■ORIGINAL ARTICLE

Changes in Health-Related Quality of Life After Driving Cessation in Older Adults

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Abstract: Purpose: This study aimed to examine the effects of driving cessation on the health-related quality of life (HRQOL) of older adults who do not have a driver's license.
Method: A cross-sectional study using a web-based questionnaire was conducted. Participants were 1,200 individuals aged 65 years or older who did not have a driver's license in Japan. Participants answered questions about their HRQOL (HUI3 and SF-8) and driving cessation using a self-administered questionnaire. Those who had surrendered their driver's license were also asked about their HRQOL before driving cessation.
Results: The HRQOL scores of the drivers who ceased driving were significantly lower than those of non-drivers. The HRQOL scores of the drivers who ceased driving were also significantly decreased—from -.816 to -.728 (< .001) for the HUI3 and from 51.5 to 49.5 (< .001) for the physical component summary of the SF-8—when comparing scores before and after driving cessation. The results of our multiple regression analysis showed that the number of years since driving cessation and incidence of major illness also affected HRQOL.
Conclusion: There is a clear relationship between driving cessation and a decrease in HRQOL. This confirms the necessity of implementing measures in the future to address this issue, such as securing means of transportation for older people who have ceased driving.

Keywords: driving cessation, health-related quality of life, older adults

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Introduction

In recent years, the number of *older drivers* has been increasing in Japan: the number of *driver's license* holders aged 70 years or older has increased to 11.95 million in 2019, accounting for 14.5% of all driver's license holders. [1]

As a result, accidents caused by older drivers, such as those caused by driving in the wrong direction or mistakenly stepping on the gas pedal and brake, have become a social problem. While the number of fatal accidents per 100,000 licensed population under the age of 75 is 3.1, the number is more than double that—6.9 per 100,000—for those over 75 years old. [2] Furthermore, nearly 50% of those who had undergone cognitive function tests prior to the accident were judged to have "possible dementia" or "possible cognitive decline." In 2017, the Road Traffic Laws were amended to make it compulsory for drivers aged 75 and above to take an older adult's driving course and cognitive function test when renewing their license every three years. [3]

The number of people who voluntarily surrender their driver's license is increasing, as the trend of encouraging older adults, as well as their families, to do so spreads. In 2012, 81,711 people surrendered their licenses; this number increased to 200,000 in 2015, 358,740 in 2019, and 510,9188 in 2020. [1].

Recent studies on *driving cessation* among older adults find that driving cessation is accompanied by substantial declines in physical and social function, physical performance, and physical role. Edwards *et al*. followed the lives of community-dwelling older adults for five years and report a rapid decline in *health-related quality of life* (HRQOL) with driving cessation. [4] Edwards *et al*. also report that driving cessation increased mortality

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by up to four to six times after three years. [5] There are also existing reports of a significant increase in depressive symptoms after driving cessation and results showing that not driving increases the risk of future nursing home placement. [6, 7] Furthermore, a study in Japan reports that driving cessation is associated with an increased risk of functional limitations in older adults; however, the study states that this risk of functional limitations may be reduced if independent mobility can be maintained using public transportation or bicycles after driving cessation. [8]

To date, no study has examined the impact of driving cessation on the HRQOL of older adults in Japan. In addition, if HRQOL is decreased by the surrendering of a driver's license, it is necessary to clarify the factors that contribute to this decrease. Therefore, this study examines the changes in HRQOL related to the surrender of a driver's license and examine how much the driving cessation affects the body and mind.

Methods

Study Design and Participants

We conducted a cross-sectional study using a web-based questionnaire. The survey was conducted by Rakuten Insight, Inc. in December 2020. The number of participants was set at 1,200 and the ratio of male to female participants was set at 1:1. Participants who did not have a driver's license were recruited from a panel of one account per person pre-registered on Rakuten Insight, Inc. For each question, the respondents were asked to answer in a selective manner, except for some free descriptions. To eliminate differences between the metropolitan and rural areas, the number of questionnaires collected in Tokyo and Osaka was limited to 200 per city, and the same upper limit was set for each prefecture.

Questionnaires

Participants answered questions related to their HRQOL and driving status in a self-administered questionnaire. Those who had ceased driving were retrospectively asked about their HRQOL before they surrendered their driver's license. Respondents' HRQOL was measured using the Short Form-8 survey (SF-8) and the Health Utilities Index – Mark 3 (HUI3). The SF-8 is an abridged version of the Short Form-36 survey that measures HRQOL. [9] The SF-8 contains eight items that are separated into two components; physical health (domains: physical functioning, role physical, bodily pain, and general health) and mental health (domains: vitality, social functioning, role emotional, and mental health). Each subscale used norm-based scoring, with a higher value indicating a higher HRQOL. [10] The HUI3 is a generic, multi-attribute, preference-based system for assessing HRQOL. [11] The system defines 972,000 unique health statuses, as it focuses on eight attributes (vision, hearing, speech, ambulation, dexterity, emotion, cognition, and pain or discomfort), with each stratified into five to six functional levels. The global score shows health utility, with 0 indicating death and 1 indicating perfect health. The scoring function developed by Noto *et al*. was used to calculate the global HUI3 score. [12]

Those who had ceased to drive were asked the following questions: 1) How long ago they surrendered their driver's license, 2) Who made the decision to surrender their driver's license, 3) Whether they had any illness or injury that interfered with their life after surrendering their driver's license, 4) The purpose of their car, 5) The problems they faced when they surrendered their driver's license, and 6) What services they received after surrendering their driver's license.

Statistical Analysis and Ethical Procedures

The HRQOL of those who surrendered their driver's license and those who did not drive were compared; further, for those who surrendered their license, their HRQOL scores before and after surrender were compared using a paired *t*-test. A multiple regression analysis was conducted using the HRQOL scores after driver's license surrender as the objective variable. The explanatory variables used were age, gender, economic status, distance from home to the transportation facility normally used, and whether or not the license was surrendered. In addition, the difference in HRQOL before and after the surrender of the driver's license was determined, and with that as the objective variable, related factors were examined by multiple regression analysis. The significance level was set at 0.05. Statistical analyses were performed using STATA 16.0 software. This study was approved by the Ethics Committee of the Niigata University of Health and Welfare (No. 18549–201221). Written informed consent was obtained from all participants who took part in the study.

Results

Participant Characteristics

Table 1 shows the results in terms of the entire sample, those who did not drive, and those who had ceased driving. The mean age of the total sample was 72.3 (±5.3) years, 71.2 (±5.1) years for those who never had a driver's license, and 73.9 (±5.3) years for those who had ceased driving. Our comparison of the two groups showed differences in education, income per month, and family structure. There was no difference in

Table 1. Socio-demographic characteristics of respondents

		Total sample (n=1200)		Non-drivers (n=733)		Ceased drivers (n=467)		
Variable		Mean	SD	Mean	SD	Mean	SD	*p* value
Age		72.3	5.3	71.2	5.1	73.9	5.3	<0.001
Sex	Male	600		287		313		<0.001
	Female	600		446		154		
Education								0.002
	Junior High	45		27		18		
	High	484		320		164		
	Junior College	197		130		67		
	University	421		230		191		
	Graduate	53		26		27		
Monthly income (JPY)								<0.001
	<100,000	363		255		108		
	100,000-200,000	444		268		176		
	200,000-300,000	248		138		110		
	> 300,000	145		72		73		
Household status								0.001
	Single household	289		170		119		
	Couple only	600		343		257		
	Two households	267		191		76		
	Three households	44		29		15		
Distance from public transportation								0.564
	< 5 minutes							
	5-10 minutes	420		255		165		
	10-15 minutes	424		265		159		
	15-20 minutes	214		121		93		
	>20 minutes	70		45		25		
		72		47		25		

SD: Standard Deviation

terms of distance from public transportation.

HRQOL Scores

Table 2 shows the global HUI3 and SF-8 scores. The overall HUI3 score was .777 (±.205) for non-drivers and .728 (±.235) for those who ceased driving, showing a significant difference ($p < .001$). In terms of the SF-8, there was a difference in physical functioning, role physical, and physical component summary (PCS) between the two groups. Table 3 shows a comparison of the results of those who ceased driving before and after surrendering their licenses; there was a significant decrease in the global HUI3 score and in all SF-8 subscores.

Responses regarding driving cessation

A variety of responses were obtained to the questions posed to those who ceased driving. The most common illnesses and injuries that occurred after driving cessation were cancer, fracture, heart failure, and stroke. The most common uses of the car were commuting and daily life. The most common problems after surrendering the license were work, distance to the station, and identification. As for the services they received, they answered that they received discounts for transportation and shopping.

Regression Analysis

Table 4 shows the results of the multiple regression analysis with the global HUI3 score and the SF-8 score as the objective variables. Considering the global HUI3 score and the PCS component of the SF-8, in addition to driving cessation, low income per month and distance from public transportation had a negative impact on

Table 2. Summary statistics of HRQOL scores

	Total (n=1200)		Non-drivers (n=733)		Ceased drivers (n=467)		
	Mean	SD	Mean	SD	Mean	SD	*p* value
HUI3	0.758	0.219	0.777	0.205	0.728	0.235	<0.001
PF	51.6	5	52	4.7	50.9	5.5	<0.001
RP	52.1	5.5	52.5	5	51.3	6.1	<0.001
BP	50.9	7.5	51.1	7.4	50.7	7.5	0.382
GH	53.1	6.7	53.3	6.6	52.8	6.9	0.162
VT	52.4	5.5	52.5	5.4	52.2	5.6	0.292
SF	51.9	6.3	52.1	6.1	51.6	6.5	0.138
RE	52.2	5.3	52.3	5.4	52.2	5.2	0.695
MH	52.7	5.4	52.6	5.5	52.9	5.4	0.265
PCS	50.3	5.9	50.8	5.7	49.5	6.2	<0.001
MCS	51.9	5.5	51.7	5.6	52.2	5.4	0.18

Table 3. Comparison of HRQOL scores before and after driving cessation

	Before		After		
	Mean	SD	Mean	SD	*p* value
HUI3	0.816	0.202	0.728	0.235	<0.001
PF	52.1	4.7	50.9	5.5	<0.001
RP	52.3	5.7	51.3	6.1	<0.001
BP	53.9	6.5	50.7	7.5	<0.001
GH	55.1	6.5	52.8	6.9	<0.001
VT	53.9	4.8	52.2	5.6	<0.001
SF	53.1	4.9	51.6	6.5	<0.001
RE	53.1	4.7	52.2	5.2	<0.001
MH	54.4	4.4	52.9	5.4	<0.001
PCS	51.5	5.4	49.5	6.2	<0.001
MCS	53.1	4.4	52.7	5.4	<0.001

HRQOL. Moreover, in terms of the mental component summary (MCS) of the SF-8, driving cessation had no significant effect. Table 5 shows the results of our multiple regression analysis, with the difference between the global HUI3 score and the PCS and MCS scores of SF-8 before and after driving cessation as the objective variables. The global HUI3 score and the PCS component of the SF-8 were affected by driving cessation and incidence of illness, while the MCS component of the SF-8 was affected only by incidence of illness.

Discussion

This study used an online questionnaire survey to determine whether driving cessation is a factor in the decline of HRQOL among older adults. Of the 1,200 respondents, 467 ceased driving; we believe that we were able to collect a large enough sample to withstand statistical processing.

HRQOL Scores

First, we compared the HRQOL results —according to the HUI3 and SF-8 measures—of all respondents with the national norm. According to Shiroiwa *et al*., the average HRQOL scores for males and females in their 70s was .807 and .818, respectively; our results were lower than these values. [13] A possible reason for this difference is that Shiroiwa *et al*. used a face-to-face survey, while our study used a web-based survey. They also reported that the ePRO survey showed lower scores than the paper-based survey, which may be related to same factors. [14] However, it has been reported that

Table 4 Relation between HRQOL scores, characteristics and driving cessation

Variable		Coefficient	*p* value	95%Cl
HUI3				
	Sex	0.063	<0.001	0.036 to 0.090
	Age	–0.004	0.001	–0.006 to –0.002
	Driving Cessation	–0.034	0.011	–0.060 to –0.008
1 month income	<100,000	–0.120	<0.001	–0.163 to –0.076
	100,000-200,000	–0.093	<0.001	–0.133 to –0.053
	200,000-300,000	–0.043	0.052	–0.087 to 0.000
	> 300,000	reference		
Distance	< 5 minutes	0.095	<0.001	0.042 to 0.148
	5-10 minutes	0.061	0.025	0.008 to 0.114
	10-15 minutes	0.070	0.016	0.013 to 0.126
	15-20 minutes	0.031	0.384	–0.039 to 0.101
	>20 minutes	reference		
PCS				
	Sex	1.125	0.003	0.382 to 1.868
	Age	–0.111	0.001	–0.176 to –0.047
	Driving Cessation	–0.832	0.024	–1.553 to –0.110
1 month income	<100,000	–1.598	0.009	–2.793 to –0.404
	100,000-200,000	–1.303	0.021	–2.407 to –0.199
	200,000-300,000	–0.689	0.261	–1.891 to 0.513
	> 300,000	reference		
Distance	< 5 minutes	2.433	0.001	0.972 to 3.893
	5-10 minutes	1.992	0.007	0.534 to 3.451
	10-15 minutes	1.934	0.015	0.373 to 3.494
	15-20 minutes	1.800	0.066	–0.121 to 3.720
	>20 minutes	reference		
MCS				
	Sex	–0.135	0.702	–0.829 to 0.558
	Age	0.032	0.298	–0.028 to 0.092
	Driving Cessation	0.093	0.787	–0.581 to 0.766
1 month income	<100,000	–2.137	<0.001	–3.252 to –1.022
	100,000-200,000	–1.057	0.044	–2.087 to –0.027
	200,000-300,000	–0.222	0.698	–1.344 to 0.900
	> 300,000	reference		
Distance	< 5 minutes	0.801	0.249	–0.562 to 2.165
	5-10 minutes	0.704	0.311	–0.657 to 2.065
	10-15 minutes	0.234	0.753	–1.223 to 1.690
	15-20 minutes	0.393	0.667	–1.399 to 2.186
	>20 minutes	reference		

Adjusted R2: 0.071 for HUI3, 0.039 for PCS, 0.028 for MCS. CI: confidence interval.

there was no significant difference between the ePRO and paper-based surveys in other countries [15, 16]; therefore, the influence of Japanese characteristics needs to be further examined. As for the SF-8 scores, the results were higher than the adjusted thresh-old of 50 for general health, and the difference in HRQOL indicated by the HUI3 became apparent. This may be because HRQOL is calculated by HUI3, a preference-based in-

Table 5. Relation between HRQOL scores and issues related driving cessation

Variable	Coefficient	*p* value	95%Cl
HUI3			
Sex	–0.034	0.049	–0.067 to 0.000
Age	–0.003	0.075	–0.006 to 0.000
Years of Driving Cessation	–0.005	<0.001	–0.007 to 0.003
Decided by myself	0.007	0.860	–0.073 to 0.087
Major illness	–0.056	0.007	–0.096 to –0.015
Trouble	–0.017	0.347	–0.019 to 0.053
Receive service	–0.005	0.771	–0.030 to 0.041
PCS			
Sex	0.372	0.478	–0.659 to 1.403
Age	–0.045	0.336	–0.138 to 0.047
Years of Driving Cessation	–0.177	<0.001	–0.242 to 0.112
Decided by myself	–0.355	0.777	–2.818 to 2.108
Major illness	–1.756	0.006	–3.004 to –0.507
Trouble	–0.909	0.108	–2.019 to 0.201
Receive service	–0.187	0.739	–0.912 to 1.286
MCS			
Sex	–1.079	0.014	–1.943 to 0.215
Age	–0.065	0.100	–0.143 to 0.013
Years of Driving Cessation	–0.005	0.847	–0.049 to 0.060
Decided by myself	–0.332	0.752	–2.396 to 1.733
Major illness	–1.676	0.002	–2.723 to –0.630
Trouble	–0.196	0.678	–1.127 to 0.734
Receive service	0.615	0.190	–0.306 to 1.536

Adjusted R2: 0.090 for HUI3, 0.103 for PCS, 0.042 for MCS. CI: confidence interval.

dex-type measure, which is more likely to show changes than SF-8, which is a profile-type measure.

Comparison of HRQOL between Non-drivers and Ceased Drivers

In the comparison of HRQOL between non-drivers and those who ceased driving, the physical functioning, role physical, and PCS of the HUI-global score and SF-8 were lower for those who ceased driving.

Furthermore, our multiple regression analysis showed that the factor of never driving or ceasing to drive was significantly associated with a decrease in HRQOL, confirming the results of Edwards *et al*., who reported that health deteriorated after driving cessation. [4] The results of our multiple regression analysis showed that the distance from the nearest public transportation was significantly related to a decrease in HRQOL, which we found meaningful. It is known that driving cessation decreases the level of activity outside the home. [17,18] A study by Hirai *et al*. suggests that older adults may be at increased risk of functional limitations if they cease driving, but that this risk may be reduced to some extent if they are able to maintain independent mobility by using public transportation or by bicycling. [8] Furthermore, it has been reported that people are more likely to be homebound if the distance to the closest retail store is farther. [19] We believe that the distance of public transportation from home is an important factor of reduced HRQOL, for both non-drivers and for those who have ceased driving.

Comparison of HRQOL Before and After Driving Cessation

Significant differences in HRQOL before and after the driving cessation were found for two items: time passed since driving cessation and whether the person experienced any major illness or injury after cessation. Although it is not clear whether the factors affecting these items were due to driving cessation or to illness after the cessation, it is worth noting that these results are similar to those of Edwards *et al*. [4]

In present study, people who stopped driving were

asked to recall the time before they stopped driving and to fill in their HRQOL at that time. It is known, however, that a response shift often occurs in an HRQOL survey over time [20,21]; therefore, we cannot deny that there was an effect of this factor. Thus, it should be noted that a cross-sectional study such as ours cannot clarify this causal relationship, and we believe that future prospective studies are needed.

Currently, older people in Japan are more positive about the cessation of driving than ever before. However, older adults are able to maintain independent mobility and meet their daily needs by driving, using public transportation, and bicycles. Therefore, we posit that older adults who have ceased driving should be supported by introducing alternative transportation that is convenient and safe to use. For the questionnaire item asking whether they received any service after surrender their license, 349 out of 467 respondents answered that they did not receive any alternative transport services. We were unable to determine whether the services are not available, or whether they know about the services but do not make use of them; regardless, we believe that ensuring a full range of transportation for older adults who have ceased driving is important for reducing the subsequent decline in their HRQOL.

Relationship between occupational therapy and driving cessation

Driving is not only a means of transportation, but also a way to enjoy driving itself and to directly connect driving with leisure and other activities that are meaningful to the person. Therefore, the loss of driving has the potential to lead to the loss of meaningful occupation itself. Occupational therapy should be actively involved in the development of safe driving techniques and the provision of alternative transportation in the community.

Limitations

Despite its clear contributions, there are certain limitations to this study. We used an online survey platform and asked people aged 65 and above to complete the web-based questionnaire; therefore, we cannot discount the possibility that there was a selection bias of older adults who are accustomed to using the Internet. In addition, we set a maximum value for the number of respondents recruited who are living in urban areas, to thereby reduce bias by region; however, as it was only set for each prefecture, we could not strictly distinguish between urban and rural areas. As the effects of driving cessation in urban and rural areas are expected to be decisively different, it was thought important to set the sample with this point in mind in the future. Furthermore, when asked if they had any problems after returning their driver's license, 334 out of 467 respondents answered that they did not have any problems, suggesting that the reason for returning their driver's license may have been that some may no longer have needed a car. A follow-up study is necessary to examine the details of the reasons for driving cessation and to clarify the relationship with HRQOL.

Conclusion

This cross-sectional study using a web-based questionnaire among older adults aged 65 years or older who did not hold a driver's license showed that those who ceased driving had lower HRQOL than those who did not drive. In addition, among older adults who surrendered their driver's licenses, HRQOL was significantly lower after driving cessation than before; moreover, this factor was affected by the number of years since driving cessation and incidence of major illness. Although the causal relationship between driving cessation and illness could not be clarified, the results suggest that measures such as securing transportation for older adults who have ceased driving are necessary.

Conflicts of Interest Statement

The authors have no conflicts of interest relevant to this article.

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■ORIGINAL ARTICLE

Factors Predicting the Use of Paralyzed Upper Limbs in the Daily Life of Patients with Acute Stroke

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Abstract

Background and Purpose: In patients with stroke, predictors of the use of paralyzed upper limbs in each activity of daily life, including eating and toileting, are not clear. Therefore, we aimed to identify factors that predict the use of paralyzed upper limbs in specific activities of daily life in patients with acute stroke.

Method: This prospective observational study enrolled 155 patients with acute stroke. We used the paralytic arm participation measure (PPM) to evaluate the use of the paralyzed upper limb in daily life. Eating and toileting were assessed at admission and discharge. Factors that predicted the use of the paralyzed upper limb at discharge were analyzed by binomial logistic regression analysis.

Results: The predictors of the use of paralyzed upper limbs for eating at discharge were age [odds ratio (OR)=0.93, p=.011], paralysis of the dominant hand (OR=3.75, p=.044), and motor function of the paralyzed upper limb (OR=2.16, p<.001). For toileting, the predictors were motor function of the paralyzed upper limb (OR=1.75, p<.001), sensory function of the paralyzed upper limb (OR=1.66, p=.004), and muscle strength of the quadriceps on the non-paralyzed side (OR=3.65, p=.005).

Conclusion: These identified predictors may provide clues to interventions promoting the use of paralyzed upper limbs in the daily life of hospitalized patients with acute stroke. Observation and evaluation of each activity by an occupational therapist using the PPM is potentially useful in encouraging patients to consciously use the paralyzed upper limbs in daily life.

Keywords: activities of daily living; acute phase; predictor; stroke; use of paralyzed upper limb

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1. Introduction

Upper limb sensorimotor dysfunction due to stroke sequelae adversely affects the performance of activities of daily living (ADLs) in patients [1]. Improving upper limb dysfunction in patients with stroke and enabling the use of paralyzed upper limbs in ADL are important roles of occupational therapists [2]. When considering interventions promoting the use of paralyzed upper limbs, it is important to investigate factors associated with the use of the paralyzed upper limb in ADL first. In previous studies on patients with acute stroke, the paralyzed upper limbs were significantly less-used compared to the non-paralyzed upper limbs [3, 4]. The factors determining the use of the paralyzed upper limbs are reportedly the following: age [5], severity of upper limb motor paralysis [4, 6, 7], muscle strength [3, 5], motor functional independence measure (FIM) [3, 4], and various upper limb function tests [3]. However, the above studies investigated factors related to the total movement of the paralyzed upper limbs in daily life, not those related to each specific activity, such as eating and toileting. We hypothesized that the factors related to each ADL activity would be different because of the different movements and tools involved in each ADL activity. To help occupational therapists design interventions that can improve the usage of the paralyzed upper limbs in functions of ADL, investigating the use of the paralyzed upper limb for each ADL is necessary.

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In addition, the acute phase is the period when paralysis of the upper limb improves the most [8]; thus, patients should be actively encouraged to use the paralyzed limb in this period. It is also necessary to investigate the status of use of the paralyzed upper limb in the acute phase to examine the method of intervention that will be appropriate for this period. Furthermore, eating and toileting are among the basic ADLs and are of the highest priority for intervention in the acute phase, based on our clinical experience.

Therefore, this study aimed to clarify the use of paralyzed upper limbs in actual activities of daily living, such as eating and toileting, and to identify the predictors of the use of paralyzed upper limbs in the above-stated activities at the time of discharge.

2. Materials and Methods

Design and setting

This prospective observational study was conducted in a regional core general hospital. The STROBE guidelines for observational studies were followed [9]. Patients with stroke were admitted to the hospital and received acute medical care. After the doctor's examination, rehabilitation along with full-risk management and control was provided to patients from the day of admission or the next day. In occupational therapy, early intervention is required to achieve functional recovery of the affected upper limb and to improve the performance of ADLs. At our institution, the patients underwent rehabilitation for 20 or 40 minutes a day, 7 days a week, for total of approximately 240 minutes. Upper limb function training included the following exercises, which were performed alone or in combination: instrument manipulation training, neuromuscular facilitation training, and therapeutic electrical stimulation.

Participants

Patients ≥20 years old, who were diagnosed with stroke, and admitted to the hospital between October 2018 and October 2019 were enrolled in this study. A diagnosis of stroke was confirmed by a physician based on clinical symptoms and findings on computed tomography, magnetic resonance imaging, and other diagnostic imaging techniques. The exclusion criteria of this study were (1) patients diagnosed with transient ischemic attacks; (2) patients 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) patients with a score of >100 in the Japan Coma Scale (score of >100 in the Japan Coma Scale indicates "unarousable by any forceful stimuli"); (4) patients who could not provide informed consent; (5) patients with recurrent stroke during hospitalization; and (6) patients with ataxia.

Clinical characteristics

The following patient characteristics were obtained from their medical records: age, sex, length of hospital stay, disease type, affected dominant hand, presence of ADL support before stroke onset, Glasgow coma scale score, National Institutes of Health Stroke Scale (NIHSS) score, and FIM score at admission. We used FIM to evaluate the actual continuous performance of ADLs in the ward. Additionally, the stroke impairment assessment set (SIAS) was used by occupational therapists to comprehensively assess the severity of the stroke. The SIAS is classified into the following nine types of impairments [10]: motor function (upper limb: 0–10, lower limb: 0–15), muscle tone (upper and lower limbs: 0–6 each), sensory function (upper and lower limbs: 0–6 each), range of motion (upper and lower limbs: 0–3 each), pain (0–3), trunk function (0–6), visuospatial function (0–3), speech (0–3), and non-paralyzed limb function (grip and muscle strengths of quadriceps: 0–3 each). A higher score indicates better function.

Assessment

The use of the paralyzed upper limb in daily life was assessed using the paralytic arm participation measure (PPM). Normally, motor activity log (MAL), [11, 12] and accelerometers [13, 14] are commonly used to evaluate paralyzed upper limb use. MAL is a self-assessment performed through interviews; thus, it is not very suitable for assessing patients with cognitive dysfunction or aphasia. Accelerometers can assess the amount of continuous activity, but they cannot be used to evaluate the specific type of activity performed. In this study, we used the PPM to observe and evaluate the actual performance of a particular ADL. This assessment measure was developed at Fujita Health University Nanakuri Memorial Hospital, and its reliability and validity are guaranteed [15, 16]. It consists of the following 15 items: dressing (8 items), toileting (2 items), shaping/cleaning (4 items), and eating (1 item). Each item was assessed using a 4-point scale from 0 to 3 points. The scoring criteria was as follows: 3 points, the paralyzed upper limb can smoothly perform the desired movement; 2 points, movement can be performed till the end, but is awkward and takes longer; 1 point, the limb is partially used; 0 point, totally not used. The criteria were based on the quality and extent of use of the paralyzed upper limb [15, 16]. We investigated the patients' eating and toileting, which are high-priority activities in the acute phase. Eating was evaluated based on either holding a

Table 1. Characteristics of the patients at admission

Characteristics		Total (n=155)	Eating			Toileting (lowering pants)			Toileting (pulling up pants)		
			Use (n=72)	No use (n=83)	P-value	Use (n=60)	No use (n=95)	P-value	Use (n=59)	No use (n=96)	P-value
Age	Median years (IQR)	77 (67–84)	73 (63–79.25)	80 (71–85)	0.001	71.5 (63.75–78.25)	79 (70.5–85)	0.001	71 (63.5–78.5)	79 (70.75–85)	0.001
Sex	Male/Female(%)	93(60)/ 62(40)	47(65.3)/ 25(34.7)	46(55.4)/ 37(44.6)	0.251	41(68.3)/ 19(31.7)	52(54.7)/ 43(45.3)	0.129	40(67.8)/ 19(32.2)	53(55.2)/ 43(44.8)	0.132
Length of hospital stay	Median days (IQR)	23 (12–32.5)	12.5 (9–21.5)	29 (22–37.5)	<0.001	11.5 (8.75–17.25)	30 (22–36.5)	<0.001	11 (8.5–16.5)	29.5 (22–36.25)	<0.001
Disease type	Lacunar infarction/other (%)	28(18.1)/ 127(81.9)	23(31.9)/ 49(68.1)	5(6)/ 78(94.0)	<0.001	26(43.3)/ 34(56.7)	2(2.1)/ 93(97.9)	<0.001	26(44.1)/ 33(55.9)	2(2.1)/ 94(97.9)	<0.001
Affected hand	Right/Left (%)	81(52.3)/ 74(47.7)	41(56.9)/ 31(43.1)	40(48.2)/ 43(51.8)	0.334	34(56.7)/ 26(43.3)	47(49.5)/ 48(50.5)	0.413	33(55.9)/ 26(44.1)	48(50)/ 48(50)	0.511
Dominant hand	Right/Left (%)	151(97.4)/ 4(2.6)	69(95.8)/ 3(4.2)	82(98.8)/ 1(1.2)	0.338	57(95.0)/ 3(5.0)	94(98.9)/ 1(1.1)	0.299	56(94.9)/ 3(5.1)	95(99)/ 1(1)	0.155
Paralysis of the dominant hand	Yes/No (%)	81(52.3)/ 74(47.7)	40(55.6)/ 32(44.4)	41(49.4)/ 42(50.6)	0.52	33(55)/ 27(45)	48(50.5)/ 47(49.5)	0.623	32(54.2)/ 27(45.8)	49(51)/ 47(49)	0.742
Premorbid dependence	Independence/ Dependence (%)	139(89.7)/ 16(10.3)	69(95.8)/ 3(4.2)	70(84.3)/ 13(15.7)	0.032	59(98.3)/ 1(1.7)	80(84.2)/ 15(15.8)	0.005	58(98.3)/ 1(1.7)	81(84.4)/ 15(15.6)	0.005
GCS	Median (IQR)	15(13–15)	15.00 (14.75–15.00)	14(11–15)	<0.001	15(15–15)	14(11–15)	<0.001	15(15–15)	14(11–15)	<0.001
NIHSS	Median (IQR)	4(2–11)	2(1–4)	9(4–16.5)	<0.001	2(1–3)	8(4–16)	<0.001	2(1–3)	8(4–16)	<0.001
FIM	Median (IQR)										
Motor		17(13–45)	45.50 (25.50–49.00)	13(13–17)	<0.001	48(40–49)	13(13–16.5)	<0.001	48(41–49)	13(13–17)	<0.001
Cognitive		18(7–29)	29(21–35)	7(5–17.5)	<0.001	29(25–35)	8(5–20.5)	<0.001	29(25–35)	8(5–20.25)	<0.001
Toilet transfer		1(1–5)	5(1–5)	1(1–1)	<0.001	5(4–5)	1(1–1)	<0.001	5(4–5)	1(1–1)	<0.001
SIAS	Median (IQR)										
Upper limb motor function		8(3–10)	10(8–10)	3(0–8)	<0.001	10(8–10)	4(0.5–8)	<0.001	10(8–10)	4(0.75–8)	<0.001
Lower limb motor function		12(6–15)	15(12.75–15)	7(1–12)	<0.001	15(13–15)	9(2–14)	<0.001	15(13–15)	9(2–14)	<0.001
Upper limb sensory function		5(2–6)	6(5–6)	2(1–5)	<0.001	6(5–6)	2(1–5)	<0.001	6(5–6)	2(1–5)	<0.001
Lower limb sensory function		5(2–6)	6(5–6)	3(1–6)	<0.001	6(5.75–6)	3(1–6)	<0.001	6(5.5–6)	3(1–6)	<0.001
Trunk function		4(1–6)	6(5–6)	2(0–4.5)	<0.001	6(5–6)	2(0–5)	<0.001	6(5–6)	2(0–5)	<0.001
Visuospatial function		3(1–3)	3(3–3)	1(1–3)	<0.001	3(3–3)	2(1–3)	<0.001	3(3–3)	2(1–3)	<0.001
Muscle strength of quadriceps on the non-paralyzed side		3(2–3)	3(3–3)	2(1–3)	<0.001	3(3–3)	3(1–3)	<0.001	3(3–3)	3(1–3)	<0.001
Grip strength on the non-paralyzed side		2(1–2.5)	2(2–3)	1(1–2)	<0.001	2(2–3)	1(1–2)	<0.001	2(2–3)	1(1–2)	<0.001

