determine the model reproducibility.

Statistical analyses were conducted using GNU R3.4.3 [14] and G*Power3 [15]. Statistical tests were performed using the 95% confidence level and two-tailed method.

Experiment 1: Verification of validity based on upper arm model

Purpose

To verify the theoretical validity of our mathematical model.

Methods

A steel rod with uniform mass and a measured mass of $W_{T1} = 678.0$ g was used as an upper arm model (Fig. 3a) and was placed on the measurement platform. The measurement platform was placed on a tripod (GPD2; Vixen., Co, Ltd. Tokorozawa, Saitama, Japan), thereby allowing for fine positional adjustments.

The measurement platform comprised an L-shaped flat steel bar with compression-type load cells *G*1, *G*2, and *G*4 (TC-SR(T)10N-G; TEAC, Tokyo, Japan) connected to a digital indicator (TD-700T, TEAC), from which values were read. The load cell *G*3 was considered a test dummy and yielded values equivalent to *G*2. Designating measurements at *G*1, *G*2, *G*3, and *G*4 as force vectors *PG*1, *PG*2, *PG*3, and *PG*4, respectively, resulted in the following equations: $PG1 = P_S$, $PG2 = PG3$, and $P_E = \sqrt{(2PG2)^2 + (PG4)^2}$ (Fig. 3b). During the measurements, the forces exerted on the small compression-type load cells were recorded at measurement platform inclination angles from 10° to 90° in increments of 10°. As the coefficient k cannot be calculated at an inclination angle of 0° ($\sin 0 = 0$), no measurements were performed at this angle. All the measurements were performed at a constant temperature of 25°C.

Statistical processing and experimental procedures

In accordance with the discussion on statistical power testing proposed for psychological experiments

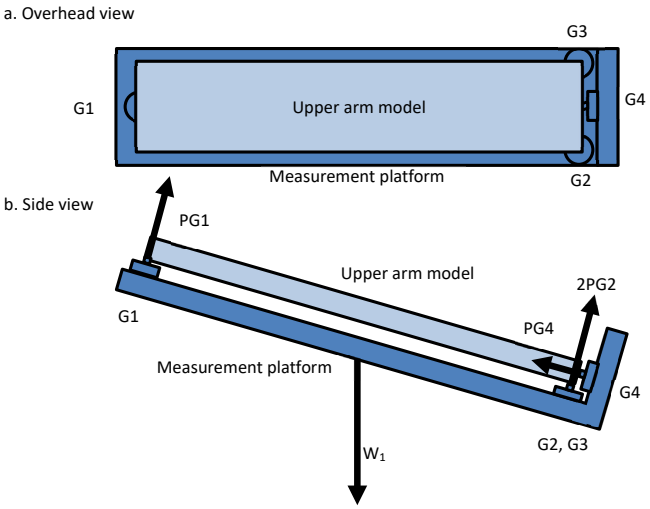

Fig. 3. Schematic of the measurement platform showing the parameters used in the verification equations. The measurement platform is an L-shaped flat steel bar bearing the compression-type load cells *G*1, *G*2, and *G*4, which are connected to a digital indicator. Note that *G*3 is a point of support yielding similar values to *G*2. The force direction arrows represent *PG*1, 2*PG*2, *PG*4, and P_E.

by Cohen, *a priori* statistical power testing for a one-sample *t*-test was performed (effect size: $d = 0.5$; significance threshold: $p = 0.05$; statistical power: 1-β = 0.8; two-tailed) [15, 16]. A sample size (n) of 34 was used for each angle.

If the statistical power was < 0.5, the measurement was continued. After the measurement at each angle was performed, the arm masses were calculated using the aforementioned methods. Descriptive statistics, namely a Shapiro–Wilk test of normality and an F-test, were performed for each angle. Based on these test results, a one-sample *t*-test was performed using a population mean of $W_{T1} = 678.0$ g, d, 1-β, and 95% confidence interval (CI).

Results

The mean mass (M) at each angle ranged from 677.5 g to 678.5 g, with a standard deviation (SD) of 0.7–2.3. The angle-dependent measurements showed a normal distribution according to the Shapiro–Wilk normality test, $W = (0.95–0.98)$, $p = (0.06–0.45)$ (Table 1).

The one-sample *t*-tests showed no significant differences irrespective of the angle, $t = -1.89–1.13$, $p = 0.07–0.68$, $d = 0.00–0.28$, 1-β = 0.50–0.70. For each angle, the true mass (W_{T1}) measured at the beginning of the experiment was situated within the upper and lower limits of the 95% CI.