IQR, interquartile range; 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; Use, PPM 1-3 points; No use, PPM 0

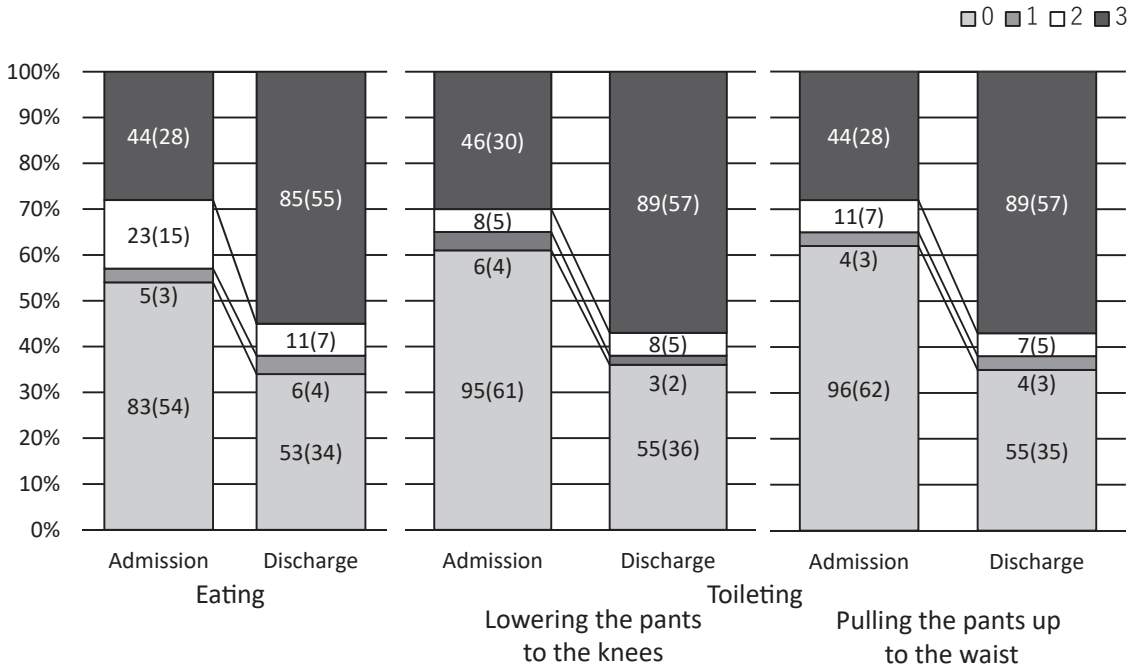

Fig. 1. Number and percentage of patients with paralytic arm participation measure scores at admission and discharge for each item
3: the paralyzed upper limb can smoothly perform the desired movement, 2: movement can be performed throughout the entire activity, but awkwardly or/and slowly, 1: the limb can perform part of an activity, 0: does not perform the activity at all Eating was evaluated based on either holding a bowl or operating chopsticks or a spoon. Toileting was evaluated based on the following two items: lowering the pants to the knees and pulling the pants up to the waist.

bowl or maneuvering chopsticks or a spoon. Toileting was evaluated based on two items: lowering the pants to the knees and pulling the pants up to the waist.

Statistical analysis

Normal distribution was assessed using the Shapiro-Wilk test, according to which, our data were not normally distributed. Patients with mild-to-no motor paralysis were considered as having an SIAS motor function score of ≥8 points in the paralyzed upper limb. The Wilcoxon signed-rank test was used to compare the PPM score at admission with that at discharge. Regarding the use of the paralyzed upper limb, 1–3 points of PPM was defined as "use" and 0 point as "no." Binomial logistic regression analysis was conducted to identify predictors associated with the use of the paralyzed upper limb at discharge. The explanatory variables common for eating and toileting were: age, sex, premorbid dependence, paralysis of the dominant hand, stroke type (lacunar infarction/other), cognitive FIM at admission, PPM at admission, and SIAS sub-items at admission (including motor function of the paralyzed upper limb, sensory function of the paralyzed upper limb, trunk function, and visuospatial function); variable unique to eating was: grip strength on the non-paretic side; and variables unique to toileting: toilet transfer FIM at admission and muscle strength of the quadriceps on the non-paretic side. Since motor function of the paralyzed lower limb had a multicollinearity problem with motor function of the paralyzed upper limb, we prioritized the upper limb and used it for the analysis. However, we also performed the analysis using motor function of the paralyzed lower limb, since it is also an important predictor.

For the extracted factors, a receiver-operating characteristic curve was drawn, and the cutoff value and area under the curve were calculated.

P-values of <0.05 were considered statistically significant. All statistical analyses were performed using EZR ver. 1.37 software (Saitama, Japan) [17].

Ethics

This study was conducted following the ethical standards of the Declaration of Helsinki and the ethical guidelines for medical and health research involving human subjects. This study was approved by the Ethics Review Committee of our hospital (approval number: 2; approval date: 2018/9/19). All patients in this study provided written informed consent.

Table 2. Predictors associated with the use of the paralyzed upper limb at discharge and their cutoff values (n=155)

Explanatory variables	OR	95% CI	P-value	Cutoff value	AUC
Eating					
Age (years)	0.93	0.89–0.99	0.011	80	0.682
Paralysis of the dominant hand	3.75	1.03–13.60	0.044	1	0.582
Motor function of the paralyzed upper limb	2.16	1.71–2.73	<0.001	5	0.949
Toileting					
Motor function of the paralyzed upper limb	1.75	1.36–2.25	<0.001	7	0.959
Sensory function of the paralyzed upper limb	1.66	1.17–2.37	0.004	4	0.915
Muscle strength of the quadriceps on the non-paralyzed side	3.65	1.45–9.18	0.005	3	0.810

OR, odds ratio; CI, confidence interval; AUC, area under the curve

3. Results

Altogether, 164 patients were enrolled in this study. In the analysis, 155 patients were included, as four patients who had recurrent stroke, three patients who had ataxia, and two who died after providing informed consent were excluded. The patients' characteristics and the median interquartile range values for Glasgow Coma Scale, NIHSS, FIM, and SIAS are shown in Table 1.

The median PPM values for eating and toileting improved significantly (p<.001) from 0 (interquartile range: 0–3) at admission to 3 (interquartile range: 0–3) at discharge. Figure 1 shows the number and percentage of patients with specific PPM scores at admission and discharge. Nearly 60% of the patients were able to use the paralyzed upper limb normally at discharge for each item. The following was the distribution of patients with mild-to-no motor paralysis who did not use the paralyzed upper limbs: eating, 8 (8%); lowering pants to the knees, 9 (9%); and pulling pants up to the waist, 9 (9%).

The predictors and cutoff values that predicted the use of paralyzed upper limbs while eating and toileting at discharge, as revealed by binomial logistic regression analyses, are shown in Table 2. For eating, the independent predictors of the use of paralyzed upper limbs at discharge were age, paralysis of the dominant hand, and motor function of the paralyzed upper limb. For toileting, the results of logistic regression analyses for lowering the pants to the knees and pulling pants up to the waist were the same because patients who used the paralyzed upper limbs at discharge were matched. The independent predictors of the use of paralyzed upper limbs at discharge were upper limb sensory function and quadriceps muscle strength on the non-paralyzed side. The results obtained by substituting the motor function of the paralyzed lower limb for the motor function of the paralyzed upper limb were as follows: motor function of the paralyzed lower limb (odds ratio = 1.73, 95% confidence interval = 1.37–2.18, p<.001).

4. Discussion

Use of the paralyzed upper limb in patients with acute stroke

The PPM scores for eating and toileting were significantly higher at discharge than that at admission, indicating an improvement in the use of the paralyzed limbs. Additionally, the proportion of patients who used the paralyzed upper limb normally in daily life increased from nearly 30% at admission to nearly 60% at discharge. Since improvement in upper limb function in the acute phase is expected, upper limb function training and ADL training are important. However, the proportion of patients who did not use the paralyzed side upper limbs at discharge, despite mild to almost no motor paralysis, was 8% and 9% for eating and toileting, respectively. In the future, it is necessary to explore interventions to encourage the use of these limbs in these patients.

Factors predicting the use of paralyzed upper limb in daily life

With regard to eating, the predictors of the use of the paralyzed upper limbs at discharge were age, paralysis of the dominant hand, and motor function of the paralyzed upper limb. A previous study also reported that older age is a factor inhibiting the use of the paralyzed upper limb at discharge in the acute stroke phase [5]. Additionally, elderly patients with stroke have poorer functional recovery compared to younger patients [18]. The cutoff value for age obtained in this study was 80 years, suggesting that poor functional recovery due to

advanced age may further affect the use of the paralyzed upper limbs. Patients >80 years old face difficulty recovering the ability to perform ADL during the acute phase; thus, long-term rehabilitation and changing hand dominance should be considered. With regard to paralysis of the dominant hand, in a previous study, the paralyzed upper limbs of the dominant and the non-dominant sides were used almost equally in the daily life of patients with stroke [19]. However, our study results were different. Eating is an activity that is strongly influenced by the dominant hand. In Japanese eating etiquette, the dominant hand is used to hold spoons, chopsticks, and other devices, while the non-dominant hand holds the bowl. When the non-dominant hand is paralyzed, the food can be eaten with only the dominant hand because the bowl is fixed using a self-help bowl or a non-slip mat. Therefore, it is possible that patients with paralysis of the non-dominant hand eventually stop using that hand at all to eat, while patients with paralysis of the dominant hand try to use it to manipulate spoons and chopsticks. With regard to the paralyzed upper limb function, several reports have shown that the paralyzed upper limbs are not used by patients with severe motor paralysis [4, 6, 7], which is similar to our results. In this study, the cutoff value of the paralyzed upper limb function was 5 in all patients. The severity of motor paralysis in the early stage is a predictive factor for recovery from motor paralysis [20]. Patients with scores <5 points have poor motor function recovery, which may affect the use of the paralyzed upper limbs. Meanwhile, the sensory function of the fingers associated with fine manipulation of tableware was not extracted as a predictor of the use of the paralyzed upper limb for eating. It is possible that the sensory impairment of the upper limbs was compensated by the visual sense and the nature of the self-help tableware.

As for toileting, predictors of the use of the paralyzed upper limbs at discharge were motor function of the paralyzed upper limb at admission, motor function of the paralyzed lower limb at admission, sensory function of the upper limb, and muscle strength of the quadriceps on the non-paralyzed side. The severity of proprioceptive deficit of the paralyzed upper limb inhibits the use of the paralyzed upper limb in daily life [21]. Sensory impairment of the upper limb is associated with difficulties in fine manipulation [22]. Upper limb sensory impairment inhibits the use of the paralyzed upper limb in toileting because the sensory function of the fingers is required to lower and pull up the pants, especially because the part of the pants that is behind and the part that is hidden by the shirt cannot be visually confirmed. Regarding lower limb function, no studies have examined the relationship between quadriceps muscle strength on the non-paralyzed or paralyzed lower limb and the use of the paralyzed upper limb in toileting. When pulling up and lowering pants, it is necessary to maintain a stable standing position to exert the paralyzed upper limb function. Therefore, since the quadriceps muscle strength on the non-paralyzed side and the degree of paralysis of the lower limb on the paralyzed side affect the maintenance of a stable standing position, they were extracted as predictors in this study.

In the future, in order to promote the use of the paralyzed upper limb, it is necessary to examine occupational therapy approaches for the early stage of stroke using the predictors revealed in this study. For eating, interventions, such as those that enhance the motor function of the paralyzed upper limb and positive ADL instructions for using the paralyzed upper limb when the non-dominant hand is on the paralyzed side, are also important. For toileting, interventions that improve the stability of the patient while standing are necessary. A few effective interventions for sensory disorders have been reported [23, 24]; nonetheless, actively adopting them is important.

Limitations

This study has several limitations. First, it was conducted at a single institution and included only patients who provided consent to participate. Therefore, selection bias might have occurred. Our results should be cautiously generalized and interpreted. Second, we did not consider psychological factors, such as patients' motivation or attention, as predictors. Therefore, a study with inclusion of psychological factors as assessment variables is warranted. Third, since there are other activities involved in toileting such as handling toilet paper and wiping the buttocks, it is necessary to investigate the use of paralyzed upper limbs for these activities in the future. Fourth, ADL activities such as cleaning and dressing are also important in the acute phase and are included in the PPM. However, implementing all PPM items within the therapy duration was difficult. Studies investigating the use of paralyzed upper limbs in the future should include these activities. Finally, this study was conducted in the acute phase. Long-term follow-up of the use of paralyzed upper limb is required for patients who did not use the paralyzed upper limb in the acute phase.

In conclusion, the use of paralyzed upper limbs in eating and toileting in patients with acute stroke was significantly improved at discharge. Factors that predicted the use of the paralyzed upper limb while eating and toileting at discharge were also identified. The results of this study suggest that occupational therapy

promotes the use of paralyzed limbs while performing these activities. The predictive factors at admission and their cutoff values obtained in this study can be used to predict the use of the upper extremities on the paralyzed side at discharge in real life, and can be used to formulate treatment strategies. Evaluations using PPM, which is a movement-evaluation tool for real-life situations, can guide occupational therapists to encourage patients to consciously use their paralyzed upper limbs during activities of daily life. This may improve the frequency and quality of the patients' use of their paralyzed upper limbs in daily life.

Declaration of Interest

No potential conflict of interest was reported by the authors.

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■ORIGINAL ARTICLE

Community-based Peer Support Programs to Improve Quality of Life for Cancer Survivors: A Systematic Review

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Abstract: Introduction: Peer support programs are mainly studied by hospitals and medical professionals, and further research is needed on their impact on quality of life (QOL). The purpose of this study was to investigate the type of community-based peer support program that is effective for improving the QOL of cancer survivors.
Method: A systematic review was performed using the following procedures: (1) randomized controlled trials aimed at improving QOL were searched from PubMed and Igaku Chuo Zasshi, (2) papers that met the inclusion criteria were selected, and (3) the papers were assessed for quality by using the revised Cochrane risk-of-bias tool for randomized trials.
Results: Results showed that four studies met the eligibility criteria, and three of them showed statistically significant improvements in QOL. The peers instructed in programs were breast cancer survivors who had been diagnosed one to three years earlier. Furthermore, peers received special training for approximately eight hours per session for a total of two to seven days before providing support to the participants.
Conclusion: Few programs have been fully applied in Japan. In terms of program effectiveness and risk of bias, programs that include obtaining support and managing activities that affect mood may be effective. Furthermore, the importance of taking enough time to help cancer survivors trust each other and provide support according to the patient's wishes and available community resources was demonstrated.

Keywords: cancer, community, peer support, quality of life, systematic review

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1. Introduction

In Japan, it is estimated that 1.52 million people need cancer treatment [1], and the period of survival for those affected by cancer has been increasing [2]. Baxter et al. [3] reported that cancer treatments have been saving lives. However, survivors were often left with residual physical and psychosocial complications that prevented them from fully engaging in their everyday lives. These complications subsequently result in a compromised quality of life (QOL). Furthermore, the number of cancer patients who receive treatment or die at home is expected to increase because of policies such as the shortening of the admission period and promoting home medical care [4].

Many cancer patients undergo chemotherapy, radiation therapy, and surgery; experience side effects and complications from these treatments; and often live in the community with cancer recurrence, financial uncertainty, and pain. For the reasons mentioned above, it is presumed that a cancer survivor may find it difficult to perform well in daily life after discharged from the hospital. Peer support is one of the most effective supports in such cases. Peer support can be defined as the process of giving and receiving nonprofessional, nonclinical assistance from individuals with similar conditions or circumstances to achieve long-term recovery [5]. Furthermore, peer supporters often work with patients and/or healthcare providers to address system-level barriers, such as fragmented care, financial constraints, other

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practical challenges (e.g., transportation, employment concerns, and childcare), and communication difficulties [6]. In Japan, there are two types of associations that provide peer support: hospitals and patient groups. In some cases, hospitals commission patient groups to provide peer support at the hospital [7]. Currently, the actual situations and effectiveness of peer support are being examined by the Ministry of Health, Labor and Welfare in Japan [8]. We believe that it is important for cancer survivors living at home to be able to receive peer support comfortably and securely in order to improve their QOL, whether the associations providing the support is hospitals or patient associations.

Several studies on peer support programs for cancer survivors have shown that such programs increase participant satisfaction and improve psychological adjustment [9, 10]. In Japan, Ikeuchi et al. [11] conducted a systematic review of community-based occupational therapy programs to improve the QOL of cancer survivors and reported that it is important to provide programs with peers who have the same disease. Furthermore, in the nursing field, the effect of peer support has been explained using the direct effect model [12], that is, the following are reported to have positive impacts on health- related outcome measures: (a) decreasing isolation and feelings of loneliness, (b) deterring maladaptive behavior or responses, (c) promoting positive psychological states and individual motivation, and (d) providing information regarding access to medical services or the benefits of behavior that positively influence health and well-being. On the other hand, peer support also has aspects that can have adverse outcomes, for example, criticism, reinforcement of poor behaviors, and diminished feelings of self- efficacy [12].

In terms of QOL, in general, randomized controlled trials (RCTs) did not find significant effects of participation in peer support programs on QOL [9]. However, further research is needed because of the impact of methodological issues such as a small sample size, lack of long-term follow-up, and limited outcome measures, as well as social resource issues such as the relatively high abundance of support (peer and professional) already available because the study participants only had breast cancer (BC). Furthermore, the study participants were recruited primarily by hospitals and specialists. In general, it is thought that cancer survivors have fewer opportunities to contact peers in the community than in hospitals admission; thus, we believe that further research is needed on the degree of peer support provided in the community. In summary, peer support programs are mainly studied by hospitals and medical professionals, and further research is needed on their impact on QOL.

Therefore, it is necessary to examine the effects of peer support programs that aim to improve QOL in community settings. This study aimed to identify an effective community-based peer support program to improve the QOL of cancer survivors. This study has the potential to promote mutually supportive relationships among cancer survivors when they live in the community. To investigate effective peer support programs, this study focused on RCTs with a higher level of evidence.

2. Methods

2.1 Study Design

This study was a systematic review and was conducted by following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [13, 14].

2.2 Data Sources and Searching Strategies

PubMed and Igaku Chuo Zasshi [15] were the databases used in the current study. Igaku Chuo Zasshi contains bibliographic citations and abstracts from more than 2,500 biomedical journals and other serial publications in Japan. A hand search was also performed. The search terms in English were ((community) OR (home)) AND (peer) AND (cancer) AND (quality of life), and those in Japanese were ((tiiki) OR (zaitaku)) AND (pia) AND (gan) AND ((seimei-no-shitsu) OR (seikatsu-no-shitsu)). The last date of the search was December 3, 2020, for both Japanese and English.

2.3 Inclusion Criteria

The inclusion criteria were as follows: (1) the program was conducted in the community or at home, (2) the program participants were cancer survivors aged 18 years or older, (3) the program participants were not in the terminal stage, (4) the program was conducted with peers, (5) the program was peer- reviewed, (6) the study design was an RCT, (7) the language was English or Japanese, and (8) the full text was available for ordering.

2.4 Papers Extraction

Identification, screening, eligibility, and included were performed according to the PRISMA Flow Diagram [14] for research inclusion (Figure 1). In the screening stage, we excluded papers that clearly would not meet inclusion criteria (1) to (8) on the basis of their titles and abstracts. Papers that could not be judged by the title and abstract or in which the title and abstract met the inclusion criteria were carefully reviewed after a thorough reading of the full text at the eligibility stage. After paper extraction was completed, an abstract table was created for the studies included in the qualitative

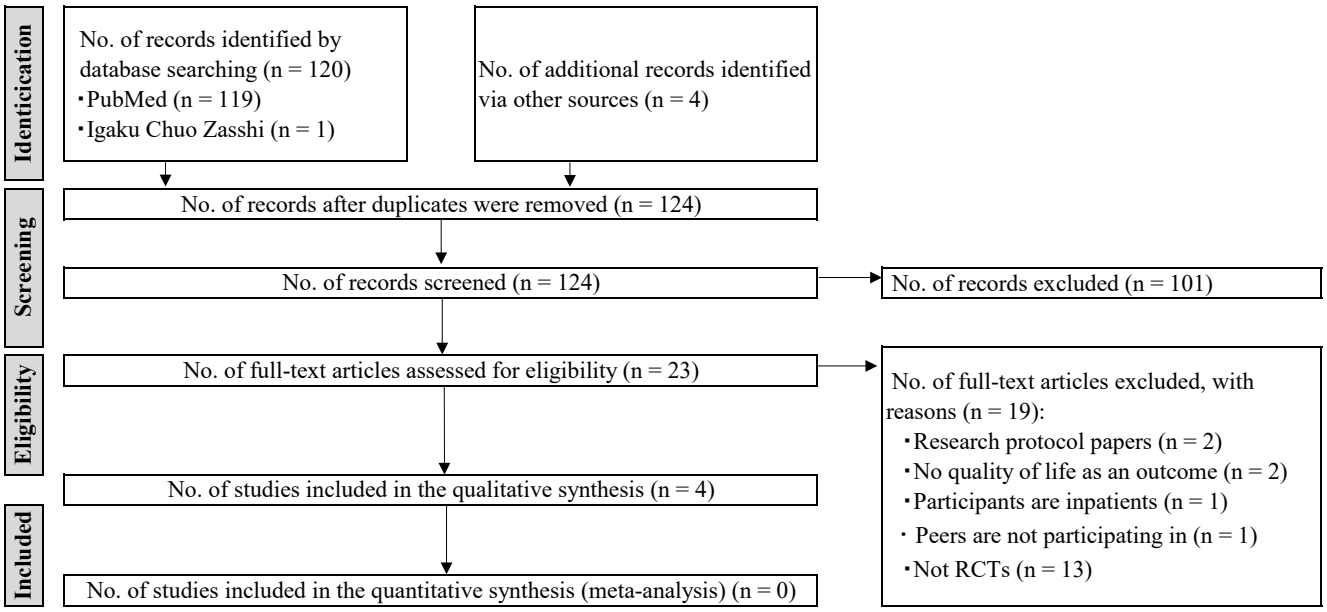

Fig. 1. PRISMA Flow Diagram
The process of identifying papers to adopting them is shown.

synthesis (Table 1).

2.5 Evaluating the Quality of Papers

After the eligibility stage, two or more authors assessed the quality of the included articles according to the manual described in the Cochrane risk-of-bias tool for RCTs (RoB 2.0) [16, 17] in the *Cochrane Handbook*. Two of the authors had experience with systematic reviews. There were five types of bias risk: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in the measurement of the outcome, and bias in the selection of the reported result. To determine the risk of bias, we had to check the manual and then answer two to six signaling questions corresponding to each bias (Table 2). For example, when bias arises from the randomization process, we answered signaling questions such as "1.1 Was the allocation sequence random?" and "1.3 Were there baseline imbalances that suggest a problem with the randomization process?." When answering signaling questions, respondents selected yes, probably yes, no, probably no, no information, and not applicable. After answering these signaling questions, five types of bias risk could be classified as "low risk," "some concerns," and "high risk" (Table 3).

3. Results

3.1 Process of Adopting Papers (Figure 1)

After searching the database, 120 articles were listed (119 articles in PubMed and 1 article in Igaku Chuo Zasshi). We screened 124 papers, including 4 papers collected by hand searching. In the screening, 101 papers that clearly would not meet inclusion criteria (1) to (8) on the basis of their title and abstract were excluded. Nineteen papers were excluded in terms of eligibility. In other words, four papers [18–21] were included. Nineteen papers were excluded for eligibility because 2 papers were research protocol papers with unknown results, 2 papers did not have QOL as an outcome measure, 1 paper had inpatients as participants, 1 paper had cancer survivors who did not participate in programs with peers, and the other 13 papers were not RCTs. There have been no studies on the process of quantitative integration (meta-analysis).

3.2 A Review of Accepted Papers (Table 1)

Among the four articles that were accepted, all study participants were women with BC. Furthermore, QOL was significantly improved in three of the papers [18, 20, 21]. The peers instructed in programs were BC survivors who had been diagnosed one to three years earlier, and some studies required peers to be free of recurrence for several years or more. Peers also received special training of approximately eight hours per session for a total of two to seven days before providing support to the participants. The programs of the intervention groups in the three papers that significantly improved QOL are described below.

Nápoles et al. [18] evaluated a community-based,

Table 1. An abstract table for accepted papers
Information on the adopted papers (n = 4) are organized.

No.	First author, Year (Country)	Design	Cancer type Number of Participants	Intervention contents (Number of Participants)	Main outcome measure	QOL outcomes with significant improvements
18	Nápoles, 2015 (USA)	RCT	BC n = 151	Intervention: Nuevo Amanecer (n = 76) Control: Usual care (n = 75)	QOL: FACT-B, General distress symptoms: BSI, Breast cancer- specific distress: a subscale of the IES-R	Emotional well-being of FACT-B
19	Nápoles, 2020 (USA)	RCT	BC n = 153	Intervention: Nuevo Amanecer-II (n = 76) Control: usual care (n = 77)	QOL: FACT-B, General distress symptoms: PHQ-8, PSS, BSI and MOCS-A	None
20	Giese-Davis, 2016 (USA)	RCT	BC n = 104	Intervention: peer-counseling (n = 52) Control: usual care (n = 52)	QOL: BSW and TOI in FACT-B, Cancer - related trauma symptoms: PCL-C, Cancer self-efficacy: CBI, Marital interaction: LWMAT, Depression symptoms: CES-D, BC resources: BCRQ	BSW in FACT-B
21	Toija AS, 2019 (Finland)	RCT	BC n = 260	Intervention: usual care and peer support via telephone (n = 130) Control: usual care (n = 130)	Generic state of health: 15D, QOL: EORTC QLQ-C30, EORTC-QLQ-BR23	Sexual function in EORTC QLQ-C30 and EORTC-QLQ-BR23

RCT: Randomized Controlled Trial, BC: Breast Cancer, QOL: Quality of Life, FACT-B: Functional Assessment of Cancer Therapy- Breast, BSI: Brief Symptom Inventory, IES-R: Impact of Event Scale-Revised, PHQ-8: eight-item Patient Health Questionnaire depression scale, PSS: the Perceived Stress Scale-10, BSI: Brief Symptom Inventory, MOCS-A: Measure of Current Status part A, BSW: Breast Cancer-Specific Well-being, TOI: Trial Outcome Index, PCL-C: Posttraumatic stress disorder (PTSD) CheckList-Civilian, CBI: Cancer Behavior Inventory, LWMAT: The Locke-Wallace Marital Adjustment Test, CES-D: Center for Epidemiologic Studies- Depression, BCRQ: Breast Cancer Resources Questionnaire, 15D: a generic, preference-based instrument for measuring health- related QoL, EORTC QLQ-C30: The European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30, EORTC-QLQ-BR23: The European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Breast23

Table 2. Answering signaling questions
Answers to signaling questions are described.

Reference number	Bias arising from the randomization process			Bias due to deviations from intended interventions						Bias due to missing outcome data			Bias in measurement of the outcome		Bias in selection of the reported result	
	1.1	1.2	1.3	2.1	2.2	2.3	2.4	2.5	2.6	3.1	3.2	3.3	4.1	4.2	5.1	5.2
18	Y	Y	N	PY	PY	PN	PN	N	NA	Y	NA	NA	Y	PY	N	N
19	Y	Y	N	PY	PY	PN	PY	N	NA	PY	NA	NA	Y	Y	N	N
20	NI	PY	N	PY	PY	PY	PY	N	PN	N	N	N	Y	Y	N	N
21	Y	Y	N	PY	PY	PN	PN	N	NA	Y	NI	NA	Y	Y	PN	PY

Y: Yes, PY: Probably yes, N: No, PN: Probably no, NI: No information, NA: Not applicable
Signaling questions are as follows:

1.1 Was the allocation sequence random?
1.2 Was the allocation sequence concealed until participants were recruited and assigned to interventions?
1.3 Were there baseline imbalances that suggest a problem with the randomization process?
2.1 Were participants aware of their assigned intervention during the trial?
2.2. Were carers and trial personnel aware of participants' assigned intervention during the trial?
2.3 Were there deviations from the intended intervention beyond what would be expected in usual practice?
2.4 Were these deviations from intended intervention unbalanced between groups and likely to have affected the outcome?
2.5 Were any participants analysed in a group different from the one to which they were assigned?
2.6 Was there potential for a substantial impact (on the estimated effect of intervention) of analysing participants in the wrong group?
3.1 Were outcome data available for all, or nearly all, participants randomized?
3.2 Are the proportions of missing outcome data and reasons for missing outcome data similar across intervention groups?
3.3 Is there evidence that results were robust to the presence of missing outcome data?
4.1 Were outcome assessors aware of the intervention received by study participants?
4.2 Was the assessment of the outcome likely to be influenced by knowledge of intervention received?
5.1 Multiple outcome measurements (e.g. scales, definitions, time points) within the outcome domain?
5.2 Multiple analyses of the data?

Table 3 Rating quality of papers
Results of the assessment of the five types of bias risk; the five biases are answered with "low risk," "some concerns," and "high risk."

Reference number	Bias arising from the randomization process	Bias due to deviations from intended interventions	Bias due to missing outcome data	Bias in measurement of the outcome	Bias in selection of the reported result
18	Low risk	Low risk	Low risk	High risk	Low risk
19	Low risk	Low risk	Low risk	High risk	Low risk
20	Low risk	High risk	High risk	High risk	Low risk
21	Low risk	Low risk	Low risk	High risk	High risk

translational stress management program called Nuevo Amanecer (NA) to improve health-related QOL in Spanish-speaking Latinas with BC. The specifics of the NA involved managing the initial impact of cancer, finding cancer information, obtaining support, identifying helpful and unhelpful thoughts, managing thoughts and mood, stress management techniques, managing activities that affect mood, and goal setting. The NA was conducted once a week for a total of eight sessions of 90 minutes each.

Giese-Davis et al. [20] conducted an RCT of peer counseling for patients with newly diagnosed BC. Peer navigators provided support during medical treatment, made connections to community resources, recognized trauma symptoms, and helped sojourners know whether to seek professional help for distress. The pair could meet weekly by telephone, email, or in person for up to six months.

Toija et al. [21] explored the effectiveness of a simple and low-cost peer support program on the health-related QOL of patients with BC. This peer support was provided by trained volunteer BC survivors via telephone, thus enabling newly diagnosed BC patients to get in contact with survivors in a simple and uncomplicated manner to ask questions and receive emotional support when needed. Moreover, it was continued according to the patients' preferences as long as it was necessary, with approximately one call per week.

3.3 Evaluating the Quality of Papers

The results of the responses to the signaling questions (Table 2) guided the evaluation of the quality of the papers (Table 3). For example, in a study by Nápoles et al. [18], the answer to signaling question 1.1 "Was the allocation sequence random?" was "Yes." In answering the other signaling questions, four items of the article quality rating were "low risk" and one item was "high risk." The studies with the lowest risk of bias were those of Nápoles et al. [18, 19], followed by Toija et al. [21]. The study with the highest risk of bias was that of Davis et al. [20].

4. Discussion

4.1 Reported Programs

Three studies [18, 20, 21] showed significant enhancements in QOL, among which the study by Nápoles et al. [18] had the lowest risk of bias, followed by the studies by Toija et al. [21] and Giese- Davis et al. [20]. The following describe the details of the three papers [18, 20, 21] that showed significant improvements in QOL.

The NA conducted by Nápoles et al. [18] showed a statistically significant improvement in emotional well-being in FACT-B at six months. Their sample consisted mostly of Mexican and Central American Latinas, and participant cancer survivors with low educational and economic status were included in the NA. Therefore, this study may not be generalizable to Japanese groups. On the other hand, it may be useful for Japan because NA has contents that are strongly related to the community life of cancer patients, such as searching for cancer information; good skills when communicating with health professionals, family, and friends; managing activities that affect mood; and goal setting [22].

Giese-Davis et al. [20] reported that peer counseling performed for a maximum of 6 months showed a statistically and clinically significant difference in FACT-B BSW at 12 months. The content of this program, which helps peers talk about their experiences, make connections with community resources, and decide whether to seek professional help, is likely to be applicable in Japan. However, it should be noted that the risk of bias was the highest among the four papers adopted in this study.

Toija et al. [21] reported a small but statistically significant improvement in sexual function in EORTC-QOL30 and EORTC-QLQ-BR23 at six months follow-up. Unfortunately, there are many limitations to this study: the number of phone calls made differed between participants; data on participants' disease stage and treatment were not reported; and data on sexual function in the EORTC- QOL30 and EORTC-QLQQ-BR23, which showed statistically significant improvements, were not

shown. Therefore, generalizing this program is difficult.

The three studies [18, 20, 21] that showed significant improvements in QOL all incorporated a follow- up period of more than six months into their study design. This finding is consistent with that of Hoey et al. [9], who stated that an extended period of time may be required before people can develop relationships and build sufficient rapport to enable them to gain benefits from peer support. When running a peer support program in the community, it is also necessary to support cancer survivors so that they can take time to fully build trusting relationships with each other.

By contrast, Nápoles et al. [19] found no significant improvement in QOL. This program for Latinos living in rural areas is a revision of the NA [18, 22] for Latinos living in urban areas. As a result of revisions, NA-II was expanded from 8 to 10 sessions, the use of audiovisual materials was increased, and a handout for family members providing information on the program was created. Nápoles et al. [19] stated that the reason for the lack of significant improvement in QOL with NA-II was that all women who received NA were enrolled mostly within three months of diagnosis or within one year, whereas women who received NA-II were enrolled farther from the date of their initial diagnosis (within 2.5 years on average). This may be due to the longer time since the diagnosis and that the baseline levels of QOL among women in the NA-II were better than those in their prior RCT, thus leaving less room for improvement. This is similar to what Hong-Li et al. [23] reported when following the QOL of nonmetastatic BC patients after initial treatment with surgery and chemotherapy for one, two, and five years; they found that the QOL at one year was the lowest. Therefore, it is important to concentrate on providing QOL support to BC survivors within the first year after diagnosis or initial treatment.

From the above four studies, there was a scarcity of programs that could be fully applied in Japan because every study has its advantages and limitations.

4.2 What Kind of Support Should A Specific Peer Provide?

Peers in the four studies were BC survivors who had been diagnosed one to three years previously and had received several specific training sessions of approximately eight hours each. Therefore, educated peers provided support to the participants. By contrast, Petruseviciene et al. [24] conducted a program in which untrained BC survivors formed groups to knit, make paper cranes, and attend lectures by an occupational therapist. As a result, participants reported a significant improvement in QOL, which was suggested to be due to the mental well-being of women with the same disease doing the same program. As shown above, peer support can be provided by trained cancer survivors or by a group of untrained individuals. Furthermore, a study showed that programs [25] provided by healthcare professionals, not peers, have improved QOL. As mentioned above, there are hospitals and patient groups that provide peer support in Japan. These two types of peer support programs have their advantages and disadvantages. For example, although the peer support provided at hospitals is for any cancer survivor and their family members, some patients may feel burdened to participate because they have to go to the hospital. In addition, while the provided information is highly reliable as medical staff oversees, services focused on the patient's life are less likely to be provided [26]. On the other hand, peer support provided by patient groups is less difficult to participate and can provide support that is more relevant to the patient's life, yet it is necessary to consider whether or not the information provided is reliable. Therefore, it is essential to educate peers because peer support programs provided by hospitals and patient groups have advantages and disadvantages. Also, it is important that peer support provided by hospitals and patient groups complement each other and provide services so that cancer survivors can use peer support comfortably and securely, taking into consideration the wishes of cancer survivors and the community resources that should be provided when providing community-based support to improve QOL.

4.3 Limitations and Prospects

A limitation of this study is that the small number of RCTs that met the inclusion criteria did not allow for a meta-analysis to be performed. Given that there were only three programs that showed significant improvements in QOL, research that includes QOL as an outcome measure should be conducted in the future. This systematic review should be updated when new and more effective studies are published or when approximately three to five years have passed.

5. Summary and Conclusion

A systematic review was studied with the aim of investigating community-based peer support programs for improving QOL. The results showed that four studies met the eligibility criteria, and three of them showed statistically significant improvements in QOL. However, few programs can be fully applied in Japan. In terms of program effectiveness and risk of bias, programs that include obtaining support and managing activities that affect mood may be effective. Furthermore, the importance of taking enough time to help cancer survivors

trust each other and provide support according to the survivors' wishes and available community resources was demonstrated.

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■ORIGINAL ARTICLE

The Effect of Cognitive Function on Imitation Skills in Patients with Schizophrenia.

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Abstract: The purpose of this study is to identify how cognitive functions such as attention and cognitive processes, such as the retention process to maintain an image needed in the learning by imitation process, are related to the ability to convert this into action (imitation) in patients with schizophrenia. Many people with schizophrenia have a lower imitation ability compared to healthy persons. Those with low imitation ability had lower scores for cognitive functions such as MMSE and visuospatial cognitive functions such as the number of correct answers in MRT. As described above, reduced imitation ability in patients with schizophrenia is caused by problems in information processing which temporarily retains and manipulates visual information during the performance of a task.

Keywords: schizophrenia, imitation, cognitive function

(*Asian J Occup Ther* **18**: 25−30, 2022)

Introduction

Patients with schizophrenia have difficulty in daily living activities, such as dressing, taking medication, money management, communication, and using social resources [1]. Among these, difficulty grooming and communication lead to further isolation from society [2]. Normally, these skills are acquired by recognizing and imitating the actions and behaviors of people around us during the growth process. Consequently, among difficulties in daily life by patients with schizophrenia, those involving lifestyle-related routines are considered to be caused by a failure to learn through experience while growing up. Learning by imitation includes observing the detailed actions of another person as a target of imitation, converting the action into a visual image or concept, retaining that image, and then converting it into an action [3]. In previous studies on imitation by patients with schizophrenia, patients with lower imitation skills were shown to have difficulty understanding the feelings of other people and properly expressing their own emotions [4-6]. Matthews, et al. [7] stated that when patients with schizophrenia were instructed to mimic images, such as hand and mouth shapes and facial expressions which were displayed on a monitor, many could not imitate the images compared to healthy subjects. Park, et al. [8] analyzed the relationship between imitation skills, psychiatric symptoms, and social functions using the same method, and found that those with poor imitation skills had more negative symptoms and decreased social function. In addition, patients with schizophrenia are known to have an impaired working memory, attention deficiency, and lower information processing ability [2]. Although previous studies have reported that poor imitation skills in patients with schizophrenia are related to mental symptoms and a reduction in emotional cognition and social function, the studies provide insufficient details regarding the relation between imitation ability and cognitive function, and no correlation between poor imitation skills in patients with schizophrenia and reduced cognitive ability has been clearly identified.

Consequently, the purpose of this study was to identify how cognitive functions such as attention, and cognitive processes such as the retention process to maintain an image (needed in the learning- by- imitation process), are related to the ability to convert this into

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action (imitation) in patients with schizophrenia.

This study was conducted with the approval of the Ethics Committee of the Hirosaki University Graduate School of Health Sciences (Ref. No. 2016-029).

Methods

I. Subjects

The participants (Schizophrenia group) were 59 adult patients (29 outpatients and 30 inpatients) with schizophrenia, as confirmed by the Structured Clinical Interview for DSM-V. All participants were clinically stable and recruited from Fuse Hospital in Aomori, Japan. Patients were excluded if they had a neurological disease, were mentally retarded, or had suffered an acute psychotic episode in the last six months.

For comparison, 40 healthy persons (Healthy group) were also included in the study. These (18 males, 22 females) were recruited from local residents, to match the patient group in age, gender distribution, and formal education. All subjects were informed of the purpose of the survey, that they could refuse to answer, and that refusal would not result in disadvantage. After explanation, consent to participate in the study was obtained.

II. Survey contents

A survey was carried out by individual interview for each participant during the survey period (October 4-14, 2016). Survey contents are as follows.

Assessment

1) Imitation ability

The Standard Performance Test for Apraxia(SPTA) [9] was used to assess imitation ability. SPTA is a test to detect apraxia as well as various behavioral and fine motor dysfunctions that cannot be explained by motor paralysis, ataxia, involuntary movement and general mental dysfunction in persons with brain injury. The test was created to detect, differentiate, and analyze higher order dysfunction. The purpose of this study is to assess the imitation ability of patients with schizophrenia. Seven assessment items were set. For imitation of the upper limb (one hand) finger configuration “Chin hand of Ruria”,”I, II, IV ring”,”I,V ring”. For imitation of motion of the upper limb (both hands) without an object, “Figure 8”, “Butterfly “,”Paper/Rock Interaction Test”. And for continuous upper limb (one hand) motion “Ruria and Stretch Fist”. In addition, “Reverse fox” was used to screen for mild dementia [10].

Total score (0-16 points) of the eight items was calculated. Subjects sat facing the investigator, and were asked to mimic the movement of the investigator. Anchor points for each item were set as matching (two points), partially matching (one point), and not matching (zero points), and the higher the score, the higher the imitation ability .

2) Cognitive function

The Mini-Mental State Examination (MMSE) [11] was used to assess cognitive function. 11 assessment items were set, including “Time orientation”, “Location orientation”, “Instant recall”, “Calculation”, “Delayed reproduction”, “Object naming”, “Sentence repetition”, “Verbal instruction”, “Writing a complete sentence”, “Spontaneous writing”, “Figure copying”. Total score (0-30 points) was calculated. The higher the score, the higher cognitive function.

3) Visuospatial cognitive function

The Mental Rotation Test (MRT) was used to assess the visuospatial cognitive function. MRT is a visuospatial cognitive task to assess the ability to imagine how an object will appear when rotated in 2- or 3-dimensional space. We created the original evaluation scale with reference to the method of Yamada, et al. [12]. Subjects were shown 10 photographs of hands and feet taken from various angles on a 11.6 inch display, one at a time. Subjects were then asked to answer right or left, as quickly and accurately as possible. The number of correct answers and total time were used to assess total visuospatial cognitive function.

III. Statistical analysis

The a priori hypothesis was that cognitive function and imitation skills would differ for the Schizophrenia group versus the Healthy group. Accordingly, comparison was made using a Mann-Whitney U test and t-test. The Mann-Whitney U test was used to compare the total MRT, MMSE, and imitation test scores, between the Schizophrenia group and Healthy group. The normal distribution of total MRT time was examined using the Shapiro-Wilk -test (p = .000). Next, the respective total MRT times of the Schizophrenia and Healthy groups were compared using Welch’s t-test. Spearman’s rank correlation coefficient was used to analyze the total imitation test scores and MMSE scores, number of correct MRT answers and total time in the Schizophrenia group. Significant difference was set as $P < 0.05$. The analysis was performed using Excel -Toukei version 2010 (Social Survey Research Information Co., Ltd.).

Results

Basic attributes of the Schizophrenia group and the

Table.1 Participants

		Schizophrenia group (*n* 59) *M (SD)*	Healthy group (*n* 40) *M (SD)*	*p*-value
Age (years)		59 (8.3)	57.1 (11.5)	.356
Gender	Male Female	37 22	18 22	.101
Diagnosis	Schizophrenia	59	—	
Form of treatment	Out patients In patients	30 29	— —	

Age (years) : t test Gender: Fisher's exact test

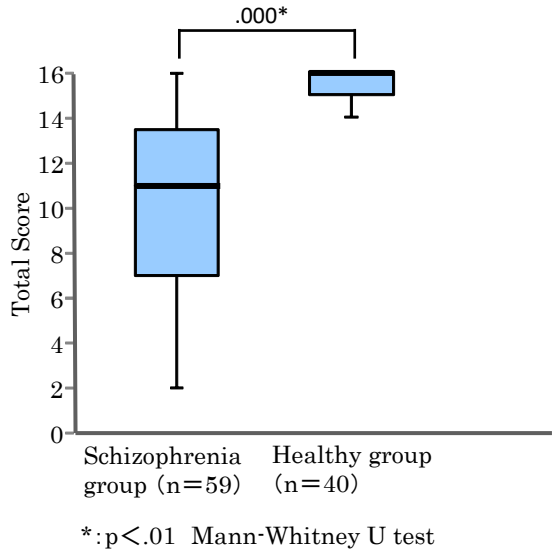

Fig. 1. Total imitation test scores for the Schizophrenia Group and the Healthy Group

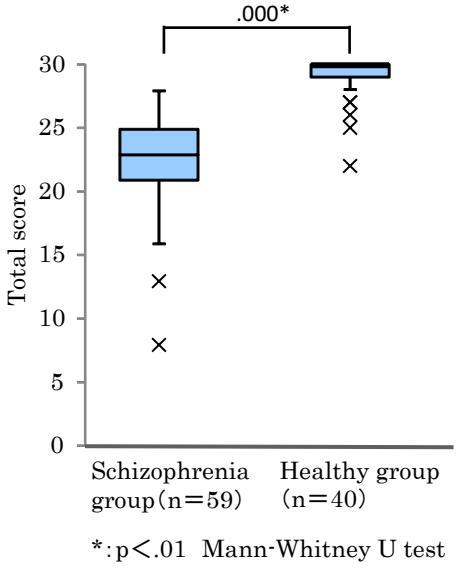

Fig. 2. Total M MSE scores for the Schizophrenia Group and the Healthy Group

Healthy group are described in Table 1. Average age and gender of the Schizophrenia group and the Healthy group were 59 years (SD 8.3) and 37 males and 22 females; and 57.1 years (SD 11.5) and 18 males and 22 females, respectively. Treatment regimen for the Schizophrenia group was 30 outpatients and 29 inpatients. No statistical significant difference between the two groups regarding age and gender was observed. Total scores for the imitation test for the Schizophrenia group and the Healthy group are shown in Figure 1. The median total score of the imitation test for the Schizophrenia group was 11.0 points, which is significantly lower (p=.000) than that of the Healthy group at 16 points.

Total MMSE scores for the Schizophrenia group and the Healthy group are shown in Figure 2. The median total MMSE score for the Schizophrenia group was 23.0 points, which was significantly lower (p=.000) than that of the Healthy group at 30 points.

Comparison of results of the number of correct MRT answers for the Schizophrenia group and the Healthy group are shown in Figure 3. Median MRT score for the Schizophrenia group was 8.0 points, which was significantly lower than that for the Healthy group at 10.0 points (p=.000).

Total MRT time for the Schizophrenia group and the Healthy group are shown in Figure 4. Median total MRT time for the Schizophrenia group was 28.7 sec, and no significant difference with the Healthy group at 29.0 secs was observed.

Results of correlation between total scores of the imitation test and MMSE/MRT for the Schizophrenia group are shown in Table 2. A moderate positive correlation between the imitation test total score and the total MMSE score (r = .55, p = .000), "Calculation" (r = .46, p = .000), "Sentence repetition" (r= .47, p = .000),

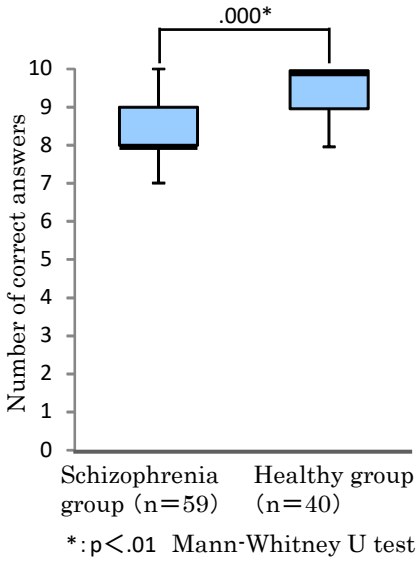

Fig 3 Number of correct MRT answers in the Schizophrenia group and the Healthy group

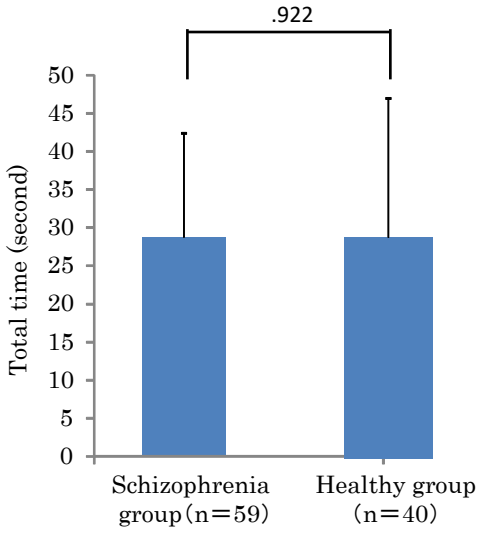

Fig 4. Total MRT time for the Schizophrenia group and the Healthy group

Table 2. Correlation between Total Imitation test scores, MMSE and MRT

	Items	*r*	*p*-value
MMSE	Total Score	.55	.000
	Time orientation	.00	.966
	Location orientation	.25	.053
	Instant Recall	.23	.055
	Calculation	.46	.000
	Delayed reproduction	.22	.099
	Object naming	.19	.220
	Sentence repetition	.47	.000
	Verbal instruction	.22	.090
	Writing a complete sentence	.35	.063
	Spontaneous writing	.24	.063
	Figure copying	.41	.002
MRT	Number of correct answers	.38	.005
	Total time	.29	.036

Spearman's rank correlation coefficients

"Figure copying" (r = .41, p = .002) was observed. A weak positive correlation between total imitation test score and number of correct MRT answers (r = .38, p = .005) was observed.

Discussion

Imitation is a series of motor learning exercises that can change a person's movement to match a targeted model and reproduce it [13]. Learning by imitation includes a cautionary process to pay attention to the clues and features of the target, a retention process to maintain a representation form, and then a process to reproduce the movement by physical motion. An image of task implementation is said to be formed and these tasks are carried out by the normal functioning of these elements [14]. In this study, the correlation between cognitive functions such as attention, and cognitive processes, such as the retention process to maintain an image (needed in the learning- by- imitation process), and the ability to convert this into action (imitation) in patients with schizophrenia was analyzed.

In the comparison of imitation ability between the Schizophrenia group and the Healthy group, the total imitation test scores in the Schizophrenia group were significantly lower. These findings agree with the results from the study by Matthews, et al. [7] that many patients with schizophrenia have a more difficult time imitating

than healthy subjects do. This difficulty in imitation ability in schizophrenia patients is considered to affect guidance in occupational therapy. Since difficulty in imitation ability in patients with schizophrenia is related to impairment in social cognition and behavior [8], further examination is considered necessary.

In the comparison of cognitive functions between the Schizophrenia group and the Healthy group, the total MMSE score in the Schizophrenia group was shown to be significantly lower. Previous studies have also reported that total MMSE scores for patients with schizophrenia were lower than those for healthy people of the same age regardless of type of treatment, such as hospitalization or outpatient care [15,16]. The cognitive function is considered to be an essential function when performing various tasks [17]. Major cognitive dysfunction in person with schizophrenia is thought to be due to information processing problems. In the comparison of the number of correct MRT answers in the Schizophrenia group and the Healthy group, the MRT scores for the Schizophrenia group were significantly lower. In the MRT, subjects were asked to perform tasks such as differentiating visual images while rotating them, in order to compare them with the displayed visual stimuli. These visuospatial cognitive functions are necessary to understand spatial positioning relationships such as right side, left side, and depth of an object, and are thought to be related to the ability to perform various tasks. In order to assess visuospatial cognitive function in patients with schizophrenia, Vignemont et al. [18] displayed pictures of letters and numbers on a screen and asked the subject to identify whether they were mirrored characters, then recorded the total time for response and the number of correct answers. From the results, patients with schizophrenia showed a significantly longer time than healthy subjects, and subjects with more severe psychiatric symptoms had fewer correct responses. In the present study, even the results by MRT to differentiate between left/right limbs were similar to those in previous studies. These results suggest that mental rotation in patients with schizophrenia is weaker when maintaining and moving their own limbs during physical exercise.

A moderate positive correlation between total imitation test scores and MMSE total scores, “Calculation”, “Sentence repetition”, “Figure copying” was observed. A weak positive correlation between total imitation test scores and “Writing a complete sentence” was observed. ”Calculation” and “sentence repetition” require the ability to pay attention to numbers, sentences, and figures, and to temporarily retain information during processing. In observational learning by imitation, the main function involved is the attention process that selects the most relevant event from the stimulus, accurately perceives clues, and then retains the stimulus as a symbol [14]. Consequently, a positive correlation between the items of “calculation” and “sentence repetition” can be considered. In addition, although imitation and figure copying differ in terms of body, graphics and expression methods, both have the same actions in terms of matching tasks, which is considered to suggest a positive correlation. When instructed to “Write a complete sentence”, the subject was told “Please close your eyes” and required to close their eyes. To do so, subjects were required not only to understand the intent of the sentence, but also to perform the exercise with closed eyes. Since the process of understanding intention is based on linguistic information and converting this into movement, this is a point in common with imitation learning, where the intention is understood based on visual information and converted to movement [19]. A positive correlation between “imitation” and “writing a complete sentence” is suggested. Regarding information processing ability in patients with schizophrenia, it has been pointed out that the ability to maintain attention and selectivity, as well as the control function, is reduced [20,21]. Therefore, careful consideration as to how information processing ability is related to imitation ability, in connection with cognitive dysfunction which is unique to schizophrenia, is needed.

From the analysis of the correlation between total imitation test scores in the Schizophrenia group and number of correct MRT answers and total time, MRT scores showed a weak positive correlation. Visuospatial cognitive function required for MRT is necessary for recognizing the spatial positional relationship between an object and the subject’s own body [12]. If the visuospatial cognitive function is impaired, it becomes difficult to recognize top, bottom, left, and right of multiple objects and the positional relationship between objects. Because the imitation test used in this study was composed of techniques such as alternately turning both hands and shifting the positional relationships between front and back, a positive correlation between total imitation test scores and total MRT scores was suggested. Because the ability to understand spatial positional relationships between an object and the subject’s body is weak, it is difficult to learn different left and right movements and complicated movements. This problem is thought to hinder patients with schizophrenia from acquiring new abilities. Therefore, when occupational therapists provide movement guidance instructing patients with schizophrenia to imitate a movement, dividing complicated movements into several individual steps and keeping in mind that instead of providing instructions face to face, providing instructions alongside the patient so the right and left are more easily distin-

guished, is important.

Conclusion

Many people with schizophrenia have a lower imitation ability compared to healthy persons. Those with low imitation ability had lower scores for cognitive functions such as ”calculation”, ”sentence repetition”, ”figure copying”, and ”writing a complete sentence”, and visuospatial cognitive functions such as the number of correct answers in the rotational test, etc. As described above, reduced imitation ability in patients with schizophrenia is caused by problems in information processing which temporarily retains and manipulates visual information during the performance of a task.

Therefore, when learning movement by imitation, it is necessary to consider things such as simplifying the movement at the position facing in the same direction.

Limitation

MMSE is commonly used in medicine to screen for dementia. Therefore, it does not accurately represent the actual state of cognitive function in schizophrenia. In the future, it will be necessary to use a cognitive function test specialized for patients with schizophrenia.

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■ORIGINAL ARTICLE

Comparison of Forearm Muscle Activation and Relationship with Pressure Distribution in Various Grip Patterns

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Abstract: Introduction: In racket sports, it is necessary to devise a gripping method that facilitates both the efficient transmission of power and injury prevention. This study quantified grip pressure distribution (PD) in the hand using various gripping methods and investigated the relationship between these distributions and muscle activation.
Methods: In a laboratory setting, a grip sensor was used to measure hand PD in 15 healthy adults during each task. Participants gripped the sensor device using three grip patterns with simultaneous electromyography (EMG) recordings from the extensor digitorum communis (EDC), extensor carpi radialis, flexor digitorum superficialis (FDS), and flexor carpi ulnaris (FCU). The device's hand-contact area was assigned anatomical regions, and the percentage PD of each region was calculated for each task. We compared the EMG in each grip pattern and analyzed the correlation between grip force and EMG.
Results: The main outcomes measured were EMG and PD. For radial and power grips, there was a significant relationship between EDC and grip force ($r = 0.52, 0.47$). For the ulnar grip, there was a significant relationship between FDS and grip force ($r = 0.55$). Furthermore, the ulnar grip's EDC activity was significantly lower than that of the power grip, and FCU activity was significantly higher than that of the radial grip ($p < 0.05$).
Discussion: The ulnar grip had significantly lower EDC activity than the power grip and higher FCU activity, which is involved in the elbow joint's stability, than the radial grip. The ulnar grip may be effective in preventing injuries.

Keywords: pressure distribution, muscle activation, racket sports, grip patterns, guidance

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1 Introduction

With the development of the sports and health industry, the number of recreational tennis players has increased internationally. [1−3] The incidence of tennis injuries ranges from 0.05 to 2.9 per player per year, and upper limb injuries are more likely to become chronic than lower limb injuries. [1] Therefore, it is important to prevent recurrence by providing treatment and guidance, especially for upper limb disorders. Lateral epicondylitis (tennis elbow), a typical tennis disorder, is a painful condition of the extensor tendons attached to the lateral condyle of the humerus. The extensor carpi radialis brevis (ECRB) muscle is the affected tendon in almost 90% of cases. [4−5] Over 30 treatments are described for the tennis elbow; therefore, many of them are used routinely such that there is no single optimum treatment. [6] Patient education is provided as part of the treatment, [7] including instructions on using the elbow band and gripping the racket. The four traditional single-handed hand grip positions are the continental, Eastern, semi-western, and Western. [8] Tagliafico et al. investigated the grip styles of tennis players and found the damage caused by different grip styles. It has been reported to be related to the Eastern grip with radial-sided injuries and the Western or semi-western grip with

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ulnar-sided injuries. [9] In addition to the grip position, information on the pressure distribution (PD) of the finger being applied is important. Studies using grip strength devices have reported that the involvement of the ulnar fingers, such as the ring finger and little finger, was useful for exerting grip strength. [10] Furthermore, the force of the index finger before impact reportedly affects the force after impact. [11] It was suggested that a weaker index finger is desirable to suppress excessive contraction. However, the relationship between forearm muscle activation and the grip pressure distribution has not been clarified.

As there have been studies examining the PD of each finger using various test devices (cylinder of various sizes with sensors, [12] dynamometer with pulley assembly, [13] and digital dynamometer[14] with force sensor), it was found that the PD of the index finger and the middle finger is more involved in the grip strength. Recently, qualitative and quantitative data on the whole-hand PD have been reported using a cylinder with surface-pressure sensors. Mühldorfer et al. measured the load in each anatomical hand region during a grip task and reported similar results in previous studies. [15] Similarly, the same authors studied changes in load distribution that accompanied changes in grip strength and use for wrist fusion patients. [16] Since these techniques can quantitatively confirm information on gripping and PD, converting qualitative information, such as guidance on gripping, into quantitative information for comparison has become possible. It is necessary to consider whether the flexor grip (centered on the index finger and middle finger) or the ulnar grip (centered on the index finger and little finger) is better to transmit force and prevent injury efficiently. Our research question was how PD relates to forearm muscle activation when the radial or ulnar fingers are predominantly gripped (radial grip or ulnar grip) during a power grip compared to when all fingers are gripped evenly (power grip).

Surface electromyography (EMG) is commonly used as a non-invasive tool for evaluating muscle function in clinical settings and research institutions. Several studies have used EMG to document muscle activation during a power grip task to assess the relationship between grip strength and activity in forearm muscles, [17−18] while others have documented muscle activation in styles other than the power grip. [19−20] These latter studies only observed the relationship between muscle activation and total grip strength, and no study has examined the simultaneous relationship between regional forces in the hand and the activity of muscles involved in the grip task. Understanding the regional distribution of forces during hand grasping and their relationship with the activity of the muscles responsible for the task will lead to a better overall understanding of grasping and its disorders. In a systematic review of EMG studies of the tennis elbow, representative of both the extensor carpi radialis (ECR) brevis and longus combined or selective for the ECRB alone, extensor digitorum communis (EDC), flexor carpi ulnaris (FCU), flexor carpi radialis, flexor digitorum superficialis (FDS), pronator teres, and triceps brachii have been selected. [21] Since we focused on the main movement of the wrist joint and finger muscles during grip, we acquired the muscle activities of the EDC, ECR, FDS, and FCU muscles. This study aimed to: (1) quantify the load distribution in the hand during various styles of the gripping task and (2) investigate the relationships of these distributions with muscle activation. We hypothesized that the grip force of the radial grip is associated with the activity of the extensor muscles, such as the ECR and EDC, and the ulnar grip is associated with the activity of the flexor muscles such as the FDS and FCU. Furthermore, we predicted that ECR activity in the flexor grip was significantly higher than that in the ulnar grip.