Table 1 Results of the theoretical validity investigation

Elevation angle[a] (°)	*M* (*SD*) [g]	95% *CI*	*MSE*	Shapiro–Wilk test of normality		One-sample *t*-test		Post hoc power test for one-sample *t*-test	
				W	*p*	*t*	*p*	*d* (Cohen)	1-β
10	678.1 (1.2)	[677.7, 678.4]	0.18	0.96	0.14	0.42	0.68	0.06	0.70
20	678.2 (1.4)	[677.8, 678.6]	0.20	0.96	0.09	1.13	0.26	0.17	0.52
30	677.8 (0.7)	[677.6, 678.0]	0.11	0.97	0.38	−1.89	0.07	0.28	0.50
40	677.5 (2.0)	[676.9, 678.1]	0.30	0.96	0.12	−1.67	0.10	0.25	0.50
50	677.8 (1.8)	[677.3, 678.4]	0.27	0.96	0.14	−0.63	0.53	0.09	0.61
60	678.5 (1.9)	[677.9, 679.0]	0.29	0.98	0.45	1.68	0.10	0.25	0.50
70	677.5 (2.3)	[676.8, 678.1]	0.34	0.95	0.07	−1.56	0.13	0.24	0.50
80	677.7 (1.1)	[677.4, 678.0]	0.16	0.95	0.06	−1.81	0.08	0.27	0.50
90	677.7 (1.3)	[677.6, 678.4]	0.20	0.95	0.06	0.00	1.00	0.00	1.00

Note. [a] $n = 44$. *SD* = standard deviation; *CI* = confidence interval; *MSE* = mean standard error; *W* = test statistic; *p* = asymptotic significance probability; *t* = test statistic; 1-β = statistical power.

Experiment 1 Discussion

Based on the effect size and appropriate sample number, no significant differences were found between W_{T1} and the angle-resolved mean mass values, indicating that the proposed method could estimate the true mass. The measurement conditions were the same for each angle. This can be attributed to factors such as angle configuration. These results demonstrate the theoretical validity of the proposed method.

Experiment 2: Verifying reproducibility in living subjects

Purpose

To verify the reproducibility and accuracy of the measurements.

Methods

Because resting state muscle tone, length, and center of gravity can change with differences in arm elevation, we expected corresponding changes in mass according to the elevation angle. However, this only verified our proposed method at the angular position described in the "Overview of the measurement method" section. Multiple assessors (28 women; 8 men; mean age, 21.2 years; age range, 19–22; all occupational therapy students who completed 1,000 hours of fieldwork) conducted two mass measurements on a Japanese man (age, 55 years, height, 167 cm, weight, 72 kg), height of chair, 43 cm; height of desk, 70 cm. Measurements were performed using platform scales 1 and 2 (KD2002141; maximum weight, 5 kg; minimum weight, 5 g; KD2002161; maximum weight, 1 kg; minimum weight, 1 g; height of scales, 74 mm; TANITA, Tokyo, Japan;). After providing instructions and demonstrations regarding the measurement method, several tests were conducted to assess whether each reviewer could adequately perform the measurement method. After the first measurement was performed, the second measurement was conducted 30 min later.

Experimental procedures and statistical processing

Statistical analyses were performed using the paired *t*-tests. The required experimental sample size ($n = 27$) was calculated *a priori* based on statistical power testing ($r = 0.5$, $\alpha = 0.05$, 1-$\beta = 0.8$) [16]. Once the experiment commenced, the post hoc power tests on $n = 27$ showed that 1-β was lower than 0.5, and the sampling was continued. The final sample size was found to be 34. Outlying data (points beyond twice the SD) were rejected; therefore, the final data represented the W_1 and W_2 values for 29 participants (Table 2).

Results

Table 2 shows the descriptive statistics for each measurement. The Shapiro–Wilk test for normality showed that each distribution was normal. The F-test for the 1st and 2nd measurement sets had the same variance. The paired *t*-test showed no significant difference in W_1 W_2. Post hoc power tests for the paired *t*-test yielded 1-$\beta = 0.83$, $d = 0.04$, and 1-$\beta = 0.51$, $d = 0.29$ for W_1 and W_2, respectively. The intraclass correlation coefficient (ICC) (2, 29) for W_1 and W_2 were 0.00, and 0.51, respectively.

Experiment 2 Discussion

The four measurements showed normal distributions and the same variance, indicating that the measurement conditions were almost identical. No significant differences were observed using the paired *t*-test, while the post hoc power tests (1-$\beta > .5$) showed middle

Table 2 Verification of reproducibility

Estimation Parameter[a]	Measurement	*M* (*SD*) [g]	95% *CI*	Shapiro–Wilk test of normality		F-test		Paired *t*-test		Post hoc power test for paired *t*-test	
				W	*p*	*F*	*p*	*t*	*p*	*d* (Cohen)	1-β
W_1	1st	1284.41 (119.28)	[1241.00, 1327.82]	0.98	0.93						
	2nd	1291.37 (137.84)	[1241.20, 1341.54]	0.98	0.73						
	1st & 2nd					0.75	0.45	–0.22	0.83	0.04	0.83
W_2	1st	1411.10 (101.08)	[1374.31, 1447.89]	0.97	0.53						
	2nd	1375.79 (99.69)	[1339.51, 1412.07]	0.97	0.64						
	1st & 2nd					1.03	0.94	1.55	0.13	0.29	0.51

Note. [a] n = 29; *M* = Mean; *SD* = Standard deviation; *CI* = Confidence interval; *W*, *F* , *t* = test statistics; *p* = asymptotic significance probability; *d* = Effect size, 1-β = Statistical power.