2 Methods

2.1 Participants

The participants of this cross-sectional study were 15 healthy students from a national university. They were all informed about the experiments, and those who provided informed consent were included. The exclusion criteria were as follows: (1) persistent pain that leads to an inability to grip, (2) a history of musculoskeletal disorders, (3) severe neurological or cardiovascular disease, and (4) hand deformity. The study was approved by the Ethics Review Committee of University Graduate School and Faculty of Medicine (approval number R2018). Written informed consent was obtained from the patients for the publication of their anonymized information in this article.

2.2 Equipment

2.2.1 Measurement of grip force and load distribution

Grip force and load distribution were measured using a cylinder-shaped device with an embedded pressure sensor, allowing the capture of qualitative and quantitative data during grip tasks. The sensor sheet (200 × 300 mm) with an embedded pressure sensor (173 × 288 mm, pitch 1.2 mm) was wrapped around a hard cylinder (60 mm diameter) to record the load in various hand regions. Pressure sensor data were transferred to a computer at a frequency of 10 Hz (Figure 1). This

Fig. 1. The grip sensor system

The grip sensor is a cylindrical device (60 mm in diameter) with a sensor sheet (200 × 300 mm), wherein the pressure sensor was embedded (173 × 288 mm, pitch 1.2 mm). The pressure information of the contact area is sent from the grip sensor to the personal computer, and the colored pressure distribution can be viewed on the screen.

technology is useful for printing high-definition and high-precision electronic circuits on a flexible sheet substrate and the PD system incorporated into the sensor. This device exhibits high sensitivity and selectivity against various types of pressure. [22−24]

2.2.2 EMG

Muscle activities were recorded using the TeleMyo 2400 system (Noraxon, Scottsdale, AZ, USA) with a sampling rate of 1000 Hz. Surface electrodes were placed to record from the EDC, ECR, FDS, and FCU muscles of the forearm. These muscles were strategically selected because they represent key extrinsic hand locations and for their ease of accessibility to surface EMG recordings. We confirmed the crosstalk between each EMG recording in advance and visually confirmed that individual muscle activation did not affect other muscle activations. The skin at the electrode sites was shaved and cleaned using scrubbing gel and alcohol. Bipolar surface electrodes (Ambu A/S, Ballerup, Denmark) were placed with a 2 cm interelectrode distance on these muscles.

2.3 Experimental protocol

The participants performed the following three grip tasks using the cylindrical device: a radial grip, a power grip, and an ulnar grip, as described previously. They gripped the cylindrical device (placed vertically on a platform) with their right hand while sitting on a chair, with both shoulders in a neutral position, their right elbow flexed at 90°, and their right wrist dorsiflexed at 0° to 15°, similar to a conventional grip test. [25] They were given verbal instructions and demonstrations on gripping the device as follows: for the radial grip: hold it primarily with the index and middle fingers; the power grip: hold it around all your fingers; and the ulnar grip: hold it primarily with the ring and little fingers. Before starting each task, the participants practiced how to grasp. Subsequently, looking at the data displayed, they performed a maximum force grip of 3 seconds twice on the device. Load distribution and EMG data were recorded while gripping the device.

2.4 Data analysis

The sensor loads within the sensor matrix are displayed as a two-dimensional raster diagram. This distribution map represents the contact regions of the hand grasping the cylinder. After calculating the force value from each sensor in the sheet, their values were summed to determine the total force of the hand-contact area. The forces were calculated based on seven anatomical regions (thumb, index finger, middle finger, ring finger, little finger, thenar, and hypothenar) as previously described to analyze load distribution. [16] Setting the

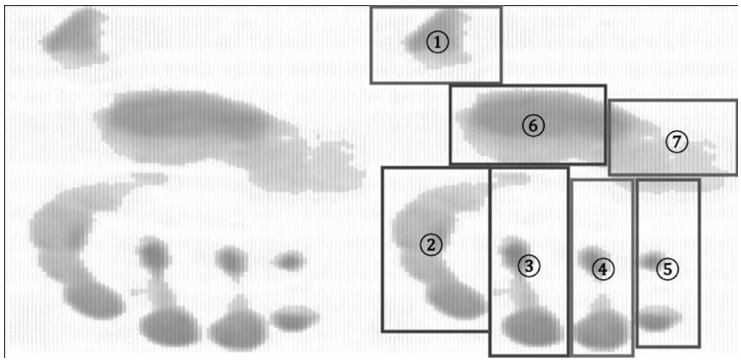

Fig. 2. Scale of hand-contact forces during a grip task

The left side of the figure shows a grey pressure distribution map of the entire hand. The right side shows the division of those areas as follows: (1) thumb, (2) index finger, (3) middle finger, (4) ring finger, (5) little finger, (6) thenar, and (7) hypothenar.

force applied across the entire contact area to 100%, each region's percentage contribution was calculated (Figure 2).

For EMG data, a 10 Hz high-pass filter and a 450 Hz low-pass filter were applied, and the root mean square method was used for signal rectification. After this waveform processing, the average amplitude (during the 3-second task) for each muscle was calculated, and the average values from two trials of each grip task were calculated for all parameters. Normalization was performed by dividing the average amplitude data by the amplitude at the time of maximum muscle strength (% maximum voluntary contraction= %MVC).

2.5 Statistical analysis

All statistical analyses were conducted using IBM SPSS Statistics version 26 (IBM, Armonk, NY, USA). The data were normalized to analyze the relationship between grip forces applied from each grip pattern and EMG, and Pearson's correlation analysis was performed. In addition, the relationships between extensors and flexors due to different grip patterns were evaluated using repetitive one-way analysis of variance (ANOVA), with post hoc comparisons performed when significance was determined using ANOVA. Furthermore, the partial

Table 1. Muscle activities and pressure distribution in each grip style

Variable	Radial grip	Power grip	Ulnar grip
Grip force (kgf)			
Thumb	2.6 (0.6)	2.0 (0.8)	2.1 (1.0)
Index finger	7.0 (2.2)	4.5 (1.8)	1.3 (0.7)
Middle finger	7.6 (3.8)	5.3 (3.9)	0.9 (0.8)
Ring finger	1.1 (1.1)	4.4 (2.7)	3.6 (1.7)
Little finger	0.6 (0.7)	2.7 (1.5)	5.0 (2.4)
Thenar	3.9 (2.0)	2.4 (1.4)	2.1 (1.1)
Hypothenar	0.2 (0.5)	0.5 (1.0)	0.4 (0.7)
Normalized (%MVC)			
EDC	100.6 (31.7)	111.4 (33.5)	91.0 (28.2)
ECR	78.5 (19.7)	83.8 (11.66)	71.4 (16.5)
FDS	67.1 (21.6)	51.9 (14.94)	56.1 (15.1)
FCU	61.1 (40.4)	76.4 (34.8)	94.8 (27.5)

Variables are expressed as mean standard deviation (SD).
Abbreviations: EDC, extensor digitorum communis; ECR, extensor carpi radialis; FDS, flexor digitorum superficialis; FCU, flexor carpi ulnaris; and %MVC, % maximum voluntary contraction.

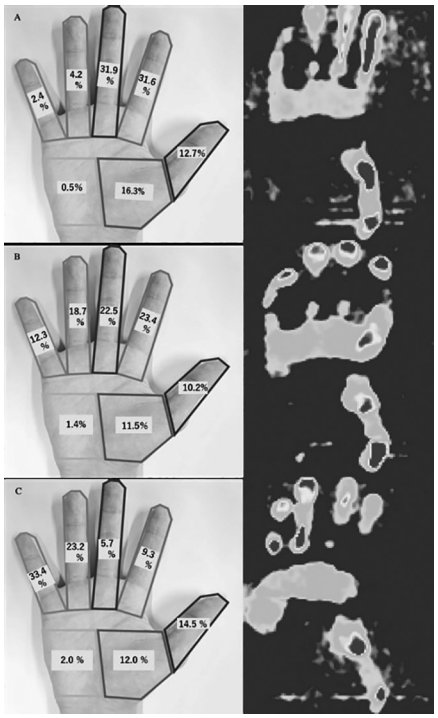

Fig. 3. The percentage contribution of the seven anatomical areas in each grip type

The (A) radial grip, (B) power grip, and (C) ulnar grip are shown in order from the top. The left side of the figure in each grip style shows the contribution of each anatomical area on the total pressure. The right side shows the pressure distribution in grey scale, wherein the darkening of color indicates the increase in pressure.

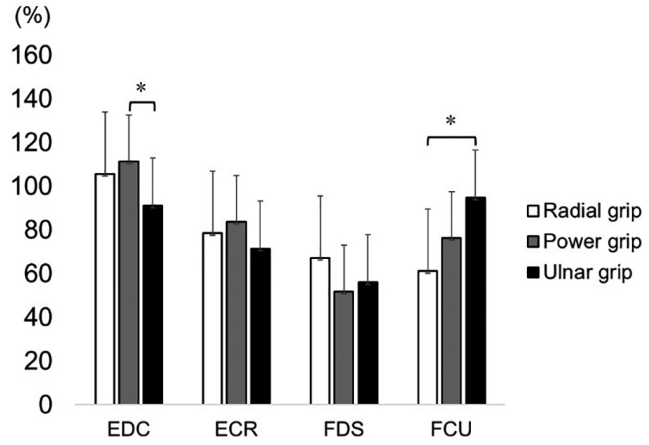

Fig. 4. Results of comparing %MVC with different grip patterns

White, radial grip; grey, power grip; and black, ulnar grip.
* $p < 0.05$. % MVC=% maximum voluntary contraction

η square (ηp2) was calculated to investigate the effect size.

3 Results

Of the participants, eight were female, the mean age was 27.8 ± 8.2 years, and all participants were right-handed. Table 1 shows the EMG and PD data for each of the three grip patterns. The forces applied differed with grip patterns in each of the anatomical regions; however, almost no force was observed in the hypothenar region using any grip. Figure 3 shows the relative contributions of the seven anatomical regions of each grip pattern. For the radial grip, the contributions of the index finger (31.6 ± 6.0%) and the middle finger (31.9 ± 9.1%) were larger than for the other grips. Forces during the power grip were distributed across the fingers as follows: index finger (23.4 ± 11.1%), middle finger (22.5 ± 9.6%), ring finger (18.7 ± 6.7%), and little finger (12.3 ± 5.0%). For the ulnar grip, the ring finger (23.2 ± 7.6%) and little finger (33.4 ± 9.8%) regions tended to have stronger grips than the other grips. The relationships between the grip forces and EMG are shown in Table 2. Grip force was correlated with EDC in both the radial grip ($r = 0.52$, $p = 0.03$) and power grip ($r = 0.47$, $p = 0.04$), while it was correlated with FDS activity in the ulnar grip ($r = 0.55$, $p = 0.02$). Figure 4 shows the comparison results of %MVC with different grip patterns. As a result of repeated one-way ANOVA, the EDC was less activated in the ulnar grip than in the power grip ($p = 0.007$, 95% confidence difference inter-

Table 2. The relationship between the grip pressure and electromyography in each grip style

	Radial grip	Power grip	Ulnar grip
EDC	0.52*	0.47*	0.23
ECR	0.15	-0.1	0.04
FDS	0.31	0.32	0.55*
FCU	0.09	0.14	0.37

Abbreviations: EDC, extensor digitorum communis; ECR, extensor carpi radialis; FDS, flexor digitorum superficialis; and FCU, flexor carpi ulnaris.
* $p < 0.05$.

val [CI] = 6.0−34.9, ηp2 = 0.44). Furthermore, the FCU was activated to a greater extent in the ulnar grip than in the radial grip (p = 0.004, 95%CI = 10.6−56.8, ηp2 = 0.49). The ECR showed a similar trend to the EDC, but no significant difference was found (p = 0.08).

4 Discussion

Our study findings showed that grip force was correlated with the EDC in both the radial grip and power grip, while it was correlated with FDS activity in the ulnar grip. The EDC was less activated in the ulnar grip than in the power grip. Furthermore, the FCU was activated to a greater extent in the ulnar grip than in the radial grip. This study found that the PD changed due to the differences in grip patterns. This information on PD confirms that the participants properly performed the grip patterns based on our purpose.

In the present study, the index and middle finger PDs were large during the power grip. Additionally, a previous study reported that when using a glove with embedded pressure sensors, the contribution of the middle finger was the largest in lifting a metal object from a desk. [26] Power grip studies of load distribution have similarly reported the index or middle finger contributions to be the largest, followed by the ring finger and little finger forces. [16] Finger length is involved in the PD of the hand, and it is reasonable that the PD of the middle finger is the largest in healthy adults. [15] Correlation analysis showed that the power grip and radial grip were associated with EDC activity, and the ulnar grip was associated with FDS activity. In a pathological autopsy of the tennis elbow, the abnormal region of the elbow contains the lateral ECRB-EDC complex, and the EDC also originates from the lateral epicondyle, which is considered a factor in the development of tennis elbow. [27] Both the radial and power grips have a large PD between the index and middle fingers, suggesting that extensor muscle activation increases when the radial side fingers are dominant. Moreover, unless the participants were instructed to grip with the ulnar fingers, the power grip tended to have a high-PD on the index and middle fingers, similar to the radial grip. Therefore, the EDC may be excessively active in amateur players who do not receive proper guidance. Furthermore, when the radial grip is performed, the racket's tip is raised more than when the ulnar grip is used; therefore, a compensatory action is required to correct it. The ECR showed a tendency to show similar muscle activity as the EDC, but there was no correlation with grip strength. Previous studies have reported that the ECR shows higher activity during the groundstroke [28]. However, in this study, the participants performed the task of gripping the device without changing the dorsiflexion angle of the wrist joint, which may have resulted in force adjustments occurring mainly in the fingers. Therefore, we considered that there was no difference in the ECR activity. The PD of the ring finger and little finger was high in the ulnar grip, suggesting that this is related to the flexor muscle groups such as the FDS and FCU. The FCU has been reported to be a major stabilizer for elbow valgus stability, [29] and the ulnar grip may be of teaching significance. Furthermore, our results suggest that the ulnar grip can increase the FCU activity and decrease the EDC activity and is considered an effective teaching method to prevent the development of tennis elbow. However, excessive flexion poses a risk of injury to the lateral wrist ulna; therefore, the degree should be considered. This study's characteristic is that the qualitative index of the difference in grip was quantified using the grip sensor. By quantification, the values of the PD of the index finger and middle finger in the power grip and radial grip were both high. Therefore, in treating tennis elbow, in addition to physical treatment, such as massage, teaching the patient how to hold the racket and properly applying force are necessary.

This study had some limitations that should be noted. First, the number of muscles was limited. Representative muscles involved in finger movements were selected based on previous studies. However, this muscle selection may be biased owing to the setup requirements. Second, there are limitations to the shape and size of the equipment used to analyze the PD. Here, the size of 60φ was adopted to prevent finger overlap. Previous studies have confirmed that different racket sizes do not affect muscle activity. [30] However, the influence of the shape and weight of the racket is predicted. Thus, in future studies, it will be necessary to measure PD and muscle activation during groundstroke, such as wrapping a sensor around a tennis racket. Moreover, the number of target muscles, such as the ECU and FCR, should be increased while focusing on muscle crosstalk. Finally, the age of onset of tennis elbow is between the 30s and 50s, and muscle activity characteristics during this period may be different than that in younger individuals. Therefore, future studies that take age into account are needed.

5 Conclusions

This quantitative study revealed different load distributions during various grip patterns, and it was clarified that the pressure distribution of the index and middle fingers was associated with the EDC activity.

Moreover, the pressure distribution in the ring finger and the little finger, such as in the ulnar grip, is related to flexor muscle activity such as that of FDS and FCU. Considering these results, the ulnar grip may be useful for preventing lateral epicondylitis.

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■ORIGINAL ARTICLE

Effects of Single-handed and Dual-handed Tasks on Myoelectric Hand Prosthesis Operability of Unilateral Transradial Amputees

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Abstract: Objective: The influence of myoelectric hand training on the ability of amputees to operate a prosthetic hand has not been fully verified. This study aimed to investigate the effects of single-handed and dual-handed tasks on the ability of amputees to use a myoelectric prosthetic hand in training.
Method: The subjects were unilateral transradial amputees (n=12). The training effects of each task were measured by assigning the myoelectric hand prosthesis users to two groups and conducting a crossover study: one group performed the single-handed task first followed by the dual-handed task, and the other group did the opposite. The Southampton Hand Assessment Procedure (SHAP) score was used to assess the subjects' ability to control the myoelectric prosthetic hand.
Results: The training effect differed significantly between the single-handed task, SHAP score: 6.3 (5.8−8.5) points, and the dual-handed task, SHAP score: 10.3 (8.8−14.2) points; however, the effect was insufficient ($p = 0.008$, $r = 0.20$).
Conclusion: The dual-handed task improved the subjects' ability to accurately operate a myoelectric hand more effectively than the single-handed task. This suggests that the dual-handed task is more effective at developing control of opening/closing movements and object handling with a myoelectric hand than the single-handed task.

Keywords: myoelectric hand prosthesis, single-handed task, dual-handed task, unilateral transradial amputees

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1. Background

Myoelectric prostheses were reported to be practical and effective by Hermansson et al. based on their myoelectric prosthesis usage survey of myoelectric prosthesis users (n=75) [1]. Moreover, there are reports affirming that myoelectric prostheses play an important role in achieving rehabilitation goals [2−4]. However, this previous research involved survey-based retrospective studies. Therefore, while these studies support the usefulness of myoelectric prostheses, their findings are not based on firm scientific evidence [1]. Furthermore, Resnik reported that the effects of myoelectric prosthesis training on the ability of amputees to operate upper limb prostheses are unclear [5]. Hence, it is necessary to clarify the effects of myoelectric hand operation training based on objective data.

Myoelectric prosthesis operation training was proposed by Atkins in 1992 [6], and associated guidance was formulated by Johnson et al. in 2015 [7]. The training was organized into single-handed and dual-handed tasks, and it was recommended that dual-handed tasks should be performed after practicing single-handed tasks [6,7]. However, there are no objective data to verify how single-handed and dual-handed tasks affect amputees' ability to operate myoelectric prostheses. The

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same applies to the relationship between the results of single-handed and dual-handed task [8]. In a study in which able-bodied subjects practiced operating a myoelectric prosthesis using a simulated myoelectric prosthesis, it was reported that dual-handed tasks resulted in greater improvements in object manipulation skill than single-handed tasks [8].

The aim of this study was to clarify the effects of single-handed and dual-handed tasks on myoelectric prosthetic hand training among transradial amputees, and the differences between the effects of the tasks. Our hypothesis was that dual-handed tasks are more effective than single-handed tasks.

2. Methods

2-1. Subjects

The subjects were unilateral transradial amputees with no experience of myoelectric prosthesis use or training. The inclusion criteria were being a unilateral transradial amputee, who is over 20 years of age, does not have difficulty donning prosthetic arms due to muscular weakness or a limited range of motion, and has no history of rehabilitation. The exclusion criteria were an amputated limb length of <10 cm, skin conditions that make it difficult to collect myoelectric signals, having difficulty donning prostheses due to cognitive dysfunction or intellectual disability, experience of myoelectric prosthetic use, and refusal to consent to the experimental conditions. Twelve unilateral transradial amputees met the above criteria and participated in this study. The subjects' attributes were as follows: 8 males and 4 females, mean age: 42.9 ± 13.9 years, mean height: 162.8 ± 7.0 cm, mean weight: 58.9 ± 6.5 kg, mean residual length of the amputated forearm: 18.2 ± 5.7 cm, mean residual percentage length of the amputated forearm: 66.3 ± 18.9%, mean maximum circumference of the amputated forearm: 22.8 ± 2.6 cm, side of amputation: 9 right and 3 left. In the experiment, none of the subjects had impaired proprioception due to diabetes or other diseases.

The subjects were randomly divided into two groups, a group in which the dual-handed task was performed after the single-handed task (group A) and another group in which the single-handed task was performed after the dual-handed task (group B). The significance of differences between the groups was analyzed using Fisher's exact test for sex and the amputated side and Mann-Whitney's U test for age. Height, body weight, residual amputated forearm length, residual percentage amputated forearm length, and maximum amputated forearm circumference were analyzed using the Student's t test. No significant intergroup differences were found for any of the examined background factors ($p>0.05$) (Table 1).

This research complied with the tenets of the Declaration of Helsinki and was conducted with the approval of the institutional review board of Kobe Gakuin University (approval code: HEB101207−4).

2-2. Design and Protocol

This study involved a crossover design. In the baseline period, the subjects practiced controlling the opening and closing movements of a virtual myoelectric hand using a software program on a personal computer for 20 minutes per day for 5 days as practice before donning the myoelectric prosthesis. Next, groups A and B performed both tasks. Group A performed the dual-handed task after performing the single-handed task, and group B performed the single-handed task after performing the dual-handed task. Each task was conducted

Table 1. Group A and Group B profile

	Group A n=6	Group B n=6	*p* 値
Sex [M/F]	3/3	5/1	n.s
Age [year]	43.8 ± 12.8	42.0 ± 16.1	n.s
Body height [cm]	161.0 ± 7.3	164.5 ± 6.9	n.s
Body weight [kg]	56.2 ± 6.6	61.7 ± 6.7	n.s
Side [R/L]	5/1	4/2	n.s
Stump length [cm]	17.3 ± 52	19.0 ± 6.5	n.s
Stump ratio [%]	66.3 ± 17.5	66.3 ± 21.8	n.s
Stump max girth [cm]	22.8 ± 1.9	22.8 ± 3.4	n.s
Amputation history [month]	112.0 ± 250.8	140.2 ± 236.3	n.s
etiology [trauma/congenital]	5/1	4/2	n.s
Body prosthesis history [mo nth]	4.0 ± 2.6	4.0 ± 5.2	n.s

Notes. Sex and amputation ratios in both groups were determined using Fisher's exact test, age was determined using Mann-Whitney's U test, Body height, Body weight, Stump length, ratio, and maximum girth using Student's t test. n.s.: not significant

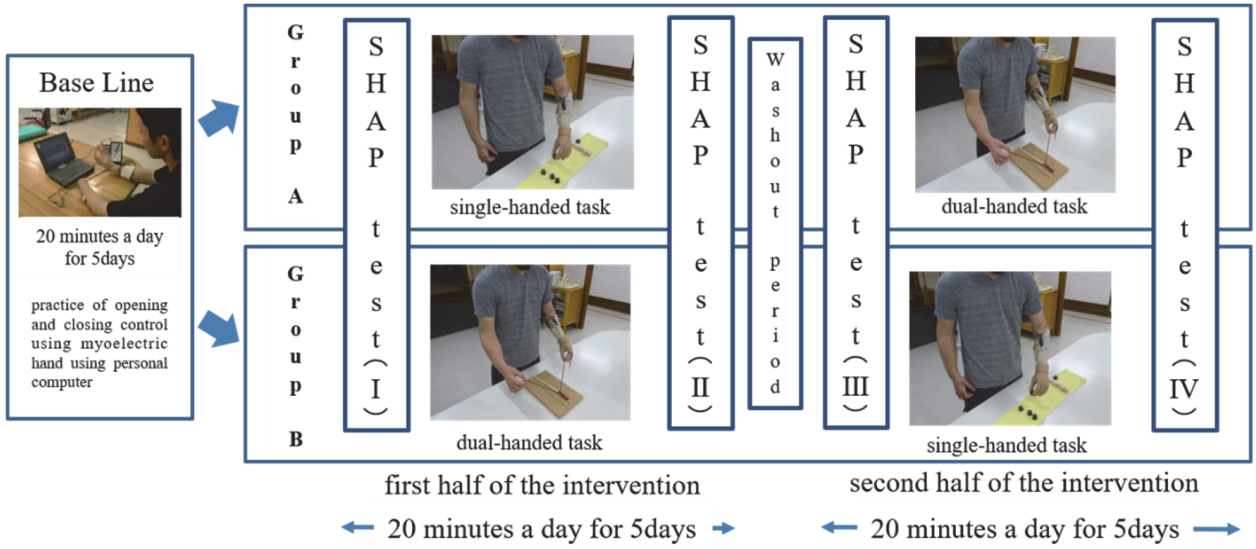

Fig. 1. Protocol

Notes. The design of thi s study adopted a crossover test method. In the baseline period of this study design, participants practiced opening and closing control using a myoelectric hand in a monitor for 20 minutes a day for 5 days as a practice before wearing myoelectric prosthesis.

for 20 minutes per day for 5 days, for a total of 10 days. The washout period was set to 2 days. Both groups underwent a myoelectric hand operation test before and after each period (Figure 1).

The myoelectric hand used in this study was the Ottobock MyoBock electric hand (8E38 = 6 DMC plus 7.1 / 4). The electrodes for opening and closing the myoelectric hand were positioned on the extensor carpi radialis longus and flexor carpi ulnaris of the residual forearm.

The single-handed and dual-handed tasks selected as training methods for this study were based on those used in clinical practice and previous myoelectric prosthesis studies [7−9]. The single-handed task involved picking up and placing (holding, moving, and releasing) a block (a cube; side length: 1 to 3 cm) or a disk (diameter: 1 to 3 cm) on a desk and was performed for 20 minutes a day for 5 days [9]. Each day, the subjects were asked to perform the task 50 times at their own pace. The subjects were also instructed not to assist the myoelectric prosthesis with their intact hand. The dual-handed task was also a 5-day assignment. In this task, macrame was performed for 20 minutes, twice a day. Specifically, the subjects were required to create 20 flat knots on a desk [9]. They were instructed to use their intact hands as they would in a normal dual-handed task. We pilot-tested the macrame task to confirm whether it had direct effects on the outcome measure of this experiment. The results showed that it had no recognizable influence. The assessment procedure did not involve string manipulation or repeated hold-and-release operations; therefore, we concluded that the macrame task was an independent task and would not interfere with the assessment procedure.

2-3. Outcome measure

The Southampton Hand Assessment Procedure (SHAP) score [9,10] was used as the outcome measure in this study. The SHAP test's credibility and validity for measuring the controllability of opening/closing myoelectric hand movements and the ability of subjects to manipulate objects using a myoelectric hand during daily activities were confirmed by Hill et al. [9,11]. The capability to manipulate objects represents the ability 1) to appropriately manipulate an object as intended, 2) to adjust the contact position and force applied so that they are appropriate for the target object, 3) to hold and move the object without dropping it, and 4) to accurately release the object at the target location [9−11]. The SHAP test consists of 6 abstract objects and 14 activities of daily living. Each task is timed by the subject and recorded on an assessment sheet by the assessor. The score is computed from the time and normalized to a 100-point scale [12] (Figure 2).

As for the experimental environment, the subjects donned the myoelectric hand and sat in front of a desk. The height of the desk was adjusted so that the angle of the elbow joint was 90 degrees during the performance

Fig. 2 The Southampton Hand Assessment Procedure (SHAP)

Notes. This test evaluates the ability to control the opening and closing of the myoelectric hand and the ability to operate items. It consists of six types of object tasks for manipulating the object whose shape is to be grasped and 14 types of daily life movement tasks [11−13]

of the task [13]. Prior to the test, each task was practiced only once by the subjects to confirm that the prosthetic hand could be used to execute the task. An occupational therapist, other than the primary researcher, with experience of training amputees to operate myoelectric prosthetic hands performed the examinations.

2-4. Statistical analysis

In this study, we used the crossover method to investigate the differences in the changes in myoelectric prosthetic hand operation ability between the single-handed and dual-handed tasks.

The carryover effect was examined by assessing whether the results obtained in the first half of the intervention were carried over to the beginning of the second half of the intervention. The carryover effect was analyzed by comparing the median of the sum of the scores for the first and second interventions between the groups. When the difference was insignificant ($p > 0.10$), we judged that there was no carryover effect, and tested the timing effect and training effect. The timing effect is the potential effect of conducting the intervention at a particular time. In this study, the timing effect was calculated by subtracting the results for the second intervention from those for the first intervention in group A, and subtracting the results for the first intervention from those for the second intervention in group B. The training effect is the difference between the effects of two or more tests [14,15]. We compared the change seen in the single-handed task with that seen in the dual-handed task in the first half of the intervention, and the change seen in the single-handed task with that seen in the dual-handed task in the second half of the intervention. The effect of the task was determined based on which task's change value was significantly higher [14,15]. The difference in the effects of the single-handed and dual-handed tasks was considered to represent the training effect in this study. We analyzed the results of groups A and B with the Mann-Whitney U test. The statistical significance level was set at 0.1 for the carryover effect test and 0.05 for the timing effect and training effect. The results obtained before and after

the single-handed and dual-handed tasks were analyzed with the Wilcoxon signed rank test, using the results for the first half of the intervention. This was done in order to exclude the effects of prior training experience [14,15]. The significance level was set at 0.05. In each test, the effect size (r), which indicated the magnitude of the effect, was calculated in addition to the significance of the difference in the training effect.

Statistical analyses were conducted by performing the Mann-Whitney U test and Wilcoxon signed rank test using statistical analysis software (IBM SPSS Statistics ver.24.0). The effect size was calculated with Microsoft Excel ver.16.0, using the Z-value obtained from the Mann-Whitney U test and Wilcoxon signed rank test.

3. Results

The results of this study are shown in Tables 2, 3, and 4.

Table 2 shows the SHAP scores for each subject in groups A and B. The results for the first to fourth tests are represented as median and interquartile range values. In group A, the scores for the first, second, third and fourth tests were 43.5 (40.0−44.5) points, 47.0 (45.5−47.0) points, 46.0 (43.0−47.5) points, and 55.0 (54.3−56.7) points, respectively. In group B, the scores for the first, second, third, and fourth tests were 41.5 (38.0−43.5) points, 53.0 (52.0−54.8) points, 51.0 (49.3−52.0) points, and 60.0 (58.5−60.0) points, respectively.

Table 3 shows the results of comparisons of the SHAP scores obtained before and after the single-handed task and those obtained before and after the

Table 2. Result of SHAP of all subjects (A group and B group)

	I	II	III	IV
Group A	43.5 (40.0−44.5)	47.0 (45.5−47.0)	46.0 (43.0−47.5)	55.0 (54.3−56.7)
	Single-handed task		Dual-handed task	
Group B	41.5 (38.0−43.5)	53.0 (52.0−54.8)	51.0 (49.3−52.0)	60.0 (58.5−60.0)
	Dual-handed task		Single-handed task	

Notes. The results of SHAP for each subject in Groups A and B.
Data are represented as median (interquartile range), SHAP score.