Table 3 Estimation of arm mass in previous research

Researcher type of subjects	*n*	age	*GUA* [%]	*GLA* [%]	*GH* [%]	W_1		W_2		W_3		W_4	
						M (*SD*) [g]	95% *CI*	*M* (*SD*) [g]	95% *CI*	*M* (*SD*) [g]	95% *CI*	*M* (*SD*) [g]	95% *CI*
Akou et al. young Japanese athletes	215	19.9	52.9	41.5	89.1	1879.2 (208.8)	[1851.3, 1970.1]	1531.2 (208.8)	[1503.3, 1559.1]	1113.6 (139.2)	[1095.0, 1132.2]	417.6 (69.6)	[408.3, 426.9]
Cheng et al. Chinese Labors	8	26.0	43.4	47.3	42.0	2560.0 (320.0)	[2338.3, 2781.8]	1382.4 (396.8)	[1107.5, 1657.4]	960.0 (192.0)	[827.0, 1093.1]	422.4 (204.8)	[280.5, 564.3]
Park et al. Korean Geriatrics	7	67.9	–	–	–	1460.1 (298.8)	[1238.7, 1681.4]	1432.9 (122.2)	[1342.4, 1523.5]	1005.1 (88.3)	[939.7, 1070.5]	427.8 (34.0)	[402.7, 453.0]

Note. *GUA* = Gravity point from the proximal part of the upper arm; *GLA* = Gravity point from the proximal part of the lower arm; *GH* = Gravity point from the proximal part pf the hand.

powers [16]. However, since the ICC for W_1 and W_2 showed low reproducibility, interpretation of the results was difficult. Because W_1 measures were calculated using W_2, which is not the appropriate use of the ICC as it is based on a one-way model (meaning one fixed effect); we could not consider the reproducibility for the suggested method using the ICC. These results indicate that the reproducibility of the measurements performed by multiple researchers for each participant was insufficient.

Discussion

Comparison with previous research

The 95% CIs of Experiment 2 were compared with those of previous studies on Asian participants [2–4]. The 95% CIs in previous research (Table 3) were derived from the M, SD, and sample numbers. W_2 was derived from W_3 (the lower arm mass without the hand) and W_4 (the hand mass without a lower arm mass).

Our 95% CIs of W_1 and W_2 (Table 2) almost overlapped with those of Park [4] (Table 3), indicating the accuracy of our method.

Furthermore, both previous [2, 3] studies and the current research used the fixed definition of the center of gravity and not the measurement method of the center of gravity. The fixed center of gravity minimized the measurement error; however, as each gravity point was different, the measurement method of the center of gravity should also be considered.

Clinical measurement

Because of insufficient reproducibility, a supplemental method, such as the adjusted backrest fitting better for all subjects, is needed; and the assessor must try to achieve reproducibility.

Appropriate training in this measurement method is important, and the assessor should interpret several samplings and 95% CIs. Notably, the requirement of 95% CI in clinical practice is unclear and needs to be considered by individual clinical practices.

Applying this method in clinical situations judged to assess the arm mass, but no suitable method was found, for example, stiffness or edema, diet therapy, or exercise therapy.

Limitations and prospects of this study

Definitions of upper and lower masses were unclear.

Adjustments may be necessary depending on the type of physical range estimated. So, the assessor must not compare the estimate using this method and the estimate using other methods.

The reproducibility in Experiment 2 was confirmed for targeting a normal subject. However, a reliability test will also be needed, although the condition of patients will not be consistent. Hence, the reliability should be confirmed by a test for each case.

Since there was no proper statistical method available for measuring reproducibility, we consider our results insufficient. The reproducibility of the suggested method should be tested again using the appropriate statistical method that can evaluate the two-way model.

The significance of this study is that it suggests a measurement method. We however could not use a statistical method to verify the reproducibility of proposed measurement method.

Conclusion

This study presents a method for conducting somatometric measurements, which are both accurate, reliable, and convenient for therapists to use in clinical environments. Statistical analyses of the measurements recorded for the participants in this study using the proposed method confirmed its validity, but reproducibility was insufficient. Next, the proposed method should be trialed by clinicians to quantify its clinical usefulness and identify areas requiring refinement. Although the proposed method may not be suitable for all subjects, it is expected to provide broad applicability.

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■ORIGINAL ARTICLE

Factors Related to Functional Outcome in Patients with Moderate or Higher Upper Limb Paralysis using ReoGo®-J – A Retrospective Observational Study –

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Abstract: Background: Several guidelines recommend robotic therapy for upper extremity motor paralysis after stroke, but the number of eligible patients is unknown. This study aimed to examine predictors of functional outcomes after robotic therapy in patients with moderate or severe upper extremity paralysis.
Methods: This retrospective observational study included 53 patients with subacute stroke. Patients received daily occupational therapy (OT) for 4 weeks and robotic therapy 3 to 4 times per week for 20 min per session. Binomial logistic regression analysis was performed to estimate predictors of participants with a minimal clinically important difference (MCID) of 9 points or greater in the Fugl-Meyer Assessment of Upper Extremity (FMA-UE) after 4 weeks based on FMA-UE shoulder and elbow forearm scores, days since onset, and amount of OT training. Cutoff values were calculated using receiver operating characteristic curves.
Results: Only the FMA-UE shoulder and elbow forearm score (odds ratio = 0.913, $p = 0.014$) was a predictor of FMA-UE improvement in MCID after 4 weeks. The cutoff value was calculated to be 12.5 points.
Conclusion: The FMA-UE shoulder and elbow forearm score at the start of interventions may be a useful predictor of functional outcomes after robotic therapy in patients with moderate or severe upper limb motor paralysis after stroke. Furthermore, an FMA shoulder and elbow forearm score of 12.5 might be necessary to show improvement over MCID in the short term.

Keywords: robot-assisted therapy, predictor, subacute phase, paralyzed upper extremity

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1. Introduction

Robotic therapy for upper limb paralysis after stroke is an evidence-based intervention method that can help participants with moderate to severe upper limb paralysis maintain training volume [1]. ReoGo®-J (RGJ) is one of the upper limb robots used in Japan, and its usefulness for upper limb voluntarism in patients with stroke has been observed [2–4]. Furthermore, due to the newly established additional fee for equipment to increase locomotion in the 2020 revision of medical reimbursement, the opportunity for indication of robotic therapy for upper limb paralysis after stroke is expected to increase.

A certain effectiveness of robotic therapy was recognized in a review of robotic therapy [5], but the need for examination of training intensity, duration, and participant characteristics was noted. In contrast, it is well known that many interacting factors influence the functional outcome of upper limb paralysis [6], but there have only been sporadic studies of factors influencing functional outcomes after robotic therapy [7–9]. Furthermore, it is critical that rehabilitation effectiveness measures are meaningful to the participant, but there are few reports [9, 10] that have predicted changes beyond the minimal clinically important difference (MCID) in the Fugl-Meyer Assessment (FMA), and we did not find

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any in RGJ as far as we could wade through. Based on the recommendations in the aforementioned guidelines [1], the target population for robotic therapy is expected to be individuals with moderate to severe upper limb paralysis, but selecting eligible patients is often difficult.

Therefore, this study aimed to investigate predictors of functional outcomes in patients with moderate to severe upper limb paralysis using RGJ to help select cases for robotic therapy.

2. Materials and Methods

Study design and participants

This is an observational study that was conducted in the past. The participants were patients with stroke with moderate to severe upper limb paralysis who were admitted to our hospital between March 2018 and December 2021 and were treated with robotic therapy using RGJ in addition to standard occupational therapy (OT). According to Daly et al. [11], the severity of upper limb paralysis was defined as FMA 49 or less. The inclusion criteria were patients who could continue robotic therapy using the RGJ for 20 min three to four times a week for four weeks, whereas the exclusion criteria were patients with recurrent stroke and those with deficiencies in the survey items described below. Patients with FMA changes of nine or more points [12], considered to have subacute MCID, were classified as the improvement group, whereas patients with FMA changes of eight points or less were classified as the nonimprovement group.

This study was carried out in accordance with the Helsinki Declaration (as revised in Brazil in 2013), and approval was obtained from the Ethical Committee of the Oita Oka Hospital Ethics Review Committee (approval number: A046). Instead of obtaining informed consent from each participant, consent was obtained by publishing study details on the homepage of the research institute website, as well as onsite posting in the facility. The survey items included age, gender, disease type, paralytic side, time from onset to start of robotic therapy (hereafter, onset period), total number of OT units during the period of robotic therapy (hereafter, total number of OT units), degree of sensory impairment, FMA, Functional Independence Measure (FIM), modified Ashworth Scale (mAS), and Frontal Assessment Battery. Each occupational therapist who was not involved in this study measured these items within 3 days of beginning robotic therapy.

Robotic therapy protocol

In this study, RGJ was used for robotic therapy, which is a Japanese-specific version of ReoGo® by Motrica Inc. of Israel. Upper limb functional training is performed by the participant by grasping a handle attached to the arm and reaching toward a target displayed on the screen. The training menu includes 17 different types of exercise trajectories that can be selected based on the participant's ability. The robot can provide five types of assistance and resistance load: full assistance, initial load, automatic assistance, trajectory assist, and automatic exercise. It is also possible to adjust the reach range, load amount, and arm movement speed [13].

Robotic therapy with RGJ was used as an adjunct therapy to traditional OT, either through voluntary practice or during the OT intervention period. The duration was 20 min per day, three to four times per week. The upper limb joint movements required for the targeted activities, as well as the joint movements that were antagonistic to the abnormal joint movement patterns, were analyzed, and menus that included these joint movements were preferred. The orbit-assist mode was the basic assistance mode, which was combined with the automatic exercise mode based on the quality of the movements performed. When adjusting the difficulty level, we observed the quality of movement (ordinal scale of quality of movement in the Motor Activity Log [14]) during the robotic therapy, referring to Takebayashi's report [15]. The reach range was adjusted to 3.5–4.0 by referring to the compensatory movements of the trunk and shoulder girdle. Moreover, the occupational therapist in charge adjusted each practice menu and difficulty level, and the difficulty level was adjusted at least once every 2 weeks.

Approaches other than robotic therapy

As part of the recovery rehabilitation, OT, including upper limb function training, was provided daily for 40–100 min. Upper limb function training included task-oriented training such as manual therapy, neuromuscular stimulation, object manipulation, and use of the paralyzed hand, as well as daily living activities and applied daily living activities provided in parallel based on the needs and demands of the patients. Daily physical therapy and speech-language pathology services were also provided, but none involved active intervention for upper limb function.