Table 3. Results of statistical analysis in the SHAP crossover test method

		median (IQR)	*p*-value	effect size (*r*)
carryover effect	Group A	13.5 (11.3−15.8)	0.421	
	GroupB	21.0 (16.3−25.8)		
timmg effect	first half of the mterventlon	−1.8 (−4.3−0.4)	0.31	
	second halfo f the mtervenhon	0.8 (0.5−3.3)		
training effect	sigle-handed task	6.3 (5.8−8.5)	0.008**	0.20 †
	dual-handed task	10.3 (8.8−14.2)		

Notes. Comparison of SHAP score GroupA and GroupB was conducted using the Mann-Whitney U test. Comparison of SHAP first half of the intervention and second half of the intervention was conducted using the Mann-Whitney U test. Comparison of SHAP single-handed task and dual-handed task was conducted using the Mann-Whitney U test and the effect size.
*p<.05. **p<.01. ***p<.001. † r≧.01. ‡ r≧.03. § r≧.05.

Table 4. Comparison of SHAP before and after single-handed task and before and after dual-handed task

	Before median (IQR)	After median (IQR)	*p*-value	effect size (*r*)
single-handed task	44 (40−45)	47 (45−48)	0.045*	0.59 §
dual-handed task	42 (38−44)	53 (52−55)	0.001***	0.78 §

Notes. C omparisono f SHAP score before and after single-handed task and dual-handed task was conducted usmg Wilcoxon signed ra11k test and the effect size.
*p<.05. **p<.01. ***p<.001. † r≧.01. ‡ r≧.03. § r≧.05.

dual-handed task. There was no significant difference in the carryover effect between groups A (13.5 (7.0−28.0) points) and B (21.0 (8.0−26.0) points) ($p = 0.421$). There was no significant difference in the timing effect between the first (-1.8 (-4.3−0.4) points) and second halves (0.8 (0.5−3.3) points) of the intervention ($p = 0.310$). There was a significant difference in the training effect between the single-handed task (6.3 (5.8−8.5) points) and the dual-handed task (10.3 (8.8−14.2) points), but the effect size was small ($p = 0.008$, $r = 0.20$). The score change seen in the dual-handed task was larger than that observed in the single-handed task.

The comparison between the results obtained before and after the training showed a significant difference (Table 4). The result obtained before the single-handed task was 44 (40−45) points, and that obtained after the single-handed task was 47 (45−48) points, and the effect size was moderate ($p = 0.045$, $r = 0.59$).

There was a significant difference between the results obtained before the dual-handed task (42 (38−44) points) and those obtained after the dual-handed task (53 (52−55) points). The effect size was large ($p < 0.001$, $r = 0.78$).

4. Discussion

This study adopted a crossover design due to the limited number of subjects, which was affected by the fact that it targeted unilateral transradial amputees and the conditions for the myoelectric hand training would have discouraged some potential subjects from taking part.

As for the results, the SHAP score increased during both the single-handed and dual-handed tasks. Furthermore, statistical analyses showed that 1) the changes seen after both the single-handed and dual-handed tasks were significant; 2) the effect of the single-handed task was moderate, and that of the dual-handed task was large; and 3) the dual-handed task had a greater effect on myoelectric hand operation than the single-handed task. Therefore, the implementation of single-handed task and dual-handed task training based on clinical experience is justified, but it is important to carefully consider the detail of such tasks.

Furthermore, when comparing the single-handed task and the dual-handed task, the carryover effect and time effect were not significant, while the training effect was significant. This indicates that the dual-handed task had a superior training effect compared with the single-handed task.

Hill reported that the aim of such dual-handed tasks is to acquire cooperative dual-handed movement between the myoelectric prosthesis and intact hand [10]. The dual-handed task required the opening and closing of the myoelectric hand to be controlled more precisely than the single-handed task and involved cooperation with the intact hand. The significantly higher score seen in the dual-handed task implies that the dual-handed task was effective at helping the subjects to acquire the ability to grasp objects accurately, adjust their grip properly, and grasp and release objects. Also, the purpose of such dual-handed tasks is to enhance the speed, accuracy, and hand-eye coordination of the myoelectric prosthesis hand [8, 9]. Hand-eye coordination, which is often referred to as visuomanual pursuit tracking, requires coordination between various areas of the central nervous system [17]. Visuomanual pursuit tracking involves controlling the movement of the upper limb by capturing positional information about the target object and the upper limb [18]. It was reported that the position of the target object is an important factor, which affects the distance and direction of the object, body, shoulder, and hand, and that gazing at the target affects the speed of movement during reaching movements [18]. Therefore, the dual-handed task increased the movement speed of the myoelectric hand when grasping the target object. In the future, we would like to examine the possibility that the dual-handed task may have affected the subjects' ability to gaze at the target object and adjust the direction of the appropriate hand as compared with the single-handed task. In addition, the dual-handed task requires cooperation with the intact hand and accurate control of opening and closing movements of the myoelectric hand, appropriately timed directional movement coordination of the myoelectric hand toward the object, and grasping and releasing the target object accurately. Presumably, the somatosensory senses of the residual limb improve accordingly. The dual-handed task may involve more effective loops for controlling the opening and closing of the myoelectric hand and the manipulation of the target object operation than the single-handed task.

Macrame was used for the dual-handed task in this study. It is necessary to consider whether the macrame task affected the results of the SHAP test; i.e., whether the macrame and SHAP tasks were similar. Macrame involves repeatedly performing an operation involving the gripping of string, but none of the tasks in the SHAP test involved string, and repeating a gripping operation is not a hindrance. Therefore, the similarities between the macrame and SHAP tasks were minimal, and any direct effect was considered to be weak.

The results of this study demonstrated that both the single-handed and dual-handed tasks are effective tools for learning how to control the opening/closing movements of a myoelectric hand and use a myoelectric

hand to perform daily activities. Compared with the single-handed task, the dual-handed task was more effective. In occupational therapy, we recommend implementing dual-handed tasks in the early stages of training. By performing dual-handed tasks more frequently than single-handed tasks, patients' ability to operate myoelectric prosthetic hands can be expected to improve more quickly. This should also reduce the length of the training period.

5. Limitations and future work

The number of subjects in this study was 12, and the number of samples was small. Therefore, the results of this study cannot be used as definitive proof of the universal effects of myoelectric prosthesis training. The results should be investigated for their reliability in a larger pool of transradial amputees. Also, Whether the amputation measurement is a dominant hand measurement can affect effectiveness and learning. Therefore, the study group need to control the dominant hand on the amputee. However, in the clinical setting, the number of upper limb amputees is small, and it is extremely difficult to obtain research cooperation from unilateral upper limb amputees who have no experience of myoelectric prosthesis training. Therefore, this study was conducted with the cooperation of 12 transradial amputees.

Regarding the study design, the two-day washout period was short. It would be desirable to employ a one-week washout period between the intervention periods. The two-day washout period was recommended by the institutional review board to reduce the stress place on the subjects.

In this study, the Ottobock MyoBock electric hand was the only myoelectric hand used. It is recommended that our results should be verified with other myoelectric hands, e.g., the Össur i-Limb quantum and Ottobock bebionic hand.

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7. Authors' contributions

All of the authors contributed equally to the preparation of this manuscript.

8. 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

The Immediate Effects of a Knee−Ankle−Foot Orthosis on Standing Reach in Individuals with Subacute Stroke

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Abstract: Background and Objectives: A knee−ankle−foot orthosis (KAFO) has been clinically used for individuals with stroke, but its effect is still unclear. This study was to evaluate the immediate effects of a KAFO on the standing reach of individuals with subacute stroke.
Method: This study adopted a cross-sectional experimental design. A total of 31 inpatients with subacute stroke (mean age, 66.5 ± 14.4 years; mean poststroke interval at admission, 26.2 ± 10.1 days) were enrolled in the study. The functional reach test (FRT) was used to measure the standing reach of the participants with or without a KAFO. The participants were divided into the following groups on the basis of the results of FRT without a KAFO: group 1 comprised patients who were unable to reach without a KAFO (n = 22), and group 2 comprised patients who had the ability to reach without a KAFO (n = 9).
Results: In group 1, the proportion of participants who could reach with a KAFO significantly increased ($p = 0.002$). In group 2, the mean standing reach with a KAFO (25.4 ± 6.7 cm) was significantly longer than that without a KAFO (20.3 ± 7.0 cm) ($p = 0.021$).
Conclusion: The use of a KAFO may immediately improve the standing reach of individuals with subacute stroke. Results show that a KAFO may be an effective device for improving standing reach and can be used to develop rehabilitation programs for individuals with subacute stroke.

Keywords: stroke, hemiplegia, rehabilitation, orthotic devices, postural balance

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Introduction

Stroke is a leading cause of long-term disability [1], and the primary goal of stroke rehabilitation is to regain independence in performing activities of daily living (ADLs). The improvement of standing balance is an essential factor of ADL performance because activities while standing, such as transferring, walking, climbing stairs, toileting, and dressing, are frequently performed in daily life. Standing balance is also important in preventing falls in individuals with stroke [2].

The clinical guidelines of the Stroke Foundation suggested that the task-specific practice of standing balance is recommended for individuals with stroke who have difficulty standing [3]. Furthermore, performing standing practice early after stroke onset is essential for improving stroke care effectiveness [4, 5]. The current concepts of biological recovery after brain injury suggest that early task-specific intensive practice has a crucial contribution in improving stroke recovery [6]. To prevent or minimize secondary changes to the musculoskeletal and cardiorespiratory systems due to immobility, performing standing practice early after stroke onset is essential [7]. In individuals with severe stroke, standing and walking activities are affected by severe impairments, and balance recovery and independent walking are limited. Therefore, improving standing abilities, such as standing reach, early after stroke onset is required for individuals with severe stroke.

In the clinical setting, lower limb orthoses, such

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as ankle-foot orthoses (AFOs) and knee–ankle–foot orthoses (KAFOs), have been used to improve standing abilities by compensating for the stability of the paretic lower limb. The therapeutic effects of lower limb orthoses are differentiated into immediate effects by wearing lower limb orthosis [8–15] and fixed-term effects by wearing and training with lower limb orthoses over a certain period [16]. The immediate effects refer to changes in performance that immediately occur after wearing lower limb orthoses. The fixed-term effects refer to the changes in performance that occur when individuals use lower limb orthoses over a specific period, and these effects include immediate effects. Therefore, to verify the fixed-term effects of using lower limb orthoses, the immediate effects need to be evaluated.

AFOs have been used to compensate for the stability of the paretic lower limb by stabilizing the ankle joint. Previous studies have shown that AFOs immediately improved walking abilities, such as walking independence [8], walking speed [9], walking endurance [10], and stride length [11], and standing abilities, such as weight bearing on the paretic lower limb [12] and body sway [13] in static standing. Furthermore, the use of AFOs improved walking speed over time [16].

Conversely, KAFOs have been used to compensate for the stability of the paretic lower limb by stabilizing the knee and ankle joints and improve the walking abilities of individuals with severe stroke [17]. However, little information has been reported on the immediate and fixed-term effects of KAFOs on the standing balance of individuals with stroke. Standing balance is divided into static and dynamic standing balance abilities [18, 19]. Previous study reported that KAFOs immediately improved the static standing of individuals with subacute stroke [15]. However, the immediate effects of KAFOs on the dynamic standing of individuals with subacute stroke have not been clarified. Dynamic balance is defined as the ability to maintain stability during weight shifting [19] and is assessed by performing reaching tasks while standing. A recent report showed that AFOs immediately improved reach distance while standing [14]. Although KAFOs are used for individuals with severe stroke instead of AFOs, KAFOs immediately improved static standing [15] similar to AFOs [12, 13]. Therefore, KAFOs can be one of the beneficial interventions for stabilizing unstable paretic lower limb and for improving the disabilities of individuals with stroke [17]; hence, the authors hypothesized that wearing KAFOs immediately improves the standing reach of individuals with stroke, similar to AFOs [14], by compensating for the stability of the paretic lower limb.

This study was to evaluate the immediate effects of KAFOs on the standing reach of individuals with subacute stroke. Identifying the immediate effects of KAFOs on standing reach could be useful for the establishment of therapeutic and rehabilitation programs with KAFOs that are designed to improve the standing reach of individuals with severe stroke.

Methods

Study design

A cross-sectional experimental design was adopted. This study was approved by the ethics committee of Kyorin University (28–4) and Hatsudai Rehabilitation Hospital (H27–85).

Table 1. Characteristics of participants.

	Group 1 (n = 22)	Group 2 (n = 9)	Statistic	*p*
Age, year[a]	72.3 (11.8) [67.1, 77.5]	52.4 (9.8) [44.9, 60.0]	-3.31[d]	< 0.001
Gender (male/female), n[b]	12 (55)/10 (45)	6 (67)/3 (33)	0.39[e]	0.534
Stroke type (hemorrhage/infarction), n[b]	7 (32)[c]/15 (68)[c]	8 (89)[c]/1 (11)[c]	8.33[e]	0.004
Affected side (right/left), n[b]	10 (45)/12 (55)	5 (56)/4 (44)	0.26[e]	0.609
Period from stroke onset to admission, day[a]	28.2 (10.0) [23.8, 32.7]	21.2 (8.9) [14.4, 28.0]	-1.72[d]	0.085
Period from stroke onset to KAFO prescription, day[a]	37.6 (12.9) [31.9, 43.3]	29.1 (12.5) [19.5, 38.7]	-1.72[d]	0.085
BRS of the paretic lower limb (II/III/IV), n[b]	16 (73)[c]/6 (27)/0 (0)[c]	1 (11)[c]/5 (56)/3 (33)[c]	13.20[e]	0.001
SIAS knee extension strength item (2/3), n[b]	6 (27)/16 (73)	0 (0)/9 (100)	3.04[e]	0.081
Type of KAFO (1/2), n[b]	20 (91)/2 (9)	9 (100)/0 (0)	0.88[e]	0.349

Note. BRS = Brunnstrom recovery stage; SIAS = Stroke impairment assessment set; KAFO = knee–ankle–foot orthosis. Type of KAFO, 1 = KAFO with spring assisted extension knee joint and Klenzak ankle joint, 2 = KAFO with ring lock knee joint and Klenzak ankle joint.
[a]Continuous variables were analyzed with Mann-Whitney *U* test, and the data were shown as M (SD) [95% confidence interval]. [b]Nominal variables were analyzed with chi-square test, and the data were showed as n (%). [c]Adjusted residual > |1.96|. [d]*Z*-score was based on Mann-Whitney *U* test. [e]χ^2-score was based on chi-squared test.

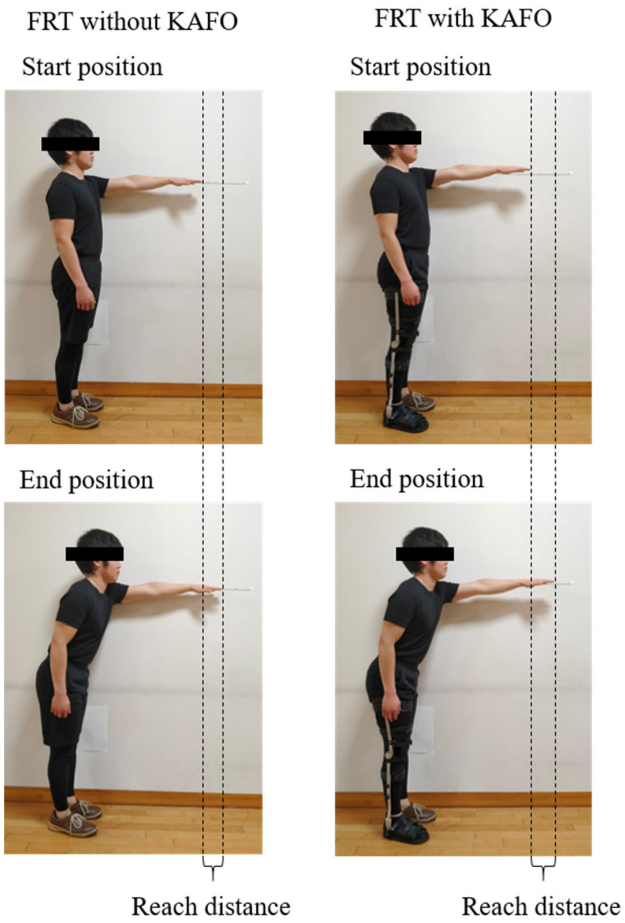

Figure 1. Measurement method of the FRT with or without KAFO

FRT = functional reach test; KAFOs = knee−ankle−foot orthoses.

Participants

This study enrolled 31 patients with subacute stroke (mean age, 66.5 ± 14.4 years; mean poststroke interval at admission, 26.2 ± 10.1 days) admitted to a rehabilitation hospital (Table 1). The inclusion criteria were as follows: (1) patients who have stroke for the first time, (2) those whose poststroke intervals at admission were within 60 days, (3) those not using lower limb orthoses (KAFOs were provided for the first time after stroke onset), and (4) those who can follow simple verbal commands or instructions. All participants provided written informed consent.

Experimental protocol

The demographic and physical characteristics of the participants were recorded within 1 week before receiving KAFOs (Table 1). Demographic characteristics, such as age, sex, stroke type, lesion side, time from stroke onset to admission or KAFO provision, and type of KAFO were investigated. As physical characteristics, paretic and nonparetic lower limb function were assessed by physical therapists. The motor paralysis severity of the paretic lower limb was evaluated using Brunnstrom recovery stage [20]. The BRS is classified under six categories (from I [flaccidity with no movement] to VI [individual joint movement with little awkwardness]) as per the motor recovery process of hemiparalysis after stroke. The nonparetic lower limb function was evaluated using the quadriceps muscle strength item of the unaffected side function subcategory in stroke impairment assessment set (SIAS) [21]. This item is rated from 0 (severely impaired) to 3 (normal).

All participants were provided with KAFOs after admission for the first time. A doctor, physical therapist, and prosthetist determined whether to provide inpatients with KAFOs after early admission. KAFOs were provided on the basis of standing and walking performances and the presence or absence of knee collapse while standing and walking with or without the use of lower limb orthoses. Specifically, lower limb orthoses were

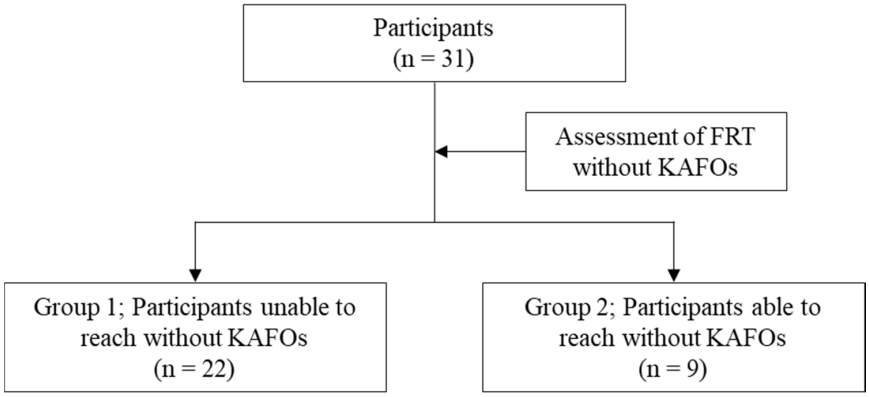

Figure 2. Two groups formed depending on the results of the FRT without KAFOs.

FRT = functional reach test; KAFOs = knee–ankle–foot orthoses.

provided when the participants (1) could undergo standing or walking training but have unstable knee and ankle joints due to severe motor impairments, (2) exhibited spasticity patterns predominantly in the flexor muscles and could not keep a knee extension position while standing or walking, and (3) displayed insufficient knee control or instability or have an AFO that inadequately controlled knee instability [22]. All participants were provided with traditional KAFOs equipped with bilateral metal struts that could be used as AFOs by removing the parts for the knee joint and thigh (Kawamura Gishi Co., Ltd., Osaka, Japan; MEDX. Co., Ltd., Tokyo, Japan).

For standing balance, the maximal forward reaching distance was measured using the functional reach test (FRT) [23] with and without a KAFO on the paretic lower limb (Fig. 1). A tape measure was placed at the level of the participants' acromion process. Before the reaching movement, the measuring tool was leveled so that it was horizontal to the floor. Reaching was performed using the nonparetic arm because it is difficult for individuals with stroke to maintain the paretic arm above shoulder level. The participants lifted their outstretched nonparetic arm to shoulder height, paused for initial reading, and reached as far forward as possible. They were instructed to "reach as far forward as they can without moving their feet or taking a step and to try keeping their hands along the tape measure." The start and end positions of the index finger of the outstretched hand were recorded, and the positional difference represented the total reach for that direction. During the examination, the participants stood in a comfortable upright posture without physical assistance and raised their unaffected arm to the height of the acromion process. Their feet were maintained flat on the floor, and the test was discarded and repeated if the feet were moved. The FRT was performed on the same day within 1 week after providing KAFOs. In tests with and without KAFOs, participants wore shoes on their nonparetic lower limb and were barefoot, respectively. In this study, the KAFOs used were those that were provided to the participants after admission. The FRT was performed three times, and the maximal reach distance was adopted as the representative value.

To assess whether the participants can perform standing reach, the "reaching forward while standing" item of the functional balance scale (FBS) [24, 25] was scored on the basis of the FRT results. The FBS is a 14-item scale that assesses the balance of individuals with stroke and has good reliability and validity [25]. The items are scored from zero points to four points. A score of zero points represents an inability to complete the task, and a score of four points represents the ability to independently complete the task. In the present study, the "reaching forward while standing" item of the FBS was scored from zero points to four points.

Data analysis

To evaluate the immediate effects of KAFOs on the FRT results, the participants were divided into the following groups on the basis of the results of the "reaching forward while standing" item of the FBS without KAFOs: participants who were unable to undergo the FRT or require assistance (zero points) were categorized as participants who were unable to reach (group 1), whereas participants who were able to undergo FRT with or without supervision (≥1 point) were categorized as participants who were able to reach (group 2) (Fig. 2).

The Mann-Whitney *U* test was performed to compare age and time from stroke onset to admission or KAFO provision between groups. The chi-squared test

Table 2. Comparisons of the proportion of participants who were able to reach with KAFOs among participants who were unable to reach without KAFOs.

	Unable to reach		Able to reach	
	n (%)	Adjusted residual	n (%)	Adjusted residual
Without KAFOs	22 (100)	3.13	0 (0)	-3.13
With KAFOs	14 (64)	-3.13	8 (36)	3.13

Note. KAFOs = knee−ankle−foot orthoses.
$\chi^2 = 9.78$. $p = 0.002$. effect size (Cramer's V) = 0.47.

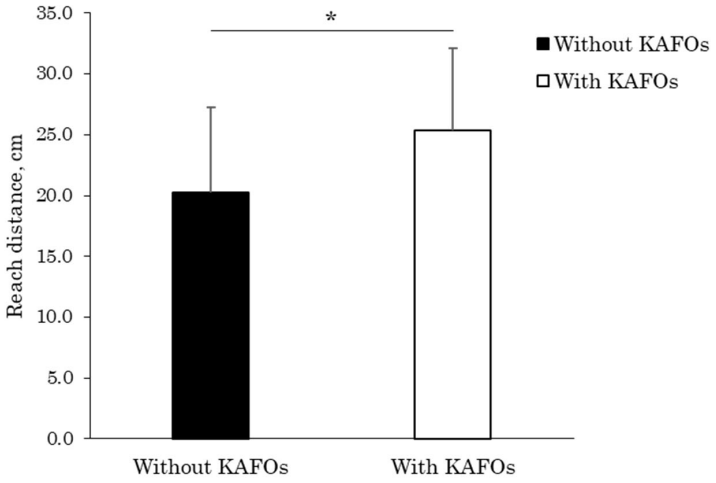

Figure 3. Comparison of reach distance during the FRT with and without KAFOs among participants who were able to reach without KAFOs.

FRT = functional reach test; KAFOs = knee−ankle−foot orthoses.
*$p < 0.05$.

was also performed to compare sex, stroke type, lesion side, the BRS of the paretic lower limb, quadriceps muscle strength items of the SIAS, and type of KAFO between groups. In group 1, the chi-squared test was used to compare the proportion of participants who were able to reach with KAFOs. In group 2, the data of reach distance during the FRT with or without KAFO followed normal distribution. However, the Wilcoxon rank-sum test was used to examine the differences in reach distance with and without KAFOs, because sample size in this study was small.

The significance level was set at $p \geq 0.05$, and all analyses were conducted using Statistical Package for the Social Sciences version 23.0 (IBM Corp., Chicago, IL, USA).

Results

The results of the "reaching forward while standing" item of the FBS without KAFOs showed that the numbers of participants in groups 1 and 2 were 22 and 9, respectively.

The Mann-Whitney U test showed that group 2 was significantly younger than group 2 (Table 1). The chi-squared test showed that the proportions of participants who had infarction or BRS IV in group 2 were higher than those in group 1 (Table 2). In addition, the chi-squared test also showed that the proportion of participants who had BRS II in group 2 was lower than that in group 1. There were no significant differences in gender, affected side, quadriceps muscle strength items of the SIAS, type of KAFO, period from stroke onset to admission, and period from the stroke onset to KAFO prescription between groups.

The chi-squared test showed that the proportion of participants in group 1 who were able to reach significantly increased with KAFO use (Table 2). Among the participants in group 1 who were able to reach with KAFOs, the mean reach distance in the FRT was 11.0 ± 6.2 cm.

In group 2, mean reach distance during the FRT with KAFOs and without KAFOs were 25.4 ± 6.7 cm, 95% confidence interval (CI) [20.2, 30.5] and 20.3 ± 7.0 cm, 95% CI [14.9, 25.7]. The Wilcoxon rank-sum test showed that the mean reach distance during the FRT with KAFOs was significantly longer than that during the FRT without KAFOs, $p = 0.021$, $Z = -2.31$, effect size (r) = 0.77, mean amount of change = 5.1 ± 4.6 cm, 95% CI for the difference [1.6, 8.7] (Fig. 3).

Discussion

This study evaluated the immediate effects of KAFOs on the standing reach of individuals with subacute stroke. There was a significant improvement in standing reach when the participants wore KAFOs. Among the participants who were unable to reach without KAFOs, the proportion of those able to reach significantly increased after wearing KAFOs. Furthermore, among the participants who were able to reach without KAFOs, standing reach significantly improved after using KAFOs. To the best of our knowledge, this is the first study to evaluate the immediate effects of KAFOs on the standing reach of individuals with subacute stroke. Regarding orthotic treatment for improving the standing reach of individuals with severe subacute stroke, this study provides information on the estimated effects of KAFOs on standing reach.

Among the participants who were unable to reach without KAFOs, the number of participants who were able to reach increased immediately after wearing KAFOs. Among the participants who were able to reach without KAFOs, wearing KAFOs improved the reach distance in the forward direction. Duncan *et al*. [21] reported that the reach distance during the FRT was highly correlated with the center of pressure (COP) displacement, which determines the limit of stability (LOS) [26]. The LOS of people with stroke is narrow because of instability of paretic lower limb affected by motor paralysis, and the upright standing of people with stroke is characterized by weight-bearing asymmetry with more weight on the nonparetic lower limb [27]. Narrow LOS restricts the COP displacement in the anterior-posterior and medial-lateral directions and makes it more difficult to control the COP movement and to perform the FRT. Participants in group 1 might be unable to reach because motor paralysis of paretic lower limb was more severe and the LOS was narrower than those of group 2. In group 2, most participants had moderate motor paralysis of paretic lower limb, and motor paralysis of paretic lower limb might decrease the LOS and reach distance during the FRT. In each group, the use of KAFO might increase the LOS by compensating for the stability of the paretic lower limbs, and make it easier to control the COP movement, resulting in immediately improvement of the FRT. On average, KAFO use increased the forward reach distance by 5.1 cm. In best of our knowledge, there were no previous studies on minimal clinically important change for FRT in people with severe stroke to compare the change of the forward reach distance in this study. However, in recently systematic review, exercise training improved the forward reach distance, and the mean difference in the forward reach distance before and after training was 3.1 cm in individuals with stroke [28]. The results of this study indicated that KAFOs immediately made positive changes in the forward reach distance equivalent to exercise training. In addition, the effect size r calculated for the change of the forward reach distance was large. Therefore, wearing KAFOs may lead to the considerable improvement for standing reach of individuals with subacute stroke.

Individuals with severe stroke have impaired abilities to perform standing activities and have decreased physical activity overall because of the severe impairments and disabilities. Decreased physical activity can induce secondary changes in the musculoskeletal [29] and cardiorespiratory systems [30] and may be harmful for rehabilitation. The early use of KAFOs in these individuals after stroke onset may improve the ability to perform standing activities and increase physical activity by immediately improving standing balance. Additionally, task-specific balance exercises improved the standing balance of individuals with stroke [31]. KAFOs can be used anywhere and allow individuals to perform task-specific standing exercises. Performing practical standing exercises with KAFOs during daily living may be useful for adaptations to the living environment and the reorganization of the brain after stroke. Further studies are needed to verify the fixed-term effects of additional exercises with KAFOs on standing reach that exceeds the immediate effects of KAFOs.

Limitation

This study used a small convenience sample. Caution is required when interpreting the results of this study for generalization and application.

Conclusion

The standing reach of individuals with subacute stroke can be improved immediately by wearing KAFOs.

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Author contributions

All authors contributed equally in the preparation of this manuscript.

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■ORIGINAL ARTICLE

Effects of Visual Impairment After Acute Stroke on Activities of Daily Living

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Abstract: Objective: In stroke patients with visual impairment, it is unclear which activities of daily living (ADL) are affected or how they are affected. This study aimed to determine the effect of the type and prevalence of visual impairments on ADL in acute stroke patients.
Method: We interviewed stroke patients without severe movement disorder, aphasia, general inattention, or hemispatial neglect who were admitted to our hospital between September 2018 and May 2020 for lesions in the cortical and subcortical white matter posterior to the central sulcus. The patients were asked via a questionnaire whether they had ADL impairments related to 13 types of visual impairments, and to provide specific examples. We determined the types of visual impairments, the prevalence of each impairment, and what effect they exerted on daily life.
Results: Sixteen participants were included. Fifteen participants had defective visual search, 14 had hemianopic dyslexia, 9 had walking trajectory deviations, and 6 had difficulty in recalling the place where they were seeing right before. In addition, there were defective visual counting, difficulty in judging distance, and pure alexia.
Conclusion: Even in cases without severe movement disorder, aphasia, general inattention, and hemispatial neglect, cerebral infarction in the posterior half of the cerebrum causes problems in ADL due to visual impairment. It is important to interview patients from the acute stage with visual impairment in mind.

Keywords: visual impairment, acute stroke, symptom, questionnaire, defective visual search

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Introduction

Approximately 30% of all stroke patients experience post-stroke visual impairment [1]. Hemianopia is the most prominent symptom in these patients, but in a survey of visual disorders after stroke, patients reported issues with visual-spatial perception, object and space recognition, contrast sensitivity, etc. [2]. These impairments are more complicated to diagnose but can be debilitating in regard to daily activities [3]. Specific interviews are critical to detecting such symptoms. The prevalence of visual problems is approximately 48% during the acute phase of stroke [4]. Often, the central aim of acute phase rehabilitation for stroke is to improve activities of daily living (ADL) related to movement disorders. Therefore, if their movement disorder is mild, patients are often discharged in the acute phase. As a result, that visual impairment that has been overlooked may have a detrimental effect on ADL. Several studies have reported effective rehabilitation, such as saccadic eye movement training in field defects, training of systematic visual search, and eye movement training for reading, for various visual impairments arising after strokes [2, 5]. We believe, therefore, that systematically examining patients for visual impairments in acute care

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hospital wards is vital to improving patients' quality of life. However, to the best of our knowledge, this has not yet been attempted in a research setting. Further, many ADL assessments relating to movement disorders in patients in acute care wards utilize reference criteria other than the bowels and bladder in the Barthel Index (BI). We believe, however, that in some cases, activities covered as BI criteria become difficult to perform due to visual impairment. However, it is not clear which activities are affected or how they are affected.

If patients, in addition to visual impairment, have aphasia, general inattention, or hemispatial neglect, it is possible that their vision disorder will be masked. Vision-related symptoms occur due to damage to the occipital, temporal, and parietal lobe of the cerebral cortex, but not when the damage is anterior of the central sulcus. In cases of cerebral infarctions there is comparatively good mapping between the location of the abnormality on brain images and the damaged area; thus, they are suitable for the study of responsible lesions. Therefore, this study aimed to determine the type and prevalence of visual impairments and the effect on ADL in acute stroke patients with lesions in the cortical and subcortical white matter posterior to the central sulcus, and without severe movement disorder, aphasia, general inattention, or hemispatial neglect.

Materials and participants

This study was conducted at the acute care hospital, Omori Red Cross Hospital. The participants comprised consecutive stroke patients who were admitted to the hospital between September 2018 and May 2020. We wished to include acute patients with infarctions in posterior cerebral regions, and without severe movement disorder, aphasia, general inattention, and hemispatial neglect. The inclusion criteria were as follows: Patients for whom stroke onset occurred within 20 days of the start of the survey, head diffusion magnetic resonance imaging during hospitalization indicated new changes in lesions in the cortical and subcortical white matter posterior to the central sulcus, a score of ≥70 on the BI, an auditory comprehension score of ≥8/10 in the Western Aphasia Battery, a digit span of ≥5, a score of ≤2 on the Catherine Bergego Scale, and no bilateral visual field loss. Patients with residual dysfunction from ocular diseases, orthopedic maladies, or neurological or psychiatric illness were excluded.

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

Methods

Measurement of the visual field

The visual field was measured using a tangent screen at a visual angle of 25° from the gazing point. A hole was made in the gazing point of the screen and the test was performed from there while the participant's gaze was confirmed.

Subjective awareness of visual field loss

Before the above-mentioned visual field measurement, participants were asked whether there was anything in their visual field that they found difficult to see. They were asked again after the visual field measurement. If the patient remained unaware of their visual field loss even after the measurement, we considered that the patient had anosognosia for hemianopia [6].

Questionnaire

The symptoms discussed in question items and the content of the questions themselves were cooperatively decided upon by a total of five occupational therapists and neurologists well-versed in the diagnosis of post-stroke visual impairment. First, after searching the literature to find all possible symptoms that can occur after a stroke, we eliminated very rare symptoms and very salient symptoms like Bálint syndrome or environmental agnosia, whose presence need not be confirmed with questions: this left a total of 13 symptoms. Next, we extracted information from the literature on how these 13 symptoms cause problems to affected people, considered how and where those problems may affect a patient's life after being hospitalized, and designed our questions. The literature used in these investigations has been cited throughout this text and in Table 2. Finally, questions related to two symptoms not described in the literature, but which the aforementioned five specialists frequently encountered in the past (detailed later) were also added. The questionnaire is provided in Table 1. Some of the questions related to the BI items are transfer, feeding, grooming, dressing, toilet use, bathing, mobility, and stairs (Table 1A), and the other questions related to ADL in other situations (Table 1B). The questions described problems that might occur due to some kind of visual impairment and asked participants whether or not they had experienced these problems after their strokes. If the patient replied that they had experienced these problems, they were asked to provide further details, which were cross-referenced with the academic literature, and the vision impairment was confirmed. After each question, we asked "Have your nurses or rehabilitation staff or

Table 1 Questions relating to activities of daily living

What activities do you have trouble within your daily life? We would like you to tell us about activities you have trouble within your daily life. Which of the following activities are you able to perform adequately? Please tell me what problems you are having and how you are compensating for them.

A. Questions Relating to the Barthel Index

Transfer (bed to chair and back)
1. Can you lie down to sleep in bed in the correct position (with your head on the pillow and your body positioned along the bed)?
   → **Disability of body orientation**
2. Can you sit correctly in a chair (if the chair has a back, with your back against the back)? → **Disability of body orientation**

Feeding
1. Can you eat on your own?
2. Have others told you that you have left food on the plate after you finished eating, or have you noticed it afterwards? → **Defective visual search**
3. Can you reach for dishes correctly and smoothly? → **Visuomotor ataxia** or **difficulty in judging distance**
4. Have you ever missed your cup when pouring tea? → **Visuomotor ataxia** or **difficulty in judging distance**
5. Please tell us about any other difficulties you have with eating.

Grooming
1. Can you perform grooming activities (hand-washing, face-washing, brushing teeth, shaving, makeup, etc.) on your own? → **Ideational apraxia**
   After you thought you had finished these activities, have others told you that you had missed some places, or have you noticed it afterwards?
   → **Personal neglect** or **defective visual search**
2. Are you easily able to find the correct grooming items if there are many items around the washbasin? → **Defective visual search**
3. Please tell us about any other problems you have with movements around the washbasin.

Dressing
1. Can you change clothes or shoes by yourself? What do you need help with?
2. Can you quickly and correctly put on your clothes? → **Dressing apraxia**
3. Please tell us about any other difficulties you have with dressing and putting on shoes.

Toilet use
1. Can you manage all toileting activities from entering the bathroom to exiting the bathroom by yourself?
   What do you find difficult?
   Is it sitting on the toilet seat? → **Disability of body orientation**
   Is it using toilet paper? Is it using the button to flush the toilet? → **Ideational apraxia**

Bathing
1. Can you manage bathing all by yourself?
2. Can you find the soap, shampoo bottle, etc. and pick them up smoothly? → **Defective visual search**
   Can you use soap and shampoo correctly? → **Ideational apraxia**
3. Please tell us about any other problems you have with bathing.

Mobility (on level surface)
1. Can you walk in a straight line down the hallways of the ward? Do your trajectory deviate? → **Walking trajectory deviation**
   Which side do your trajectory deviate?
2. When you are walking, do you sometimes bump into people or things? → **Defective visual search**
   Which side are the things you bump into on? What part of your body do you bump the most?
3. Can you move around your room when it is dark in the morning, evening and after lights out? Why are you having difficulty moving around?
   → **Defective contrast sensitivity**
4. Can you get to the dining room or communal bath on the ward by yourself? Can you get back to your room from the ward without getting lost?
   → **Heading disorientation**
5. Do you sometimes have difficulty judging how far away people or things are? → **Difficulty in judging distance**
6. Have you ever tried to sit in front of or behind a chair, or grasped an object in front of or behind where it was, or bumped into a wall thinking that there was still space between you and the wall? → **Difficulty in judging distance**

Stairs
1. Can you climb up and down stairs by yourself without any problems? If not, why not? → **Difficulty in judging distance**

B. Questions not relating to the Barthel Index

1. Can you read and write characters the same way you did before you got sick? → **Agraphia, alexia**
2. Can you read sentences the same way you did before you got sick? → **Hemianopic dyslexia**
3. Do you ever look at a familiar family member or friend and not know who they are? Do you know who they are if you hear their voice? → **Prosopagnosia**
4. Do you ever look at something and not know what it is? Do you know what it is if you touch it? → **Visual object agnosia**
5. Do you ever have trouble finding the things that you need that are around your bed? → **Defective visual search**
6. Do you ever have trouble finding the things that you need that are in your hospital room? → **Defective visual search**
7. Can you find your therapist in the rehabilitation room? → **Defective visual search**
8. Can you punch the buttons on a television remote control and the keys on a calculator without difficulty?
   What do you find difficult about it? → **Visuomotor ataxia**
9. When you type on the keyboard of a PC, do you sometimes hit the wrong keys? → **Visuomotor ataxia**
10. Do you have difficulty in recalling the place where they were seeing right before? → **Difficulty in recalling the place where they were seeing right before**
11. Do you ever find it difficult to count objects?
    Is it harder to count objects if they are scattered around? → **Defective visual search**
    Is it harder to count objects if they are lined up? Is it when they are lined up vertically or lined up horizontally? → **Defective visual counting**
12. When you have trouble identifying things, is it when objects, pictures and characters are facing up, facing down, or on their sides?
    → **Object orientation agnosia**
13. Have other people pointed out to you that you are reading the newspaper or other reading material upside down? → **Object orientation agnosia**

C. Have you had other annoying experiences that we have not yet asked you about?

The name of the symptom after the arrow expresses the probable visual impairments and other neuropsychological symptoms if the patient answers that they have problems with the questions that appear before the arrow.

Table 2 The types and characteristics of impairments

Types of impairments	Characteristics
A. Visual impairments	
Disability of body orientation	Difficulty matching the axis of one's own body and a viewed object correctly [7].
Defective visual search	Difficulty moving gaze to find objects [2, 5, 8].
Visuomotor ataxia	The hand reaching for the viewed object deviates up-down, left-right, or forward-back [9].
Difficulty in judging distance	Inability to visually judge depth distance [10, 11].
Defective contrast sensitivity	Inability to distinguish low-contrast objects [2, 5].
Alexia	Becoming unable to read characters [12].
Hemianopic dyslexia	Difficulty reading sentences, skipping words, and reading the same part of the text repeatedly [2, 5].
Prosopagnosia	Seeing faces but being unable to recognize them [13].
Visual object agnosia	Seeing objects but being unable to determine what they are [14].
Object orientation agnosia	Unable to determine object orientation [15].
Defective visual counting	Difficulty counting items [16, 17].
B. Nonvisual neuropsychological symptoms	
Personal neglect	Difficulty perceiving own body on the contralateral side of the lesion [18].
Ideational apraxia	The patient cannot use tools correctly despite knowing what they are [19].
Dressing apraxia	The patient can explain how to dress and can dress others, but cannot dress themselves properly [20].
Heading disorientation	The patient gets lost in a place where the scene cannot be viewed in its entirety [21].
Agraphia	The patient can no write characters [22].

your families pointed this out to you?" After the questionnaire was completed, we asked participants if they had any concerns other than what they had been asked about (Table 1C).

The visual impairments we assumed that could affect ADL during hospitalization were as follows. Disability of body orientation [7], defective visual search [2, 5, 8], visuomotor ataxia [9], difficulty in judging distance [10, 11], defective contrast sensitivity [2, 5], alexia [12], hemianopic dyslexia [2, 5], prosopagnosia [13], visual object agnosia [14], object orientation agnosia [15], and defective visual counting [16, 17]. In addition, the participants were asked about deviation of walking trajectory, and difficulty in recalling the place where they were seeing right before, which are common post-stroke impairments.

Furthermore, we asked about the following neuropsychological symptoms that are not visual impairments but that might occur due to changes in the cortical and subcortical white matter posterior to the central sulcus that might affect ADL during hospitalization. These were personal neglect [18], ideational apraxia [19], dressing apraxia [20], heading disorientation [21], and agraphia [22].

The type and characteristics of each of these visual impairments and non-visual neuropsychological symptoms are shown in Table 2. The name of the symptom after the arrow in Table 1 expresses the probable visual impairment and other neuropsychological symptoms if the patients answer that they have problems with the questions that appear before the arrow.

From the interview results, we determined the types of visual impairments experienced by the patients, and what effects they exert on the patients' daily life.

To validate the questionnaire's test-retest reliability, similar questions were asked ≥1 week after. This second interview was conducted by a different occupational therapist blinded to the study details and the patients' initial responses. For all binary (Yes/No) questions in Table 1, Cohen's kappa coefficient (κ) was calculated to measure the degree of agreement between the patients' first- and second-round responses.

Correspondence with rehabilitation and nursing records

We searched records compiled by physical ther-

Table 3 Demographic and clinical characteristics

Patient No.	Age (years)	Sex	Symptoms on admission	BI	WAB Auditory comprehension (max: 10)	WAB Naming (max: 10)	Digit span	CBS (range: 0-30)	BIT Line bisection (max: 9)	BIT Line Cancellation (max: 36)	BIT Star cancellation (max: 54)	Lesions
1	79	m	Right hemiplegia, vertigo	80	10	10	6	1	6	30	53	Left LOinf, FUS, LIN, and PLIC
2	53	f	Left hemianopia	100	10	10	9	0	9	36	54	Right LIN and PHIP
3	43	f	Right hemianopia, right hemiplegia	100	10	10	9	0	9	36	54	Left PHIP, FUS, and LOinf
4	68	m	Weakness in the left lower limb	80	10	10	5	2	9	35	52	Right PostC, CUN. Left SFG, CS, and IPS
5	75	m	Dysarthria, left hemiplegia	95	10	10	5	1	9	35	50	Right ITG, MTG, CR, PreC, PostC and ANG; left IC
6	66	m	Collide with objects on the right	100	8.8	6.8	6	0	9	36	53	Left HIP, PHIP,LIN, and LT
7	68	m	Vertigo	100	10	10	7	1	9	35	52	Right CCspl, LIN, and PHIP
8	77	m	Right hemianopia	100	10	10	8	1	9	36	54	Left LOsup, LIN, PHIP, and FUS
9	63	f	Transient loss of consciousness	95	10	9.2	7	2	9	36	53	Left IPS, right CR
10	70	f	Left hemianopia	100	10	10	7	0	9	36	52	Right FUS, LIN, and PHIP; left CERB
11	49	m	Right hemianopia	100	10	9.2	6	0	9	36	54	Light PHIP, LIN, and MTG.
12	56	m	Left hemianopia	100	10	10	7	0	9	36	54	Right LIN
13	88	f	Vertigo	80	10	10	5	1	9	34	50	Left STG, MTG, and ANG
14	83	m	Left hemiplegia	75	10	10	7	2	9	33	48	Right IPS, ANG, SMG, TS, and PLT
15	78	f	Left hemianopia	100	10	10	7	0	9	36	54	Light LIN and PHIP
16	90	f	Left lower limb paresthesia	85	10	10	5	0	9	34	48	Right IPS and CR

Max: maximum; BI: Barthel Index; WAB: Western Aphasia Battery; CBS: Catherine Bergego Scale; BIT: Behavioral Inattention Test; CUN: cuneus; IPS: intraparietal sulus; CAL: calcarine sulcus; LOinf: inferior occipital gyrus; LOsup: superior occipital gyrus; FUS: fusiform gyrus; LIN: lingual gyrus; PHIP: parahippocampal gyrus; PLIC: posterior limb of internal capsule; SFG: superior frontal gyrus; CS: central sulcus; ITG: inferior temporal gyrus; MTG: middle temporal gyrus; STG: superior temporal gyrus; CR: corona radiate; PreC: precentral gyrus; PostC: postcentral gyrus; IC: insular cortex; HIP: hippocampus; PLT: posterolateral thalamus; CCspl: splenium of corpus callosum; CERB: cerebellum; ANG: angular gyrus; SMG: supramarginal gyrus; TS: temporal stem

apists and nurses during patient hospitalization for descriptions corresponding to any of the 13 symptom types detailed in our questions. If any records indicating the problems we assumed could likely occur as a result of the impairments were found, we determined that the symptom in question had been recorded.

Results

Between September 2018 and May 2020, 447 patients were admitted to our hospital with cerebral infarctions. Of them, 16 patients met the criteria for participation. Table 3 shows the demographic and clinical characteristics of each participant. The median time between stroke onset and the survey was 3.5 days (range

Table 4 Patterns of visual field loss and visual symptoms corresponding to questions

Patient No.	Homonymous field loss	Unawareness of hemianopia	Defective visual search	Hemianopic dyslexia	Walking trajectory deviation to the side opposite to the lesion	No awareness of deviation	Defective visual counting	Difficulty in recalling the place where they were seeing right before	Difficulty in judging distance	Pure alexia
1	Right HA	2	+	+	+	-	+	+	-	-
2	Left HA	0	+	+	+	+	-	-	-	-
3	Right UQ	0	+	+	-		-	+	-	-
4	Left LQ	1	+	+	+	+	-	-	+	-
5	-		+	+	+	+	-	-	-	-
6	Right UQ	2	+	+	-		-	+	-	-
7	Left UQ	0	+	+	+	+	-	+	-	-
8	Right UQ	0	+	+	+	-	-	+	-	-
9	-		+	+	+	+	-	-	-	-
10	Left UQ	1	+	+	+	+	-	-	-	-
11	Right UQ	0	+	-	-		-	-	-	+
12	Left UQ	0	+	+	-		-	-	-	-
13	-		+	+	+	+	-	-	-	-
14	Left LQ	2	+	+	-		+	-	-	-
15	Left UQ	1	-	+	-		-	+	-	-
16	-		+	-	-		-	-	-	-

0: Subjective awareness prior to visual field examination; 1: Subjective awareness after visual field examination; 2: No subjective awareness even after visual field examination; +: Symptom reported; -: Symptom not reported; HA: hemianopia; UQ: upper quadrantanopia; LQ: lower quadrantanopia

2−15 days), and the median hospital stay was 24 days (range 13−72 days). All participants were right-handed, and their midpoint BI score was 100 (range 75−100).

Regarding visual field loss, two participants had homonymous hemianopia, eight had upper quadrantanopia, two had lower quadrantanopia, and four did not have visual field loss (Table 4). Among the 12 participants with visual field loss, six did not have subjective awareness of the loss before visual field testing. Three of them became aware of the loss after the visual field testing while the other three remained unaware even after testing. That is, three participants exhibited anosognosia for hemianopia.

The following is a list of the visual impairments that affected ADL during hospitalization. Fifteen participants (94%) had defective visual search, 14 (88%) had hemianopic dyslexia, 9 (59%) had deviation of walking trajectory, 6 (36%) had difficulty in recalling the place where they were seeing right before, 2 (13%) had defective visual counting, 1 (6%) had difficulty in judging distance, and 1 (6%) had pure alexia. All of the 9 participants who had deviation of walking trajectory complained of deviations toward the opposite side of the lesion, and 7 (78%) out of the 10 participants had no subjective awareness of deviation and only described having had it pointed out by nurses and rehabilitation staff (Table 3). All patients had subjective awareness of all other symptoms. None of the participants reported difficulties related disability of body orientation, visuomotor ataxia, defective contrast sensitivity, prosopagnosia, visual object agnosia, or object orientation agnosia.

Correspondence between question answers and physical therapist/nurse records was as follows. Of the types of visual impairments discussed in our questions, one patient did not have any records from either physical therapists or nurses indicating the impairment "difficulty in recalling the place they were seeing right before," despite the fact that question results indicated that an impairment was present. However, for all other visual impairments, corresponding records by either a physical therapist or nurse were found for all patients whose question answers indicated an impairment. Further, when question results did not indicate that an impairment was present, neither form of record contained the corresponding descriptions.

Among the impairments, defective visual search,

Table 5 Voluntarily reported visual symptoms and non-visual symptoms corresponding to questions

Patient No.	Photophobia	Simple visual hallucination	Complex visual hallucination	Cerebral diplopia	Metachromatopsia	Metamorphopsia	Agraphia for Kanji	Acalculia	Amnesia
1	-	-	-	+	-	-	-	-	-
2	+	+	-	-	-	+	-	-	-
3	-	-	-	+	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-
5	-	-	-	-	+	-	-	-	-
6	-	-	-	-	-	-	-	-	+
7	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	+	-	-	-
9	-	+	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	+	+	-
12	-	+	+	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-

+: Symptom reported; -: Symptom not reported

deviation of walking trajectory, and difficulty in judging distance were reported in response to questions regarding BI. Defective visual search was reported in response to questions relating to BI and questions relating to other visual activities. Defective visual search was reported as follows in response to questions relating to the BI. To questions pertaining to "Mobility," seven participants answered that they "bumped into things," or "people suddenly appeared and startled me." To questions related to "Grooming," five participants answered that "it takes a long time to find my tools," and to questions related to "Feeding," four participants answered that they "noticed that some of their food had been left on the plate." Deviation of walking trajectory to opposite side of the lesion and difficulty in judging distance were only reported in response to questions relating to BI. To questions regarding "Mobility" and "Stairs," difficulty in judging distance was reported, such as "I was surprised to find that I was about to sit in front of the chair," "I can't tell how far I am from objects and people when I walk," and "when I go down the stairs I can't tell the height of a step, so it's scary."

Concerning the answers to questions relating to nonvisual neuropsychological symptoms, one participant reported agraphia of kanji characters, one reported acalculia, and one reported mild amnesia (Table 5). No other non-visual neuropsychological symptoms were reported.

To the final question, in which the participant was asked about experiences that concerned them other than what was asked in the interview, one participant (6%) reported photophobia; three (19%) reported simple visual hallucinations, such as "seeing stripes"; one (6%) reported complex visual hallucinations, such as "seeing people"; two (12%) reported cerebral diplopia, in which the viewed object appears to be duplicated twice; one (6%) reported metachromatopsia, where the perceived color is different from the actual color; and two (12%) reported metamorphopsia, where the perceived shape is different from the actual one (Table 5) [5, 23, 24].

The questionnaire had excellent test-retest reliability ($\kappa = 0.952$); specifically, the patients' first- and second-round responses were in almost complete agreement [25].

Discussion

This study aimed to determine the effect of the type and prevalence of visual impairments on ADL in acute stroke patients. Our results suggest that patients who

have had acute strokes with lesions in the cortical and subcortical white matter posterior to the central sulcus feel that they have problems in ADL due to various visual impairments, even if they do not have impairments that clearly hamper daily life, such as movement disorder, aphasia, general inattention, or hemispatial neglect. The symptoms frequently observed were defective visual search, hemianopic dyslexia, deviation of walking trajectory, and difficulty in recalling the place where they were seeing right before.

According to Zihl [5], 61% of patients with homonymous hemianopia complained of ADL problems due to defective visual search. The number of patients who report ADL impairments decreases with time due to the natural recovery process after stroke and because patients consciously or unconsciously perform compensatory actions. Therefore, it is to be expected that the prevalence of ADL impairments is high in the acute phase, as was observed in our study. A subset of patients report symptoms that do not improve over the long term; these patients do not use compensatory mechanisms. Such patients have lesions on the thalamus, parietal lobe or the fibers connecting them [5].

It was previously thought that defective visual search was caused by the patient being unable to make sufficiently large eye movements to compensate for the missing part of the visual field and being unable to organize visual information on the missing side. It is now known that the severity of this impairment does not correlate with the size of the remaining visual field or the patient's subjective awareness of the visual field loss [5]. It has become clear that in some cases, similar impairments occur if lesions are present in the posterior parietal area even without visual field loss [8]. Thus, it is conceivable that this symptom can be present if homonymous visual field loss or posterior parietal lesions occur in the acute period. As shown in Tables 3 and 4, all of the patients presenting with this symptom met one of these conditions. The fact that these symptoms were observed regardless of the patient's subjective awareness of visual field loss is in line with previous findings [8].

According to Zihl [5], 77% of patients with left homonymous hemianopia and 90% of those with right homonymous hemianopia complained of hemianopic dyslexia. This is in line with our current findings. Hemianopic dyslexia was previously considered to be a reading impairment caused by characters seeming to abruptly appear and disappear from the boundary between the healthy visual field and the blind visual field. However, it has been reported that similar reading difficulties can occur in the absence of visual field loss if there are posterior parietal lesions [8]. Recently, the association between such difficulties and certain types of visuospatial attention or eye movement control has been proposed [26]. Therefore, it is conceivable that these symptoms can present if there is homonymous loss of visual field or posterior parietal lesions in the acute period. As shown in Tables 3 and 4, all of the patients presenting with this symptom met one of these conditions.

There are reports that the walking trajectory of patients with hemispatial neglect deviate to the same side as the lesion [27]; however, we could not find any studies of patients with posterior lesions without hemispatial neglect whose walking trajectory deviate to the side opposite to the lesion. However, in one study, when patients were asked to point in the direction they believed was straight ahead, patients with hemispatial neglect but not homonymous hemianopia pointed to a spot that deviated from the exact center toward the lesion side, and patients with homonymous hemianopia but not hemispatial neglect pointed to a spot that deviated from the exact center toward the side opposite to the lesion [28]. It is prudent to assume that the latter patients, when attempting to walk straight ahead, will exhibit walking trajectory deviating to the side opposite to the lesion. However, the study did not survey a patient group with posterior lesions but without neglect or hemianopia; thus, it is unclear whether hemianopia is a requirement for the symptom of tilting toward the side opposite to the lesion. In this study, this symptom was also reported in patients without visual field loss. This suggests that the mechanism of this symptom is unrelated to the state of the visual field. This impairment differed from the other symptoms in that many patients were unaware of its existence. Danger arises when patients have comorbid deviation of walking trajectory and defective visual search, as they will approach obstacles without noticing them. Hence, those caring for the patient should be alert to the presentation of this symptom.

It is not uncommon for stroke patients to complain of difficulty in recalling the place where they were seeing right before. However, we were unable to find any studies that investigated this problem directly. However, it can be anticipated that this impairment will cause various problems with daily activities. For example, Inoue *et al*. [17] theorized that this symptom underlies defective visual counting.

While uncommon, some patients in our study had defective visual counting, difficulty in judging distance, or pure alexia. Defective visual counting has come to be thought of as a manifestation of visual inattention [16]. In the cases with visual inattention, severe impairment, such as the inability to count four or fewer objects, is observed. However, some patients are unable to count five or more similar items even if visual inattention is

not present [17]. This type of defective visual counting occurs even if the items are lined up and not haphazard, or if they are arranged vertically. Thus, this cannot be explained by defective visual search or hemianopia. There are reports of difficulty in judging distance with bilateral lesions [10], but this symptom can also occur with unilateral legions [11]. It has been hypothesized that the lesions responsible for this symptom occur in the cuneus [10]. The cuneus was involved in the lesions of the patient who complained of difficulty in judging distance in this study. It is assumed that the lesions responsible for pure alexia are in the left lingual gyrus and the parahippocampal gyrus [12]. Lesions in these regions were observed in the patients who complained of pure alexia in this study.

In response to questions relating to the BI, patients reported defective visual search, deviation of walking trajectory, and difficulty in judging distance. Thus, our results indicated that even within the activities assessed by the BI, under the categories of "Mobility," "Grooming," "Feeding," and "Stairs," patients had difficulties with impairment of visual function, not with movement function. Even if there is adequate improvement in movement function, patients may not be able to succeed in the activities themselves if visual impairments are not addressed.

To manage the various symptoms described above, effective rehabilitation strategies such as training, compensation, and environmental adjustment have been reported [2, 5]. It has been reported that patients who experience visual impairment following a stroke whose impairment goes unnoticed by others, who do not receive sufficient information, and who do not have the opportunity to receive systematic rehabilitation believe that the process of tackling their visual impairment is not supported [29]. In order to improve patient quality of life, we believe it is important to interview stroke patients in the acute stage in order to identify potential visual disorders, provide descriptions of symptoms, and consider necessary measures such as rehabilitation.

Study limitations

This study had a number of limitations. The number of participants was unfortunately small because we excluded patients with severe movement disorder, aphasia, general inattention, and hemispatial neglect.

The correspondence between decisions made based on question results and the presence or absence of physical therapist/nurse records was good. However, these confirmatory methods are not objective evaluation methods of the impairments themselves. In the future, we must develop testing methods to quantify each impairment, and investigate whether the results of these questions correspond to patients' actual conditions or not.

In this study, our questions were only administered to hospitalized patients in the acute phase. Not understanding how the results obtained via these questions are reflected in the various problems that might occur in home/workplace ADLs after discharge, therefore limits their usefulness. In the future, we will develop questions that consider a home or workplace setting and investigate the relationship between those and questions implemented while patients were hospitalized. Thereby, we believe we will be better able to predict problems that may arise in the acute period and extend into post-discharge life, and better develop specific countermeasures.

Conclusion

The results of this study suggest that many patients who have had acute strokes with lesions in the cortical and subcortical white matter posterior to the central sulcus have visual impairments such as defective visual search, hemianopic dyslexia, deviation of walking trajectory, and difficulty in recalling the place where they were seeing right before, and that these impairments caused difficulties with ADL. Therefore, we believe that is important to interview patients during the acute stage with visual disorders in mind, and if symptoms are discovered, to conduct the necessary rehabilitation.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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■ORIGINAL ARTICLE

Kinetics of Visual Axis and Pupil Diameter during Caregiver-assisted Eating

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Abstract: The purpose of this study was to examine the kinetics of the visual axis and pupil diameter during caregiver-assisted eating. The eating task was caregiver-assisted eating of twelve healthy volunteers. Visual axis position, spoon bowl motion, and pupil diameter were recorded using an eye tracker and a digital video camera. All participants indicated visual axis on a spoon or food during the motion of moving the spoon to the participant's mouth in caregiver-assisted eating. Critical visual point (CVP) disappeared completely in all trials of all participants. The min-to-max and max-to-min pupil diameters, differences and changing were divided to three patterns for caregiver-assisted eating in all participants. Most patterns showed decrease of pupil diameter. These data suggest that the participant looked carefully at the food or the spoon using an accommodation reflex and a convergence reflex. Caregiver-assisted eating is natural in non CVP. A participant does not have somatosensory information during eating motion in caregiver-assisted eating. Positional information of a spoon is obtained only from visual information. We speculated that participant anxiety was stronger with caregiver-assisted eating than with unassisted eating. However, the causes of an increase and lack of change in pupil diameter remain unclear. Occupational therapists, who understands biological responses during eating motion, must teach a caregiver-assistant methods that are suitable for a participant.