Statistical analysis

The Shapiro–Wilk test was performed to confirm the normality of continuous variables for the improvement and nonimprovement groups, followed by uncorrelated *t*-tests for age and motor FIM, duration of onset, total OT units, surface sensation, and deep sensation. The Mann–Whitney U test was performed for sensation, FMA, cognitive FIM, and mAS. The following factors

Table 1 Characteristics of participants

	Improvement group (n = 27)	Non-improvement group (n = 26)	*p*-value
Gender (male/female), n	14/13	15/11	0.669
Stroke type (infarction/hemorrhage), n	18/9	18/8	0.842
Age, year	71.1 ± 10.7	71.6 ± 11.5	0.872
Affected side (right/left)	13/14	18/8	0.166
Period from stroke onset, days	38.0 [31.3–44.5]	45.5 [35.3–55.0]	0.223
Length of daily occupational therapy (min)	108 [88.5–124.5]	103.5 [89.8–118]	0.408
Superficial sensory	1.0 [0.0–1.0]	1.0 [1.0–2.0]	0.52
Deep sensory	1.0 [0.3–2.0]	1.0 [1.0–2.0]	0.66
Total FMA (Point)	31 [17.3–42.3]	7.0 [4.0–21.5]	0.009**
4weeks Total FMA (Point)	42.0 [33.8–55.8]	12.0 [9.3–27.3]	< 0.001**
FMA-UE (Point)	17.0 [11.8–22.8]	6.5 [4.0–16.3]	0.007**
4weeks FMA-UE (Point)	28.0 [23.0–30.8]	10.5 [8.0–22.8]	< 0.001**
Motor FIM Score (Point)	51.9 ± 17.6	39.3 ± 13.8	0.007**
Cognitive FIM score (Point)	29.0 [26.0–33.0]	27.0 [20.3–31.0]	0.116
mAS score shoulder flexors	0 [0.0–1.0]	1.0 [0.0–1.0]	0.298
mAS score elbow flexors	1.0 [0.0–1.0]	1.0 [0.0–1.8]	0.985
mAS score wrist flexors	1.0 [0.0–1.0]	1.0 [0.0–1.0]	0.884
FAB (Point)	14.0 [11.3–15.0]	12.5 [8.3–14.8]	0.169

Mean ± Standard deviation, Median [interquartile range], **: $p < .01$
FMA, Fugl–Meyer Assessment; FIM, Functional Independence Measure; mAS, modified Ashworth Scale

were also considered: gender, disease type, and paraplegia. The $\chi 2$ test was also performed to compare gender, disease type, and paralytic side. Multivariate analyses were performed on participants who met the inclusion and exclusion criteria. In the multivariate analyses, a binomial logistic regression analysis was performed, with the dependent variable being the presence of FMA MCID (9 points) improvement at 4-week follow-up and the independent variables being FMA shoulder, elbow, and forearm items, total OT units, and days since stroke onset at the start of interventions and FMA. The reasons for selecting these independent variables are as follows. An association has been reported between FMA scores at the start of interventions and functional prognosis, and lower scores have been reported to be associated with worse functional prognosis [6]. Regarding total OT units, a greater functional improvement has been reported to be associated with more upper extremity training [16]. Regarding the number of days since stroke onset, a previous study [17] reported better functional prognosis for those who started rehabilitation earlier after stroke onset. Based on these studies, factors that could be considered to be closely related to the functional outcomes of FMA were selected as independent variables. Spearman's rank correlation coefficient and variance expansion factor (VIF) were checked for these variables to check for multicollinearity. In the binomial logistic regression analysis, if a variable was found to be significantly related to the independent variables, the Youden index on the receiver operating characteristic (ROC) curve was used to define the cutoff point at which the sum of sensitivity and specificity−1 was the greatest. This was calculated as the ("ROC curve") value. Statistical analysis was performed using SPSS 2.0. SPSS 26 was used as the statistical analysis software, and the significance level was set at 5%.

3. Results

Univariate analysis (Table 1)

The analysis included 53 of the 81 patients who met inclusion criteria, excluding 28 patients who met exclusion criteria. Of these, 27 were in the improvement group and 26 in the nonimprovement group. FMA total ($p = 0.009$), FMA shoulder elbow forearm items ($p = 0.007$), and exercise FIM ($p = 007$) showed significant differences in univariate analysis.

Multivariate analysis (binomial logistic regression analysis)

Spearman's rank correlation coefficient revealed no significant correlation between any of the variables (Table 2), and the VIF among the independent variables were all less than 2, implying that no multicollinearity existed [18]. Binomial logistic regression analysis revealed the number of FMA shoulder elbow forearm items (odds ratio (OR): 0.913, 95% confidence interval (95% CI): 0.851–0.980, $p = 0.011$), the number of OT units (OR: 0.998, 95% CI: 0.974–1.023, $p = 0.892$), and the onset period (OR: 1.023, 95% CI: 0.989–1.058, $p = 0.181$) (Table 3). Based on these findings, the ROC curve of the FMA shoulder elbow forearm item was

Table 2 Correlations among independent variables used in the binomial logistic regression analysis.

variables	FMA-UE	Length of daily occupational therapy	Period from stroke onset
FMA-UE	1.00		
Length of daily occupational therapy	−.141	1.00	
Period from stroke onset	−.108	.120	1.00

Spearman's rank correlation coefficient, FMA, Fugl–Meyer Assessment

Table 3 Logistic regression analysis with Improved FMA over MCID as a dependent variable.

Explanatory variables	*B*	OR	95%CI	*p*-value
FMA-UE	−0.91	0.913	0.851–0.980	0.011*
Length of daily occupational therapy	−0.02	0.998	0.974–1.023	0.892
Period from stroke onset	0.23	1.023	0.989–1.058	0.181

B, Partial regression coefficient; OR, odds ratio; 95% CI, 95% confidence interval; FMA, Fugl–Meyer Assessment *: $p < .05$

depicted, and the cutoff was calculated using the Youden index, which was 12.5 points (area under the curve: 0.72, sensitivity: 74%, specificity: 69%, 95% CI: 0.58–0.86), indicating a good model fit. The area under the curve was larger than the recommended value of 0.7 [19] (Fig. 1).

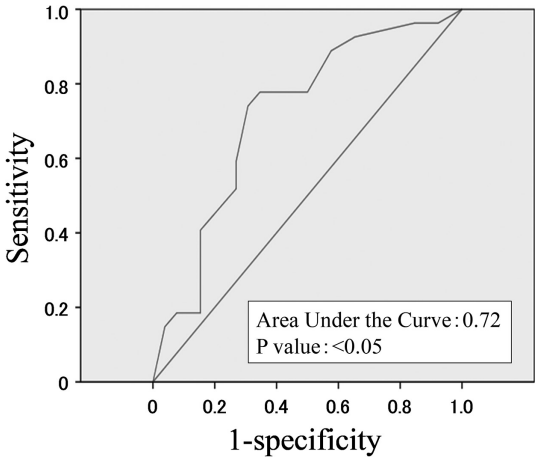

Fig. 1. Receiver operating characteristic curve for FMA-UE items.

4. Discussion

In this study, we investigated predictors of the functional outcome of FMA 4 weeks after robotic therapy based on FMA shoulder and elbow forearm items at the start of interventions, duration of onset, and total number of OT units. The findings revealed that the FMA shoulder and elbow forearm items were significantly related at the start of interventions, and a cutoff value of 12.5 points could be calculated.

Differences in basic attributes

Significant differences in FMA total, FMA shoulder and elbow forearm items, and FIM motor items were found in univariate analysis. This could be due to the voluntary nature of upper limb paralysis at the beginning of the intervention, as Coupar et al. [5] found that the severity of upper limb paralysis at the beginning of intervention affects functional outcomes. In addition to motor paralysis, other factors such as balance function [20] and higher brain dysfunction [21] are known to affect FIM motor items in patients with stroke, and the impact of these factors on upper limb function must be considered.

Usefulness of FMA as a predictor of functional outcomes after robotic therapy

The Box and Block Test (BBT) [8] and the Hand Movement Scale [10] have been proposed as predictors of functional outcomes after robotic therapy for patients with subacute stroke. However, it is well known that upper limb paralysis after stroke occurs primarily in the distal joints [22], and these assessments, which require hand joint and hand function, are expected to be difficult to use in participants with moderate to severe upper limb paralysis. The FMA is useful in this regard because it can be used easily even in cases of moderate or severe upper limb paralysis [23] because its responsiveness has been reported in cases of moderate or severe upper limb paralysis, implying that it can be used as a functional outcome after robotic therapy. As a result, this index is useful because it is simple to use in cases of moderate to severe upper limb paralysis.

According to Duret et al. [9], the FMA shoulder and elbow forearm items were included as potential predictors of MCID after robotic therapy. Recovery is thought to be task-specific [24]. Therefore, our findings supported previous studies on the relationship between FMA shoulder elbow forearm items and functional outcomes after robotic therapy.

FMA, on the other hand, has not been shown to predict improvement beyond MCID in cases of moderate to severe upper limb paralysis and associated symptoms such as sensory impairment, hemispatial neglect, and aphasia [9]. Furthermore, it has been reported that in mild to moderate cases, prediction using BBT was more useful than FMA [7]. This implies that the accuracy of

FMA as a predictor of improvement over MCID in predicting functional outcomes of robotic therapy is dependent on background factors and intervention protocols and that the results of this study should be validated in the future.

Limitations

Because this was a retrospective observational study, the content of training other than robot therapy was not controlled, and the predictors of robot therapy could not be rigorously investigated. Furthermore, the sample size was not designed to ensure adequate power. In addition, we only looked at short-term predictors over a 4-week period and did not predict mid- to long-term functional outcomes. Furthermore, because the study was conducted at a single institution, the possibility of selection bias cannot be ruled out. Based on this, it may be necessary in the future to design a sample size, select participants based on a cutoff index, develop and validate a systematic intervention strategy, re-examine mid- to long-term predictors through follow-up during hospitalization and after discharge, and conduct joint validation at other institutions for external validation. External validity must be through joint validation at other institutions, according to experts.

5. Conclusions

With robotic therapy using RGJ, the FMA-UE shoulder and elbow forearm item scores at the start of interventions were most related to the short-term FMA-UE functional outcomes. The study results suggest that a score of 12.5 is necessary for the participants to achieve short-term improvement beyond MCID.