Keywords: caregiver-assisted eating, visual axis, pupil diameter, eating motion

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Introduction

Many reports have described analysis of eating, which is important for independence of self-care [1, 2, 3, 4, 5]. Previous our report has described characteristics of healthy participants' visual axis and pupil diameter found during unassisted eating and robot-assisted eating [6]. Results show that all participants have a critical visual point (CVP) during unassisted eating as the spoon moves from the plate to the mouth. The CVP contributes to eye-hand coordination during eating, facilitating monitoring of smooth upper extremity motion and spoon manipulation. The CVP is the final point during the eating motion [7]. However, the CVP disappeared in all participants during robot-assisted eating. These findings suggested that the subjects followed the food with their eyes until just before it entered their mouths during robot-assisted eating. The Japanese geriatric health service facilities and at home needed caregiver-assisted eating in the subjects. Characteristics of the visual axis and pupil diameter during caregiver-assisted eating remain unclear. In other words, from the characteristics among unassisted eating, robot-assisted eating, and caregiver-assisted eating, we can find a theoretical basis for occupational therapists to provide caregivers with appropriate care guidance methods for their subjects. Therefore, this study examined the kinetics of the visual axis and pupil diameter during caregiver-assisted eating.

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Methods

Participants

Twelve healthy volunteers (5 men, 7 women) participated in the study. The age range was 20−26 years (mean age, 22 ± two years). All participants had vision sufficient to obtain a driver's license, with no color vision abnormality. They had affiliated psychic function and did not have diseases or injuries that would impair daily living activities. All participants provided informed consent to undergo the experimental procedures, which were approved by the Ethics Review Board of the Yamagata Prefectural University of Health Sciences (1210−09), Yamagata, Japan.

Instrumentation and data acquisition

Data were collected with a sampling frequency of 30 Hz using an eye tracker (EMR-8B; NAC Image Technology Inc., Tokyo, Japan), which detects infrared reflections from the cornea, and a digital video camera (30 frames per second, NV-GS320; Panasonic Inc., Osaka, Japan). The digital video camera, located to the side of the participant, recorded motion of the spoon bowl from the plate to the mouth. A digital motion picture waveform real-time synchronous recording system (the Teraview; Gigatex Co. Ltd., Osaki, Japan) was synchronized with a field image, a pupil image, and a video camera image.

Procedures

Experimental conditions

Brightness in the test room was fixed at 652 lux. The room temperature was set to about 24°C. Each participant sat on a chair (400−450 mm tall). The participant held the eating assistant's spoon before the trial began. The distance between the mouth and the plate during caregiver-assisted eating was fixed as 338−471 mm for all participants. The experimental food was a cereal with 15-mm-diameter toroidal pieces (Kokokun-no-chocowa; Kellogg Co., Tokyo, Japan). The participant's eyes were covered with a visual mask to prevent prior visual information. The mask was removed at the start of the eating task. The trial ended when the food was in the participant's mouth. The eating task was caregiver-assisted eating (10 trials).

First, the participant was asked to eat food just as in daily life. Therefore, we did not force the subjects to look at the food or the spoon except to say, "Please eat as usual". A caregiver observed the motion speed, spoon bowl trajectory, and eating motion accuracy. The caregiver-assisted eating of participants was observed similarly to unassisted eating.

Data analysis

1. Motion phases

Eating task motions were divided into three phases using video data: phase 1 (P1), the motion of moving the spoon to reach the food; phase 2 (P2), the motion of picking up the food; and phase 3 (P3), the motion of moving the spoon to the participant's mouth. P3 was also defined as the "eating motion."

2. Classification of eye movement

The visual axis position was ascertained from a picture using a field camera, and was pursued during the eating task. Eye movements were classified as saccadic eye movement (SEM), smooth pursuit eye movement (SPEM), fixation, and others. SEM was defined as eye movement of angle speed greater than 50°/s. SPEM was defined as eye movement of angle speed <50°/s. Fixation was defined as eye movement inactivity that continued longer than 0.10 s. Fixation was judged to have occurred when the eye mark stopped at the same position for more than three field camera images under these conditions.

3. Visual axis position and spoon bowl motion

The visual axis position was divided into four categories: The plate showed a block with the food. The spoon showed the visual axis position on the spoon bowl without the food. The food showed the visual axis position on the food. Other positions showed blinking or no placement of the plate, spoon bowl, or food. The CVP was defined as the spoon bowl position at which the visual axis was removed from the food in P3.

4. Pupil diameter

The pupil diameter was measured at 30 Hz using eye mark data analysis software (EMR-dFactory; NAC Image Technology Inc., Tokyo, Japan). The pupil diameter of each participant, which was measured before and after the near-reflex test, was used as the reference to assess differences between before and after the near reflex test. Three patterns of pupil diameter change in P3 were assessed: increase, decrease, or no change. All trials included every pattern. The quantity of change of the pupil diameter was calculated based on the difference of the maximum and the minimum (min-to-max or max-to-min) of P3.

Results

Figure 1 (participant A) presents changes in the

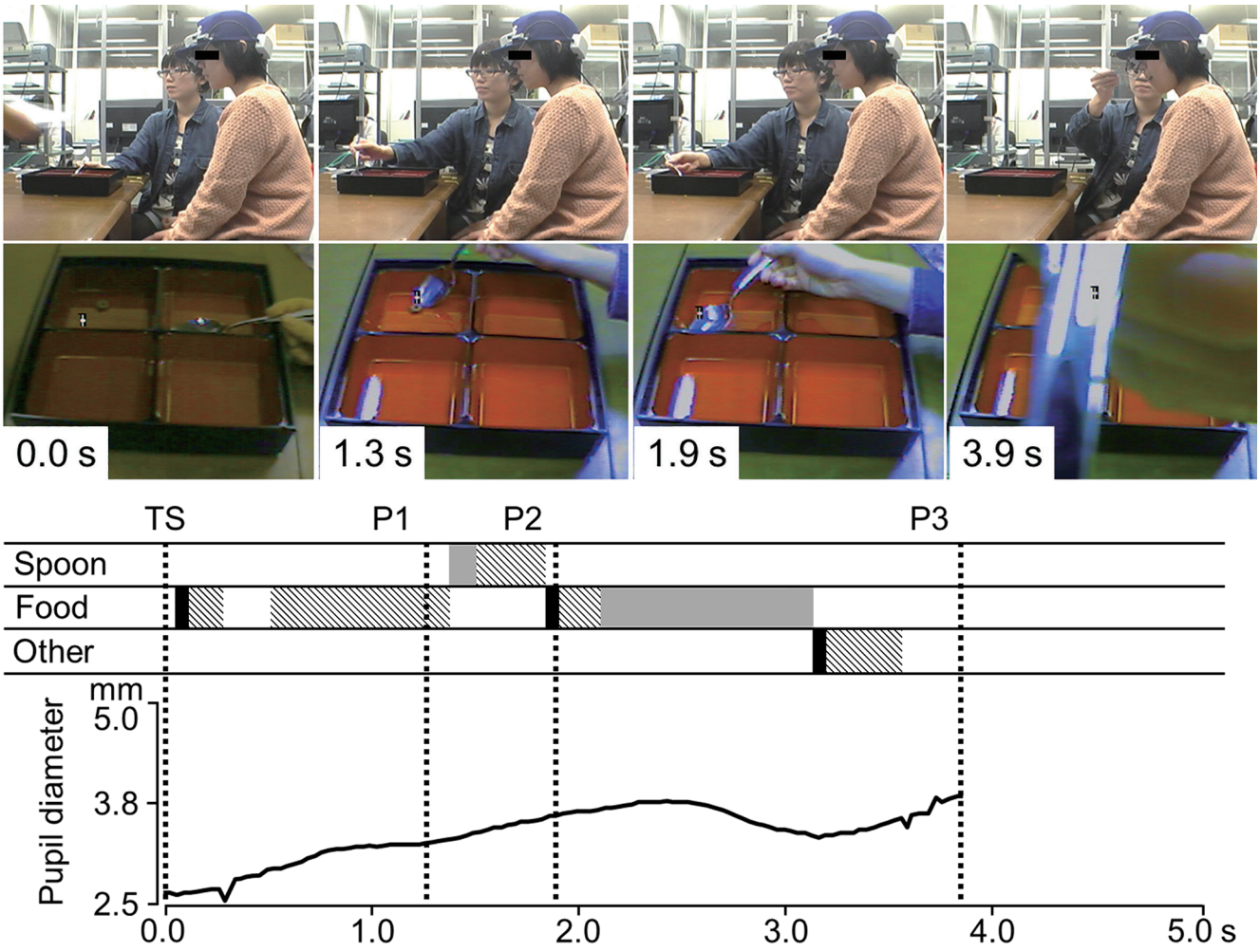

Fig. 1. Transition of visual axis and the pupil diameter during caregiver-assisted eating in the participant A

The figure shows digital video camera images (DVC), field camera images (FC), position of visual axis (VA) and pupil diameter (PD). Slash lines box of FC shows fixation of eyes. Dotted box of FC shows smooth pursuit eye movement. Black color box shows saccadic eye movement. DVC and FC show start of task, end of Phase1, end of Phase2, and end of task sequentially from the left. Left dotted line shows task start. Dotted line of P1, P2 and P3 show end of each phases.

visual axis and pupil diameter that occurred during caregiver-assisted eating. The spoon reached the food within 1.3 s from the trial start (end of P1). The visual axis of the participant was on the food. Furthermore, the participant picked up the food with the spoon in 1.9 s (end of P2). During P2, the visual axis position changed from the food, to the spoon, to the food. Next, the participant moved the spoon to the mouth. It reached the mouth in 3.9 s from the trial start (end of P3). During P3, the visual axis position changed from the food to the other 1.3 s after the trial start. The spoon at this time was located 91 mm from the left eye of the participant. No CVP was identified during P3.

Although the order of the visual axis position varied among trials, the visual axis position and the eye movement pattern were similar from P1 to P3. Additionally, all participants showed the same visual axis positions and eye movement patterns as this participant.

In P1, the visual axis was fixed on the food 0.1 s from the trial start. The eye movement pattern changed from SEM (for 0.1 s), to fixation (for 0.2 s), to other patterns (for 0.2 s), to fixation (for 0.8 s). At that moment, the pupil diameter increased by 0.6 mm, from 2.7 mm to 3.3 mm. During P2, the eye movement pattern changed from fixation (for 0.2 s duration), to SPEM (for 0.1 s), to fixation (for 0.3 s), to SEM (for 0.1 s). The pupil diameter increased by 0.3 mm, from 3.3 mm to 3.6 mm. During P3, the eye movement pattern changed from fixation (for 0.2 s), to SPEM (for 1.0 s), to SEM (for 0.1 s), to fixation (for 0.4 s), to other patterns (for 0.3 s). The pupil diameter decreased by 0.4 mm, from 3.8 mm to 3.4 mm. In the participant, the pupil diameter showed

Table 1. Pupil diameter of caregiver-assisted eating in phase 3

Subject	Pupil diameter (mm)					Near reflex (mm)		
	Max (Min) to Min (Max)		Type	Dif.	Counts	Max	Min	Dif.
A	– 3.7 –	– 3.4 –	Inc Dec No	– 0.3 –	0 10 0	3.8	2.7	1.1
B	– 4.5 –	– 3.3 –	Inc Dec No	– 1.2 –	0 10 0	4.5	2.6	1.9
C	5.4 5.4 5.3	5.8 5.2 5.3	Inc Dec No	0.4 0.2 0.0	1 7 2	4.9	3.4	1.5
D	4.0 4.2 4.0	4.1 3.9 4.0	Inc Dec No	0.1 0.3 0.0	7 2 1	4.8	2.7	2.1
E	– 3.8 –	– 3.3 –	Inc Dec No	– 0.5 –	0 10 0	3.4	2.3	1.1
F	– 4.3	– 3.8	Inc Dec No	– 0.5 –	0 10 0	5.1	3.3	1.8
G	– 4.3 –	– 3.9 –	Inc Dec No	– 0.4 –	0 10 0	4.5	3.2	1.3
H	– 5.4 –	– 5.0 –	Inc Dec No	– 0.4 –	0 10 0	5.0	3.3	1.7
I	– 5.1 –	– 4.4 –	Inc Dec No	– 0.7 –	0 10 0	4.3	3.4	0.9
J	– 3.9 –	– 3.3 –	Inc Dec No	– 0.6 –	0 10 0	3.5	2.4	1.1
K	5.0 4.9 5.4	5.3 4.8 5.4	Inc Dec No	0.3 0.1 0.0	6 2 2	4.4	3.2	1.2
L	3.4 3.6 –	3.6 3.4 –	Inc Dec No	0.2 0.2 –	2 8 0	3.2	2.7	0.5

similar changes to those of other trials. However, this participant's change in pupil diameter showed only a decrease in P3 (Table 1).

Among all participants, the CVP disappeared completely in all trials during P3.

The min-to-max and max-to-min pupil diameters, differences, and changing counts for caregiver-assisted eating in all participants during P3 are shown in Table 1.

For participant A, the max-to-min pupil diameters decreased from 3.7 to 3.4 mm. The difference in pupil diameter was 0.3 mm. The pupil diameter decreased in all trials. Eight participants showed decreased pupil diameter.

For participant K, the min-to-max and max-to-min pupil diameters increased (from 5.0 to 5.3 mm), decreased (from 4.9 to 4.8 mm), or showed no change (stable at 5.4 mm). The pupil diameter increased by 0.3 mm and decreased by 0.1 mm. The pupil diameter change counts respectively showed an increase, decrease, and no change in 6, 2, and 2 trials. The near reflex value decreased by 1.2 mm, from 4.4 mm to 3.2 mm. Three participants showed an increase, a decrease,

and no change in pupil diameter.

In participant L, the min-to-max and max-to-min pupil diameters respectively increased (from 3.4 to 3.6 mm) and decreased (from 3.6 to 3.4 mm). The pupil diameter increased by 0.2 mm and decreased by 0.2 mm. The pupil diameter change counts increased by 2 and decreased by 8 only in participant L. The near reflex value decreased by 0.5 mm: from 3.2 mm to 2.7 mm.

Discussion

All participants had visual axis on a spoon or food from P1 to P3 in caregiver-assisted eating. Moreover, CVP disappeared completely in all trials during P3 of all participants. The result was similar to a previous report [8]. CVP contributed to the role of eye-hand coordination during eating, as shown by visual monitoring of smooth upper extremity motion and spoon manipulation [7]. CVP is the final spot [7, 9]. We speculated that the participant sub-consciously or consciously moves without dropping food from the spoon at CVP during unassisted eating [7]. Previous reports have described that no CVP exists for robot-assisted eating [6]. Therefore, caregiver-assisted eating is natural in non CVP. A participant does not have somatosensory information during eating motion in caregiver-assisted eating. The positional information of a spoon is obtained only from visual information [6]. We speculated that participant anxiety was stronger with caregiver-assisted eating than with unassisted eating. All participants feel anxious when the spoon tip nears the participant.

Table 1 shows pupil diameter P3 of three patterns. Most patterns showed only about 67% decrease of pupil diameter. These findings were similar to results obtained for robot-assisted eating [6]. The pupil diameter decrease occurs in the near reflex. These data suggest that the participant looked carefully at the food or the spoon using an accommodation reflex and a convergence reflex [10]. The next pattern was a 25% increase, a decrease, and no change of pupil diameter. One other participant showed an increase and a decrease of pupil diameter. Participants C and L of different types of pupil diameter change showed that the decrease ratio of pupil diameter was frequent. Participants D and K showed that the increased ratio of pupil diameter was frequent. As described above, these findings suggest that a decrease of pupil diameter occurs in the near reflex. In unassisted eating, there was no obvious decrease in pupil diameter as in the near reflex, and the pupil diameter was sometimes increased [6]. We speculated that the timing, speed, and trajectory of eating motion in caregiver-assisted eating resembled those found for unassisted eating. However, the causes of an increase and lack of change in pupil diameter remain unclear.

This study revealed that caregiver-assisted eating resembled kinetics of visual axis and pupil diameter during robot-assisted eating. Eating in natural timing, natural speed, and natural trajectory improves the participant's eating motivation. Therefore, a caregiver must match the timing, speed, and trajectory of eating motion with those of an individual participant. For further quality of life improvement, the occupational therapist (OTR) must lead unassisted eating by the participant. The OTR, who understands biological responses during eating motion, must teach a caregiver assistance methods that are suitable for a participant.

Study limitations

Caregiver-assisted eating elicited physiological responses in healthy participants. However, challenged persons were not assessed during caregiver-assisted eating. Further studies are under consideration to investigate caregiver-assisted eating in challenged persons.

Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

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■ORIGINAL ARTICLE

Sensory Modulation and Behavior of Preschool-Aged Children with Special Education Needs

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Abstract: Objective: The number of children with special education needs (SEN) is on the rise in Japan. However, the behavior and sensory modulation functions of preschool-aged children with SEN have not been clarified. The purpose of this study was to examine the behavioral and sensory modulation characteristics of preschool-aged children with SEN compared with those of children without SEN.
Methods: We conducted a cross-sectional survey using a questionnaire on children's behavioral problems and sensory modulation, which was reported by nursery teachers who cared for children with and without SEN. Forty-two nursery teachers who were involved with the care of children with and without SEN were asked to complete the Japanese version of the Eyberg Child Behavior Inventory (ECBI) and the Japanese version of the Short Sensory Profile (SSP).
Results: The results showed that both ECBI and SSP scores were significantly higher in children with SEN than in children without SEN ($p<0.01$), and that the SSP domain scores for underresponsive/seeks sensation and auditory filtering in children with SEN were significantly correlated with ECBI scores ($p<0.05$).
Conclusion: Children with SEN had more sensory modulation bias and behavioral problems than children without SEN, and there was an association between sensory modulation bias and behavioral problems in children with SEN.

Keywords: sensory modulation, behavior assessment, preschool, special education needs

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Introduction

In 1981, the Education Act of 1981 institutionalized the concept of "special educational needs" (SEN) in the United Kingdom. Children with SEN have learning difficulties that require special educational support. Even in preschool-aged children, SEN is present when they have more difficulties in learning than their peers, or when they are likely to have difficulties in learning without special educational support. Because SEN is a pedagogical concept, it includes children with and without a diagnosis of disability [1]. Children who need educational support include those who need support for learning, daily life, and other activities and who have behavioral problems in group life such as "restlessness," "inability to control emotions," and "frequent problems with other children," and this is a broad concept distinguished from developmental disorders. Therefore, this concept depends on the subjective judgments of parents, preschool teachers, and experts who take into account the results of some developmental tests. It has been reported that the number of children with SEN is on the rise in Japan [2].

Support for children with SEN should not focus solely on the type and degree of disability, but also provide guidance and support for individual issues, focusing on the comprehensive educational needs that arise from each child's relationship with his or her environment [3]. The main supporters are specialists who provide support through treatment and education at local developmental support centers and developmental support offices and visit nursery schools and schools. In Japan, the special needs education program that started in 2007 to support

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children with SEN through visits to regular classrooms is also encouraging as a way to strengthen collaborative support for children with SEN. Most of the support and consultations are centered on the aforementioned behavioral problems of children with SEN and challenges in carrying out activities of daily living.

Sensory modulation disorder is a possible reason for the behavioral problems seen in children with SEN [4]. Conversely, autism spectrum disorder (ASD) is a disorder that primarily impairs behavior and sensory modulation. The development of assessment batteries for the sensory processing characteristics in children with ASD (e.g., Sensory Profile) and studies have been conducted systematically by Dunn et al. Occupational therapists assess these sensory modulation disorders and the influence of the living environment to identify factors that inhibit appropriate behavior and adjust the living environment at nursery schools, kindergartens, and schools. Many studies have already been conducted on the relationships between sensory modulation and behaviors of children with ASD. For example, Brown et al. pointed out that there are both aspects of sensory modulation in children with ASD that are universal and unaffected by the environment, and aspects that are affected by situations and activities [5]. Tomchek et al. reported that sensory modulation in children with ASD is related to language skills, and that children in the group with less adaptive behaviors are more likely to have tactile and movement sensitivity and sensory seeking [6]. Similarly, Lane et al. found that biases in tactile sensitivity, taste/smell sensitivity, underresponsive seeking sensation, auditory filtering, and visual/auditory sensitivity were associated with maladaptive behavior [7]. O'Donnell et al. noted that sensory modulation biases in children with ASD are associated with behaviors such as irritability, lethargy, stereotypic behavior, hyperactivity, and inappropriate speech [8]. It has also been pointed out that there is a sensory processing bias in children with attention deficit hyperactivity disorder as well as in children with ASD [9, 10]. In contrast, a study of school-aged children with SEN reported that similar to children with ASD, the sensory modulation of those with SEN is more biased and that their behavioral problems are more severe than those of TD children [11]. However, the behavior and sensory modulation functions of preschool-aged children with SEN have not been clarified.

This study aimed to determine the characteristics of the behavioral and sensory modulation functions of undiagnosed children with SEN whose nursery teachers feel they need support, in comparison to children without SEN. This study will enable inference of sensory modulation functions from the behavioral characteristics of children with SEN. This will contribute to the development of occupational therapy that supports the activities of children with SEN and improves the sensory environment around them.

Materials and Methods

Design

This was a cross-sectional survey using a questionnaire on children's behavioral problems and sensory modulation, which was reported by nursery teachers who cared for children with and without SEN.

Participants

Forty-two nursery teachers from 16 facilities in City A and 9 facilities in City B were surveyed. The inclusion criteria were those who had at least 3 years of experience in the field.

Questionnaire

The Japanese version of the Eyberg Child Behavior Inventory (ECBI) was used as a questionnaire for children's behavior. The ECBI is an assessment tool that can be answered by parents or alternative caregivers (nursery teachers, etc.). The ECBI has two subscales: an intensity scale, which captures the quantitative nature of children's problematic behavior, and a problem scale, which captures caregivers' perceptions of parenting difficulties. In this study, only the intensity scale was calculated as the intensity score, and the response column required for the calculation of the problem score was not included in the questionnaire. The participants answered the frequency of the children's behavior problem for each of the 36 ECBI items on a seven-point ordinal scale (1 = never to 7 = always) in response to the question "How often does your child currently have this problem?" The ECBI was translated into Japanese by Kamo et al. and confirmed its reliability and validity [12].

We used the Japanese version of the Short Sensory Profile (SSP) as a questionnaire for children's sensory modulation. The SSP, like ECBI, is an assessment tool that can be answered by parents and alternative caregivers. The SSP contains 38 items and is divided into seven domains: tactile sensitivity, taste/smell sensitivity, movement sensitivity, underresponsive/seeks sensation, auditory filtering, low energy/weak, and auditory/visual sensitivity. The respondents were asked to respond to each item using a five-point scale from "1 = never" to "5 = always," with higher scores indicating a stronger bias in sensory modulation. The SSP was translated into Japanese by Hagiwara et al. and confirmed its reliability and validity [13].

Procedures

This study was conducted with the cooperation of the Board of Education of City A and the Welfare Division of City B, Department of Child Welfare. An unmarked self-administered questionnaire was sent between December 2018 and January 2019 to nursery schools and kindergartens that had received permission from the head of the facility to participate in the study. The subjects' participation in the study was considered to be their consent to participate in the study when they returned the questionnaire.

The ages of targeted children for SSP and ECBI were set from 3 years and 0 months to 6 years and 11 months, respectively. We excluded children with symptoms of motor and intellectual disabilities and children with a diagnosis of some kind of developmental disorder or those with a suspicion of a developmental disorder. Prior to the selection of children with SEN, the researcher gave a written and oral explanation of the concept of SEN to the participants. After that, children who did not meet the exclusion criteria of the study, but for whom the participant wanted to consult a specialist or for whom the participant received consultation from family members, were selected as children with SEN. The participants were asked to answer the questionnaire according to the following procedure: (1) Using the class roster, mark children who the participants feel need to be supported (child with SEN). If there is more than one child with SEN in the same class, all children with SEN are marked. (2) With the exception of the child with SEN in (1), the participants mark a child without SEN by randomly pointing their finger at the class roster with their eyes closed. (3) Answer the questionnaire for the children marked with (1) and (2).

This study was approved by the ethics committee of Nagoya University, School of Health Sciences, based on the Helsinki Declaration (18-602).

Analysis

In this study, the sub-items of the ECBI were categorized in order to gain a more concrete understanding of the relationship between behavioral problems and sensory modulation functions in SEN children. We decided to classify the ECBI sub-items into three categories: oppositional defiant behavior toward adults, inattentive behavior, and conduct problem behavior, following the results of a previous study by Burns et al. that conducted a factor analysis of the ECBI [14].

IBM SPSS Statistics version 26 was used for statistical analysis. The ECBI intensity scores and SSP scores between children with and without SEN were compared using the Mann-Whitney U test. Correlations between ECBI intensity scores and SSP scores, as well as correlations between SSP domain scores, were examined using Spearman's rank correlation coefficient. The significance level was set at 5%. The effect size r was calculated by $Z/\sqrt{n}$. The effect size r is defined as small at 0.10 and above, moderate at 0.30 and above, and large at 0.50 and above [15].

Results

Forty of the 42 participants responded to the questionnaire, and the response rate was 95.2%. Data for 84 children with SEN and 42 children without SEN were collected from the questionnaire. An average of 2.1 (2 to 4) children with SEN was mentioned per participant. After removing the missing data, we finally obtained valid data for 80 children with SEN and 40 children without SEN.

The ECBI total intensity score of children with SEN was significantly higher than that of children without SEN ($p<0.01$). The effect size was 0.41, indicating a moderate size. In all three categories of ECBI that we classified, the intensity scores of children with SEN were significantly higher than those of children without SEN ($p<0.01$). The effect size of the conduct problem behavior was the smallest at 0.35, and the other items were above large size. Similarly, the total SSP score for children with SEN was significantly higher than that for children without SEN ($p<0.01$), and the effect size was larger at 0.79. The scores of children with SEN were also significantly higher than those of children without SEN in all seven domains of the SSP ($p<0.01$). Moderate effect sizes were found for taste/smell sensitivity and movement sensitivity, and large effect sizes were found for other domains (Table 1).

The relationship between each ECBI intensity score and each SSP score for children with SEN is shown in Table 2. The total score of SSP showed a significant positive correlation with all three ECBI category intensity scores ($p<0.01$). The SSP tactile sensitivity score was significantly positively correlated with ECBI intensity scores for oppositional defiant behavior toward adults ($rs=0.36$, $p<0.01$). The SSP underresponsive/seeks sensation score showed a significant positive correlation with all three ECBI category intensity scores ($p<0.05$), in particular, conduct problem behavior showed the strongest positive correlation ($rs=0.39$, $p<0.01$). The SSP auditory filtering score also showed significant positive correlations with the ECBI total intensity score and all three category intensity scores ($p<0.05$). Among them, inattentive behavior showed the strongest positive correlation ($rs=0.39$, $p<0.01$). The SSP low energy/weak score was significantly negatively correlated with the ECBI total intensity score ($p<0.05$).

Table 1. Comparison of ECBI and SSP scores between children with and without SEN

	Median (interquartile range)		Z	p	Effect size (r)
	Children without SEN (n=40)	Children with SEN (n=80)			
ECBI total intensity score	63 (46–82)	104.5 (77.5–128.5)	4.53	0.00**	0.41
ECBI category intensity score					
Oppositional defiant behavior toward adults	13 (10–18)	27.5 (18.75–42.25)	6.17	0.00**	0.56
Inattentive behavior	5.5 (4–8)	20 (14–23.25)	7.61	0.00**	0.7
Conduct problem behavior	10 (8–13)	16.5 (9–22)	3.81	0.00**	0.35
SSP total score	41 (38–43.25)	81.5 (69.75–96)	8.66	0.00**	0.79
SSP domain score					
Tactile sensitivity	7 (7–8)	11 (8–14.25)	6.03	0.00**	0.55
Taste/smell sensitivity	4 (4–5)	5 (4–7.25)	3.23	0.00**	0.3
Movement sensitivity	3 (3–4)	4 (3–6.25)	3.7	0.00**	0.34
Underresponsive/seeks sensation	7 (7–7)	18 (12–22)	7.88	0.00**	0.72
Auditory filtering	7 (6–7.25)	17 (13–20)	8.09	0.00**	0.74
Low energy/weak	6 (6–6.25)	17.5 (10–23)	7.38	0.00**	0.67
Auditory/visual sensitivity	5 (5–5)	8 (6–10)	6.9	0.00**	0.63

ECBI, Eyberg Child Behavior Inventory; SSP, Short Sensory Profile; SEN, special educational needs; Mann-Whitney U test, * p<0.05, ** p<0.01

Table 2. Relationship between each SSP score and each ECBI score in children with SEN

SSP \ ECBI	Total score	Oppositional defiant behavior toward adults	Inattentive behavior	Conduct problem behavior
Total score	0.09	0.32**	0.29**	0.29**
Tactile sensitivity	0.16	0.36**	0.02	0.15
Taste/smell sensitivity	–0.14	0.19	0.07	0.1
Movement sensitivity	–0.09	0.04	–0.12	–0.03
Underresponsive/seeks sensation	0.16	0.28*	0.28*	0.39**
Auditory filtering	0.20*	0.25*	0.39**	0.25*
Low energy/weak	–0.21*	0.05	0.19	0.08
Auditory/visual sensitivity	0.03	0.19	0.08	0.07

ECBI, Eyberg Child Behavior Inventory; SSP, Short Sensory Profile; SEN, special educational needs; Spearman's rank correlation coefficient, * p<0.05, ** p<0.01

The relationship between the SSP domain scores of children with SEN is shown in Table 3. Significant positive correlations were found between several domains, with the highest correlation coefficients between underresponsive/seeks sensation and auditory filtering (rs=0.59, p<0.01).

Discussions

Characteristics of sensory modulation and behavioral problem in preschool-aged children with SEN

The scores of SSP and ECBI were significantly higher among preschool-aged children with SEN than among children without SEN, suggesting that preschool-aged children with SEN have a larger bias

Table 3. Relationships between SSP each domain score for children with SEN

SSP domain	Tactile sensitivity	Taste/ smell sensitivity	Movement sensitivity	Underresponsive/ seeks sensation	Auditory filtering	Low energy/weak	Auditory/ visual sensitivity
Tactile sensitivity	1	0.09	0.43**	0.31**	0.29**	.16	.51**
Taste/smell sensitivity	0.09	1	0.24*	-0.02	0.04	.23*	.12
Movement sensitivity	0.43**	0.24*	1	0.04	0.19*	.29**	.23*
Underresponsive/seeks sensation	0.31**	-0.02	0.04	1	0.59**	.20*	.36**
Auditory filtering	0.29**	0.04	0.19*	0.59**	1	.30**	.35**
Low energy/weak	0.16	0.23*	0.29**	0.20*	0.30**	1	.24*
Auditory/visual sensitivity	0.51**	0.12	0.23*	0.36**	0.35**	.24*	1

SSP, Short Sensory Profile; SEN, special educational needs; Spearman's rank correlation coefficient, * $p<0.05$, ** $p<0.01$

in sensory modulation and behavioral problems than children without SEN. The characteristics of sensory modulation and behavioral problems in preschool-aged children with SEN have not been previously reported, and the results of this study are a new finding. It has already been reported that preschool-aged children with ASD have a bias in sensory modulation and behavioral problems compared with TD children [8, 16]. However, this study revealed that preschool-aged children with SEN also have a bias in sensory modulation and behavioral problems.