Conflicts of Interest

No potential conflict of interest was reported by the authors.

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■CASE REPORTS

Acquiring Practical Cooking Skills in the Non-Dominant Hand after Severe Right Hemiplegia: A Case Report

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Abstract: Purpose: There are no reported cases of reacquisition of cooking ability in patients with severe hemiplegia of the dominant hand due to stroke. Thus, this study reports a case in which a patient with severe hemiplegia on the dominant hand side due to stroke reacquired practical cooking ability after being trained on cooking using the non-dominant hand.
Methods: The patient was a right-handed woman with severe right hemiplegia due to left capsular hemorrhage who needed to be able to cook by herself. The patient had difficulty cooking with her right upper limb because of severe right hemiplegia; therefore, we examined cooking methods suited to the patient using various tools so that she could manage to cook using only her left upper limb. In addition, we asked her family members to help her repeat and practice what we had trained her to do.
Results: The mean performance score and satisfaction, obtained using the Canadian Occupational Performance Measure, improved by 3 points after the intervention. The patient was able to cook independently.
Conclusions: Our results suggest that patients with severe hemiplegia on the dominant hand side may be able to reacquire cooking ability using the non-dominant hand through repeated practice of cooking-related tasks adjusted to an appropriate level of difficulty while using cooking apparatus.

Keywords: stroke, non-dominant hand, cooking, Canadian Occupational Performance Measure, rehabilitation

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Introduction

Cooking is one of the most difficult independently performed post-stroke instrumental activities of daily living (IADLs). Approximately 77% of post-stroke patients require assistance with cooking [1]. Only 15% patients with upper limb paralysis can use their upper limbs in daily life without difficulty [2]. Therefore, considering compensatory strategies to reacquire cooking related movements is crucial.

Compensatory use of the non-dominant hand is an option for post-stroke patients with paralyzed dominant hand. Philip et al. reported that training to draw precisely with the non-dominant hand for 30 min/day for 10 days improved the speed and ease of non-dominant hand use, and the effect persisted for 6 months post training [3]. Therefore, for post-stroke patients with severe upper limb paralysis who wish to resume cooking, practicing compensatory movements with the non-dominant hand is critical.

The Canadian Occupational Performance Measure (COPM), a patient-centered instrument, allows patients to determine and rank problematic tasks of daily living [4]. In a survey of tasks using the COPM for chronic hemiplegia of the upper limbs, 17% respondents listed cooking tasks as a goal [5]. However, to our knowledge, there is no published report on chronic-stroke patients with paralyzed dominant hand reacquiring practical cooking abilities with the non-dominant hand.

We report a case of a right-handed patient with severe right hemiplegia due to left capsular hemorrhage

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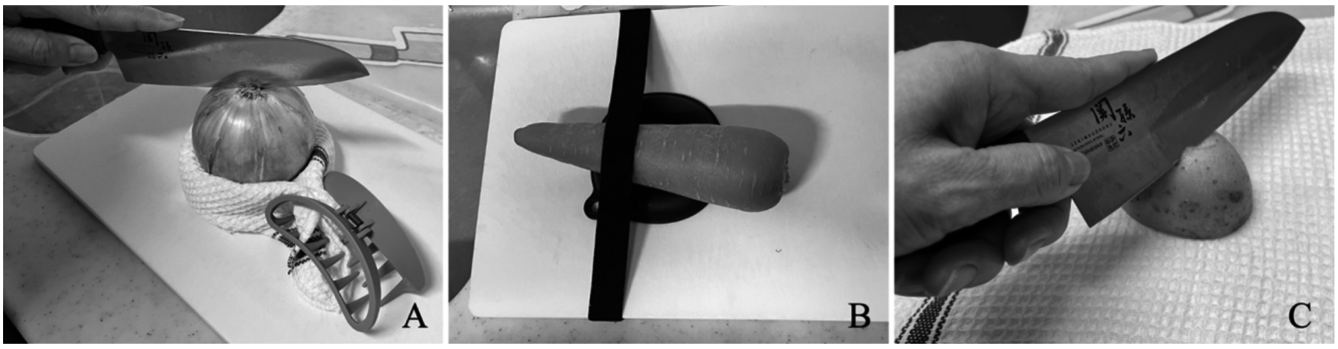

Fig. 1. Cooking methods used in the case study.
A) Fixing spherical foods: A wet towel of appropriate size was looped; its two ends were clipped together to create a hollow in which the food was placed to prevent it from rolling.
B) Fixing stick-shaped foodstuffs: A rubber band was tied to a cutting board, and the foodstuff was secured to the cutting board with the rubber band. A silicon mat was placed under the food to prevent it from sliding.
C) Peeling food: A wet towel was laid on the cutting board, and the foodstuff was placed on the towel with the cut end facing down to expand the ground contact area and prevent it from rolling.

who reacquired practical cooking ability using the non-dominant hand and had improved COPM performance and satisfaction scores.

Material and subject

This case is that of a right-handed woman in her 50s who had been independent in IADLs before stroke. The patient was discharged 141 days after stroke with a Mini-Mental State Examination score of 27. After discharge, right upper limb paralysis prevented her from cooking. To train for independent living, she had 60-min home-visit rehabilitation sessions twice weekly. The patient set the following goals: “be able to cook,” “be able to take in and fold laundry,” and “be able to go out for walks.” The importance of each of these items as perceived by the patient was scored 5, 6, and 3, respectively. During the early phase of rehabilitation, the patient began outdoor practice and soon was able to walk independently. She was able to take in the laundry, partly because she had only mild lower limb motor paralysis; she was able to fold her laundry with compensatory support from her non-paralyzed side. However, she was unable to cook with one hand or with the non-dominant hand. Thus, practicing cooking was added to the home-visit rehabilitation program. This study was conducted in accordance with the Declaration of Helsinki after obtaining both oral and written informed consent.

Methods

Pre-intervention

Methods used to cook independently, namely, cutting and peeling, were analyzed. Several problems were encountered during cooking. First, insufficient fixation of foodstuff made cutting them into pieces difficult. Second, difficulty peeling skin using a peeler along spherical contours with one hand.

Cooking Instruction

Initially, we used a cutting board with nails holding the food in place. However, even with a cutting board with nails, securing the food was difficult, and injury risk was high. Therefore, after consulting with the patient and her family, patient appropriate cooking methods were implemented.

Figure 1 illustrates the improvised cooking methods. (1) Food preparation: To prevent rolling of spherical items, we clipped both ends of a wet towel to create an appropriate-sized circle, placing the foodstuff in its hollow (Fig. 1-A). Stick-shaped food items, such as carrots, were fixed to the cutting board by securing them with a rubber band. Food items were placed on a silicon mat to prevent them from sliding (Fig. 1-B). (2) Peeling: The cut food was placed on a wet towel placed on the cutting board. The cut end of the food item was placed face down to increase the contact area and prevent rolling. Food items were then peeled from top to bottom direction (Fig. 1-C). To prevent injury, the patient was instructed to lower the knife from the tip of the blade, while being lowered vertically.

The patient was asked to cook with her family at least once weekly, gradually increasing the frequency. The patient continued these tasks for 3 months. Simultaneously, self-training exercises using hand grippers to improve her grip strength, 3 sets of 50 repetitions daily, helped her further.

Table 1 Physical function assessment pre- and post-intervention

	Pre	Post
Rt BRS (stage)		
Upper extremities	III	III
Finger	II	III
Lower limbs	IV	V
Rt SIAS motor (score)		
Knee-mouth test	2	2
Finger-function test	1A	1A
Hip-flexion test	4	4
Knee-extension test	5	5
Foot-pat test	4	4
Lt MMT (score)	5	5
Lt Grip strength (kg)	13	25

BRS, Brunnstrom Recovery Stage; SIAS, Stroke Impairment Assessment Set; MMT, Manual Muscle Test; Rt, Right; Lt, Left.
MMT measured shoulder flexor strength, shoulder abductor strength, hip flexor strength, and knee extensor strength.

Results

The Brunnstrom recovery stage to determine the degree of paralysis increased from II to III for the right hand. No significant changes were noted in the Stroke Impairment Assessment Set. The gross muscle strength of the left upper and lower limbs was measured using manual muscle test and was approximately 5 points both pre- and post-intervention. The grip strength of the left hand increased from 13 to 25 kg (Table 1).

Table 2 shows the pre- and post-COPM intervention results. Pre-intervention, the mean score for both performance and satisfaction were 5; both increased to 8 post-interventions. Furthermore, for the "be able to cook" task, both performance and satisfaction scores increased from 2 to 7 points.

The patient was able to safely cook without supervision, and she began cooking for her husband. Moreover, she began doing her own laundry and resumed her role and activities in her home.

Discussion

COPM, a patient-centered scale, has been used to determine the effectiveness of various interventions [6, 7]. The minimal clinically critical difference in COPM is a change of ≥ 2 points in the average scores of both performance and satisfaction [8]. In this study, "be able to cook" increased from 2 to 7 points in both performance and satisfaction, the largest change among the items; we believe this led to an improved COPM.

Setting appropriate difficulty level of the tasks is crucial for movement acquisition. Tasks appropriately challenging to the individual's proficiency level produce better motor learning than tasks with a constant difficulty level [9]. Conversely, tasks with difficulty level too high for the patient's proficiency level are unable to sustain performance ability [10]. Since the patient had difficulty cutting food with a knife before the intervention, we used other tools and cutting techniques to reduce the associated difficulty level to a level that was patient appropriate, which helped her regain her cooking ability. Regarding physical function, improved grip strength was observed. We believe that this was because the patient continued with the provided training and had opportunities to perform household activities apart from cooking. Assumably, improvement in grip strength perfected movements involved in cutting food.

Summary and Conclusions

Appropriate selection of utensils and improvisation of cooking techniques compensated for the reduced movement ability and enabled the patient to practice at an appropriate difficulty level. We believe this led to the acquisition of cooking skills using the non-dominant hand.

Conflicts of interest

None declared.

Acknowledgment

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Table 2 Changes in Canadian Occupational Performance Measure before and after intervention

Occupational Performance Problem	Before			After	
	Importance	Performance	Satisfaction	Performance	Satisfaction
Be able to cook	5	2	2	7	7
Be able to take in and fold laundry	6	4	4	7	7
Be able to go out for walks	3	9	9	10	10
Average Score		5	5	8	8

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