Green et al. reported that 66% of school-aged children with ASD and 32% of children with SEN had a strong sensory modulation bias on the SSP total score, and for children with SEN, a strong auditory filtering bias was present in 49%, which was the highest percentage of all domains [11]. The results of the present study showed that in preschool-aged children with SEN, all SSP domains scored significantly higher than those in children without SEN, with moderate effect sizes for taste/smell sensitivity and movement sensitivity domains and large effect sizes for the other domains. It is noteworthy that the auditory filtering domain showed the largest effect size (r=0.74), which is similar to that reported by Green et al. [11]. In addition, a study conducted by Stephanie et al. also points out the problem of audiovisual filtering in school-age children with SEN [17]. Preschool-aged children with SEN have a greater auditory filtering bias than children without SEN, and this bias is likely to continue into school years. In addition to auditory filtering, green et al. also reported a high percentage of children with SEN who showed a strong bias in underresponsive/seeks sensation and low energy/weak (32% and 28%, respectively) [11]. In the present study, underresponsive/seeks sensation and low energy/weak were also the items that showed the second largest effect size after auditory filtering. As with auditory filtering, it is likely that the characteristics of these two items from preschool age will continue into school age.

In the present study, we found the strongest positive correlation between underresponsive/seeks sensation and auditory filtering in terms of the association between SSP domains in SEN children (rs=0.59). However, in Baker et al.'s previous study of autistic children, no significant correlation was found between these two domains. On the other hand, Baker et al. reported that the strongest positive correlation was found between movement sensitivity and visual/auditory sensitivity [16]. In the present study, although a significant correlation was found between these two domains, the correlation coefficient was only rs=0.23. The difference between the results of Baker et al. and the present study may be due to differences in the characteristics of the subjects, but the relationship between the domains of SSP needs further investigation.

Similarly, for ECBI, children with SEN scored significantly higher than children without SEN in all three categories. The effect size was moderate for conduct problem behavior and large for oppositional defiant behavior and inattentive behavior. Caregivers have particular difficulty with social, attentional, and emotionally related behavioral problems, such as "disobedience," "roughness," "restlessness," and "spoiling," in their children [18]. The behavioral problems of preschool-aged children with SEN suggested in the present study may be one of the reasons why caregivers have difficulty coping with their behavior and feel the need for support.

Relationship between sensory modulation and behavior in preschool-aged children with SEN

For preschool-aged children with ASD, several studies have reported an increase in behavioral problems with greater bias in movement sensitivity, underresponsive/seeks sensation, auditory filtering, and low energy/weak domains of the SSP [16, 19, 20]. The results of the present study showed that the underresponsive/seeks sensation score of preschool-aged children with SEN was significantly positively correlated with all three category intensity scores of ECBI. The characteristics of preschool-aged children with SEN and ASD are similar in that the stronger the bias of underresponsive/seeks sensation domain, the stronger the behavioral problems. If the characteristics of underresponsive/seeks sensation are strong, these children's behavior may appear unpredictable because they overreact at some times and show no response at all at other times [13]. These characteristics may be perceived as inappropriate and disturbing to others. The auditory filtering score of preschool-aged children with SEN were significantly positively correlated with the ECBI total intensity score and all three categorical intensity scores, suggesting that preschool-aged children with SEN have similar characteristics to children with ASD in this respect as well. It has been suggested that children with auditory filtering difficulties are hypersensitive to sound or have a slower response to sound [13]. In this regard, a high percentage of children with ASD have auditory hyperesthesia [21, 22], and it has been pointed out that there is a need for an approach to the sensory modulation function in response to auditory stimuli [23]. The approach to sensory modulation is not only a direct approach to the child, but also an integrated approach to the sensory environment of the place, surroundings, and situation. In this study, inattentive behavior showed the strongest positive correlation with auditory filtering, suggesting that the sensory modulation approach to auditory stimuli may be particularly effective for inattentive behavior in children with SEN.

Thus, the children with SEN in this study showed some characteristics similar to the previously reported relationship between sensory modulation and behavior in children with ASD. Although this study excluded children who had been diagnosed with or were suspected of having some kind of disability, it should be noted that we cannot completely deny the possibility that there were children with ASD among the children with SEN included in this study.

Low energy/weak scores in preschool-aged children with SEN were significantly negatively correlated with total intensity score of ECBI. Since children who have strong characteristics of low energy/weak are considered to get tired easily [13], they may be less likely to engage in behaviors that are perceived by caregivers as dangerous or disruptive to group activities. Conversely, Baker et al. reported an increase in behavioral problems for preschool-aged children with ASD as the characteristics of low energy/weak increased. However, this previous study found a strong positive correlation between low energy/weak scores and underresponsive/seeks sensation domains in children with ASD ($r=0.65$) and, in addition, reported that seeks sensation features were strongly associated with the emergence of stereotyped behavior, and stereotyped behavior was also associated with the emergence of behavioral problems [16]. In the present study of preschool-aged children with SEN, the correlation between the low energy/weak score and the underresponsive/seeks sensation score was only weakly positive with $rs=0.20$. Therefore, the relationship between the characteristics of low energy/weak and behavioral problems may be different from those of children with ASD.

Behavioral problems increase with increased movement sensitivity in preschool-aged children with ASD [16]. Although, in this study, the movement sensitivity score did not correlate with the ECBI for each category score for the children with SEN, there was a significant difference in the movement sensitivity scores between children with and without SEN, but the effect size was smaller than the other domains. This suggests that the bias of movement sensitivity was not as strong as in the other domains and was not associated with behavioral problems for preschool-aged children with SEN.

Suggestions for occupational therapy for preschool-aged children with SEN

Since there is an association between sensory modulation and behavioral problems in preschool-aged children with SEN, an approach to sensory modulation may be an evidence for occupational therapy practice to promote adaptive behavior in preschool-aged children with SEN.

When occupational therapists visit nursery schools and other facilities to provide support to children with SEN, it may be possible to infer sensory modulation functions from information obtained from caregivers about behavioral problems in daily life, play, and communicative situations of children with SEN and suggest a direction for support. These reasoning processes may be useful when presenting a direction of support in a limited amount of time.

Occupational therapists who assess children with SEN at developmental support centers and hospitals need to practice occupational therapy that takes into account the differences in sensory environments, such as

local nursery schools.

Limitations and future directions

In this study, both ECBI and SSP were answered by the nursery teachers, not the children's parents. In other words, we need to be cautious about the fact that the answers are based on the child's behavior at the facility. It is possible that the participants have answered about children with SEN based on the usual life and play situations of children without SEN. In this study, we did not ask about the age and gender of the children to protect their personal information. Therefore, the effects of age and gender need to be examined in the future. The present study compared children with and without SEN, so the similarities between children with SEN and ASD are only hypotheses. To examine the hypotheses obtained from the present study, it is necessary to conduct a survey of preschool-aged children with SEN and ASD.

Conclusions

Preschool-aged children with SEN, except for those with a diagnosis, were shown to have more sensory modulation bias and behavioral problems than children without SEN. Preschool-aged children with SEN, except for those with a diagnosis, were shown to have more oppositional defiant behavior toward adults, inattentive behavior and conduct problem behavior when they had more biased sensory modulation of "underresponsive/seeks sensation" and "auditory filtering."

Declaration of Interest

The authors report no conflict of interest.

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■ORIGINAL ARTICLE

Motor Learning of Handwriting Using the Non-dominant Hand

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Abstract: To investigate the features associated with the mastery of neat and speedy handwriting, 23 healthy volunteers practiced writing with their non-dominant hand. The participants were randomly divided into two groups. One group (n = 12) started writing simple symbols such as dashes, circles, and triangles (−, ○, and △) and then after 1 week, advanced to writing individual characters. The other group (n = 11) started by copying entire sentences. The practice period lasted 4 weeks (7 days/week). Results showed no major differences between the groups in terms of handwriting learning effectiveness; however, there was a trade-off between the speed at which the participants wrote and the neatness of their writing. These findings suggest that the process of learning to master handwriting is consistent with the Fitts's law.

Keywords: non-dominant hand, handwriting, motor learning

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Introduction

In the field of occupational therapy, patients who lose functionality in their dominant hand due to disease or injury are often provided with guidance regarding the transfer of hand-dominance. When the objective of such a therapy is to regain the ability to write, for example in cases where returning to work is expected or when writing is an essential method of communication, the motor learning of handwriting is frequently part of the therapy program.

Chinese characters (*kanji*) were imported to Japan from China via the Korean peninsula during the 5th and 6th centuries CE. Based on these characters, two types of syllabaries (*hiragana* and *katakana*) were developed in Japan around the 9th century CE. These three character types are commonly used in Japan. Thus, Japanese patients who need to learn handwriting have to master these three character types.

Mastering handwriting requires both speed and neatness. Generally, practice progresses in the steps of increasing difficulty, beginning with simple outlined shapes (such as −, |, /, ×, and ○), then advancing to *kanji*, which comprises straight lines (三, 川, 日, 田, and 目), and finally to more complex *kanji* and the *hiragana* syllabary. [1−3] An alternative approach is "random practice," one aspect of R.A. Schmidt's theory of motor learning;[4,15] this entails the simultaneous practice of tasks at different levels of difficulty. Although progress is generally slower, this method is considered to be more effective than the block practice method for the retention of skills and the transfer of skills to practical problems. [4, 5]

Many occupational therapists utilize block practice, which involves initiating practice with simple tasks such as coloring in outlines and then advancing to writing characters, because they have more experience with this method. [1−3] However, only a few studies have investigated effective methods for improving handwriting speed and neatness through practice. In the present study, we compared the motor learning efficacy using the block and random practice methods for the development of handwriting proficiency among individuals

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undergoing hand-dominance transfer therapy. The aim of this investigation was to identify the factors which influences the motor learning of handwriting.

Methods

Participants

The study enrolled 23 healthy volunteers who used their right hand when performing common, everyday activities such as holding a pencil when writing, holding chopsticks when eating, or throwing a ball. None of the participants underwent hand-dominance transfer from their left to their right hands during childhood. Three participants were males and 20 were females. Their mean age was 20.7 ± 0.5 years. The participants were randomly assigned to two groups. The 23 participants began by writing symbols such as −, ○, and △. Subsequently, 12 subjects advanced to *kanji* (consisting of only three strokes), *hiragana*, and then sentence copying. As these tasks became increasingly difficult, these 12 participants were placed in the block practice group. Eleven participants were placed in the random practice group in which they were made to practice sentence copying from the beginning. Participants were randomly assigned to the groups.

This study was approved by the Institutional Review Board of the Kinjo University (no. 27−16). The participants were provided with the descriptions of study contents and methods. Moreover, the participants provided written informed consent before participation.

Procedures

Each day during the 4-week practice period, the participants wrote 200 characters in horizontal lines using HB pencils. The paper was lined with a grid of 1 × 1 cm squares. Because the study aimed to investigate the motor learning process when writing was practiced to gain speed and neatness, the participants were not provided with any instructions except for a description of the characters that were required to be practiced.

For the block practice group, the specific type of practice was changed according to pre-determined steps: during week 1, they practiced symbols (e.g., +, ×, and ○); during week 2, they practiced *kanji* involving strokes (e.g., 川, 三, and 口); during week 3, they practiced *hiragana*; and during week 4, they copied sentences on general topics (of a third grade elementary school level as indicated by the Japanese Ministry of Education, Culture, Sports, Science and Technology)6. In contrast, the random practice group practiced copying entire sentences on general topics throughout the practice period.

For both the groups, the sentences on general topics were of third grade elementary school level, as indicated by the Japanese Ministry of Education, Culture, Sports, Science and Technology, and included kanji with higher numbers of strokes. The level of difficulty of each task was determined by five occupational therapists and was based on the Japanese Ministry of Education, Culture, Sports, Science and Technology's Elementary School Curriculum for the Japanese Language.[6]

Outcome measures

The sentences on general topic of a sixth grade elementary school level, which included *kanji* with higher numbers of strokes, were practiced on paper lined with a 1 × 1 cm grid using HB pencils.

Seven assessments were conducted: at the baseline (T0), at the end of each week during the practice period (T1, T2, T3, T4; total 4 h), a week after the end of the practice period (T5), and 2 weeks after the end of the practice period (T6) (Figure 1).

There were two outcome measures: the number of

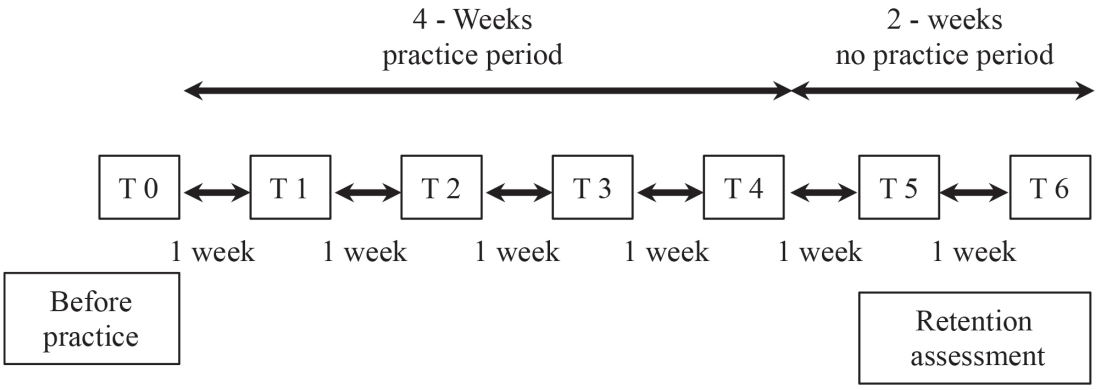
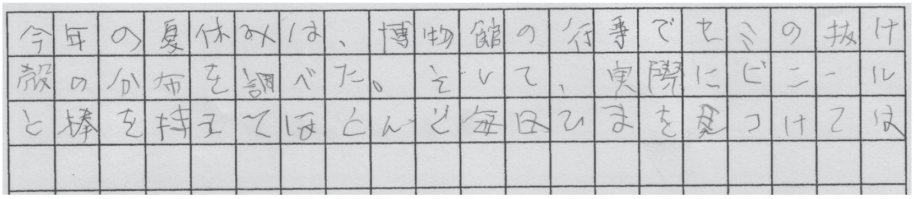


Figure 1. Writing practice period and assessment points.

The assessment was carried out seven times; before practice (Time0: T0), the end of each week (T1, T2, T3, T4, total four hours), a week after the end of the practice (T5), and two weeks after the end of the practice (T6).

Table 1. An example of character neatness scores



		Evaluator1	Evaluator2
hiragana	overlappong of lines	5	4
	wobbly lines	2	2
	correct usage of "stops" and "upward turns"	3	3
	downward sloping characters	3	3
	balance between *kanji* and ather characters	3	3
katakana	overlappong of lines	4	4
	wobbly lines	3	3
	correct usage of "stops" and "upward turns"	2	2
	downward sloping characters	4	3
	balance between *kanji* and ather characters	3	3
kanji(comprising≤7 strokes)	overlappong of lines	4	4
	wobbly lines	3	3
	correct usage of "stops" and "upward turns"	2	2
	downward sloping characters	2	2
	balance between *kanji* and ather characters	3	3
kanji(comprising≥8 strokes)	overlappong of lines	2	2
	wobbly lines	2	2
	correct usage of "stops" and "upward turns"	2	2
	downward sloping characters	3	3
	balance between *kanji* and ather characters	2	2
Character neatness scores : total		57	55
Character neatness scores: mean		**56.0**	

The baseline (T0) evaluation results of female (21 years old) in the random practice group are shown. Each of these features were scored from 1 to 5 (5 = good), and the total scores were calculated. The number of characters that this subject could write within the evaluation time was 30.

characters written and the neatness with which the characters were written.

The number of characters written was assessed by counting the number of characters the participants were able to copy within a time limit of 150 s. Character neatness was assessed using a method that was devised by us and was based on the Elementary School Curriculum for the Japanese Language of the Japanese Ministry of Education, Culture, Sports, Science and Technology. [6] The characters were divided into the following four groups for assessment: *hiragana*, *katakana*, *kanji* comprising ≤7 strokes, and *kanji* comprising ≥8 strokes. The assessments were based on the following features: the overlapping of lines; wobbly lines; the correct usage of "stops" and "upward turns"; downward sloping characters; and the balance between *kanji* and other characters, examining whether the *kanji* were more prominent than others. Each of these features were scored from 1 to 5 (5 = good), and the total scores were calculated. The maximum total score was 100. Higher scores indicated that the characters were neatly and skillfully written.

Table 1 shows the example of scoring. This subject was a 21 years old female in random practice group, copied 30 hand writing characters at baseline (T0) evaluation.

Two evaluators independently assessed character neatness, and the final character neatness scores were the mean scores of the two evaluators. The degree to which the two evaluators' scores matched was investigated by calculating intraclass correlation coefficients for each time point.

Statistical analysis

The character neatness scores of the two groups

at each time point were compared using the Mann–Whitney U test. Chronological changes were examined using the Friedman and Wilcoxon rank sum tests. In addition, the relationship between the number of characters written and character neatness was examined using the Spearman rank correlation coefficient analysis. The level of statistical significance was set at $p < 0.05$. The analyses were performed using Microsoft Excel for Mac 2016 (Microsoft) and JMP 14.0 MAC (SAS Institute Inc.).

Results

There was good correlation between the scores of the two evaluators for character neatness at each time point, with intraclass correlation coefficients between 0.67 and 0.82 (Table 2). Also, there was not significant difference between the scores of the two evaluators at each time point.

Comparisons of the number of characters written within 150 s and character neatness scores at each time point showed a significant difference between the two groups only in the number of characters at week 1 (Tables 3). No other significant differences were observed between the groups at any other time points (Tables 4).

In both groups, the number of characters written in 150 s increased gradually from the baseline to the final retention assessment ($p < 0.05$; Table 3). Character neatness scores in the block practice group showed a significant difference only between the week 4 assessment and the final retention assessment ($p < 0.05$), with no significant differences observed between any other time points (Table 4). In the random practice group, there were significant differences in character neatness scores between the week 1 and week 4 assessments and

Table 2. ICC between two evaluators on the results of the neat of characters which the leaners wrote

	Evaluator A		Evaluator B		
	Minimum ～ Maximum	Median	Minimum ～ Maximum	Median	ICC
T0	42 ～ 79	60	35 ～ 78	61	0.67
T1	43 ～ 91	60	35 ～ 81	56	0.72
T2	47 ～ 79	65	32 ～ 82	64	0.82
T3	41 ～ 91	68	33 ～ 94	59	0.77
T4	42 ～ 93	71	45 ～ 92	61	0.80
T5	40 ～ 83	67	35 ～ 92	60	0.77
T6	40 ～ 81	63	45 ～ 91	57	0.77

The values represent average of the scores determined by the two evaluators.

Table 3. The change with time on the numbers of characters which the learners wrote about two practice groups

		Block practice group		Random practice group		Both groups comparison
		Minimum ～ Maximum	Median	Minimum ～ Maximum	Median	
Before practice	T0	26 ～ 50	40	25 ～ 60	42	n.s.
	T1	25 ～ 59	45	33 ～ 71	57	p<0.05
	T2	34 ～ 63	53	40 ～ 72	62	n.s.
	T3	26 ～ 72	52	29 ～ 73	63	n.s.
	T4	37 ～ 68	56	33 ～ 74	64	n.s.
Retention assessment	T5	29 ～ 82	56	32 ～ 84	66	n.s.
	T6	32 ～ 78	58	35 ～ 83	63	n.s.

Values indicate the numbers of characters which by participants.
(* : $p < 0.05$ n.s. : not significant)

Table 4. The change with time on the neat of characters the learners wrote on two practices groups

		Block practice group			Random practice group			Both groups comparison
		Minimum ～ Maximum	Median		Minimum ～ Maximum	Median		
Before practice	T0	43.5 ～ 77.0	61.0		44.5 ～ 74.5	57.5		n.s.
	T1	42.5 ～ 85.5	64.5		45.0 ～ 77.5	58.5		n.s.
	T2	45.0 ～ 79.0	66.5		39.5 ～ 77.0	55.5	*	n.s.
	T3	52.0 ～ 81.5	66.3		37.0 ～ 92.5	61.0		n.s.
	T4	52.0 ～ 79.0	66.3		45.0 ～ 92.5	62.0		n.s.
Retention assessment	T5	43.5 ～ 78.5	64.0	*	37.5 ～ 86.0	60.0	*	n.s.
	T6	41.0 ～ 83.0	60.3		40.0 ～ 83.5	56.5		n.s.

Values indicate the neatness of characters written by participants.
(* : $p < 0.05$ n.s. : not significant)

between the week 4 assessment and the final retention assessment ($p < 0.05$), but there were no significant differences between any other assessments (Table 4).

The mean numbers of characters written in 150 s and character neatness scores in the two groups were subtracted from each case and the relationship between the scores at each time point was investigated. Scatter plots of these individual values showed that many individual scores at the baseline were in the vicinity of the mean scores and that the participants with a gradual increase in the number of characters written in 150 s showed a decrease in the rate of improvement in their character neatness scores. On the contrary, participants whose rate of increase in the number of characters declined showed a tendency toward improvement in their character neatness scores (Figure 2). There was no difference between the groups in this trend.

The correlation analysis resulted in the following

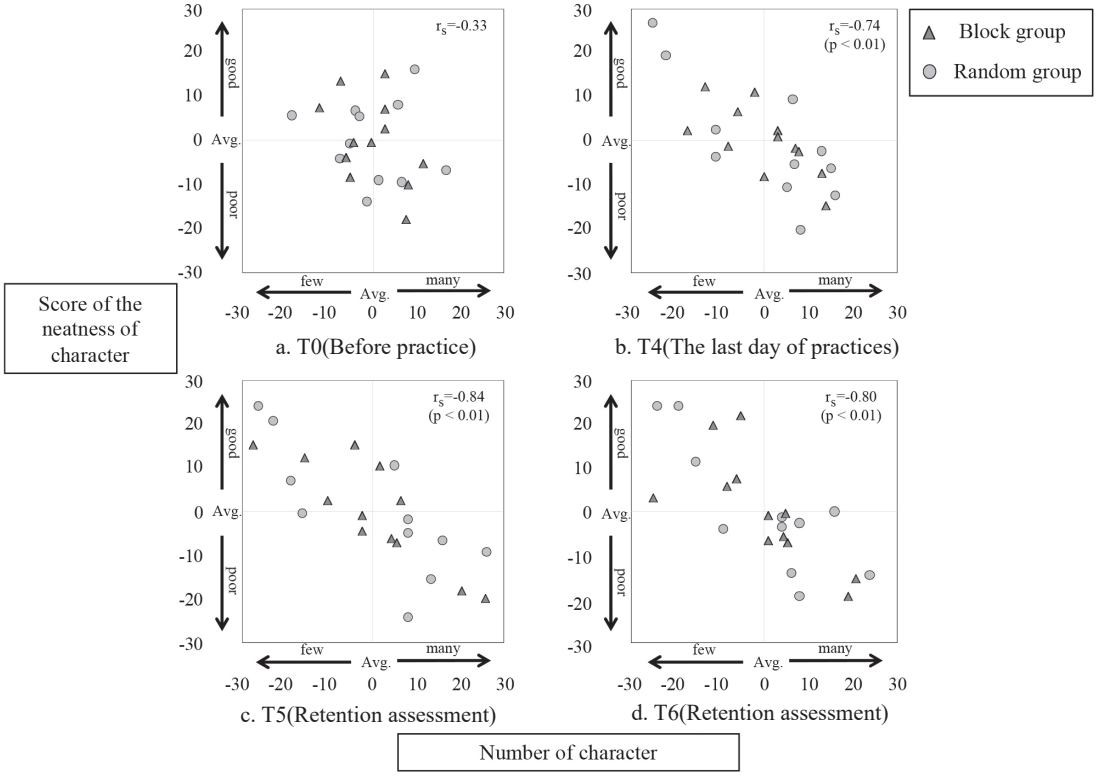


Figure 2. The correlation between the numbers of characters and the neat of characters.

Spearman rank correlation coefficients: baseline, −0.33; week 1, −0.57 ($p < 0.01$); week 2, −0.70 ($p < 0.01$); week 3, −0.73 ($p < 0.01$); week 4, −0.74 ($p < 0.01$); retention assessment 1, −0.84 ($p < 0.01$); and retention assessment 2, −0.80 ($p < 0.01$) (Figure 2).

Discussion

For performing activities of daily living, it is important to be able to write at a standard speed and with a certain neatness so as to make the writing legible to others.[7–9] Many studies have assessed the mastery of handwriting by assessing the speed at which the individual writes, the pressure applied, and the accuracy (neatness) of the writing. Reportedly, computers have been used to assess accuracy by measuring one representative character.[10,11] Moreover, studies have reported the use of computers with character-reading softwares, using which the participants' writing samples were scanned and entered into the computer and the percentage of characters that the program could recognize were assessed.[12,13] Many studies have assessed writing speed using methods that are easy to implement in clinical settings. In contrast, although there many methods for assessing the accuracy (neatness) of characters, methods that utilize computers may not be easy to use in clinical settings.

In the present study, we utilized assessment methods that do not require any kind of device and thus are easy to implement in clinical settings. Using these methods, we counted the number of characters that could be copied within a pre-determined time period (150 s) to assess writing speed. Because there is no existing method for objectively assessing character neatness, we developed a quantitative method to assess the same. An investigation of the reproducibility of our method indicated good concordance in the scores that were independently determined by the two evaluators with intraclass correlation coefficients between 0.67 and 0.82, indicating generally good reliability. To further improve reliability, we utilized the mean values of the scores determined by the two evaluators in the analyses. In addition, writing is a quiet activity, hence statue and muscle strength do not impact significantly. In this research the majority of our subjects were women, therefore we did not compare male versus female.

Differences in the practice methods used to learn a skill can have a major effect on the level of mastery of that skill.[4,5] In the present study, we compared the efficacy for learning handwriting using block and random practice methods with a particular focus on the speed and neatness with which the participants were able to write characters. We did not observe any clear differences between the two groups in terms of learning efficacy. However, the components that express handwriting performance are not limited to speed and neatness alone. They also include the way the pencil is held, a fine control of pencil, the shape of the hand, the pressure with which the pencil is held and used, and various other elements.[8–13] The writer's attitude and objectives also have an effect on learning efficacy.[2] For example, a writer may have in mind a goal of writing quickly or neatly. The elements that are required to learn handwriting may not indicate the same degree of mastery. In addition, it has been reported that at least 60 min of practice per day is required to master handwriting and that the acquisition of a serviceable speed requires 3 months whereas acquiring the ability to write neatly requires 6 months of practice.[2] Thus, mastering handwriting with a high degree of motor skill takes more than the 4-week practice period utilized in the present study, which presumably is too short to acquire this mastery. This may be one reason why we did not observe a difference between the two groups in terms of learning efficacy.

On the contrary, by contrasting the number of characters and neatness, it was noted that participants who had poor rates of improvement in the number of characters written in the time limit tended to show improved character neatness scores. The number of characters and speed was negatively correlated, with increasing significance as the practice process continued on. This suggested a trade-off between writing speed and character neatness. No difference was found by the different practice methods used. The same relationship was maintained at the retention assessments conducted after the end of the practice period. This suggests that it was difficult for the subjects to learn writing speed and neatness simultaneously.

The number of characters written indicates 'motor speed', while the neatness score indicates 'motor precision'. According to Paul M. Fitts, "when required motor precision is increased, it results in longer time for motor action (he Fitts's law,[4,15])". Similarly, this research result of trade-off relationship between the number of characters and writing speed suggests that the handwriting speed and neatness undergo a learning process consistent with the Fitts's law, regardless of the learning method used.

No objectives or other instructions regarding learning handwriting were provided to the participants. The results of this study suggest that this may have had an effect on whether they emphasized speed or neatness as they learned. We intend to further study the characteristics of mastering handwriting with the non-dominant hand over longer practice periods and by instructing the participants to emphasize either speed or neatness as an

objective of learning.

Conclusion

To investigate the characteristics of mastering handwriting, we compared learning effects in the terms of the number of characters that could be written within a time limit and character neatness over a 4-week practice period between the two groups: block practice group, in which practice began with simple symbols and then gradually progressed to more difficult tasks, and random practice group, in which entire sentences were copied from the beginning. The reason for focusing on speed and neatness was that mastering handwriting includes various components such as handwriting speed, neatness, pencil pressure, and hand shape and that simultaneously learning all of these may not provide results that represent the learning process. However, focusing these two characteristics may be one reason why we did not observe any major differences between the groups in terms of learning efficacy. It is also possible that the 4-week practice period utilized in this study was insufficient for revealing any differences in the learning efficacy between the two methods. Nevertheless, we observed a trade-off between handwriting speed and neatness, which was consistent with the Fitts's law.

Declaration of conflicting interests

The authors of this study have no conflicts of interest to declare.

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■ORIGINAL ARTICLE

Factors Related to the Visual Information Processing of Children with Learning Disabilities Who Have Difficulty Acquiring Kanji Writing: Features Revealed by the Rey–Osterrieth Complex Figure Test

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Abstract: The Rey–Osterrieth complex figure test drawings of 68 children with learning disabilities who have difficulty acquiring kanji writing were evaluated using Osterrieth's scoring system (accuracy scale) and the organizational scoring system (drawing strategy scale) to understand the factors involved in their visual information processing. After 1 week or more, a second evaluation was performed with a color-coded setting for the components in the figure. The scores of each scale were normalized into z-scores. Using the z-scores as the dependent variables, a two-factor analysis of variance was performed for the color-coding and evaluation scale factors. Children with learning disabilities who have difficulty learning kanji writing had a problem with perceiving the components of the figure as a unit, which suggests that they found it difficult to recall the figure. It is considered that the factor involved in the visual information processing of children with learning disabilities who have difficulty acquiring kanji writing is largely influenced by the disability in using the composition strategy that promotes recall. A comparison of the evaluation results, based on the presence or absence of attention-deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD), suggests that children with ADHD and ASD tend to be more affected by the impaired use of composition strategies.

Keywords: Rey–Osterrieth complex figure, learning disabilities, kanji writing, visual information processing

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Introduction

There are three different characters in Japanese: hiragana and katakana, which are phonetic characters, and kanji, which are ideographic characters. In the former two characters, there is a one-to-one correspondence between the letters and sounds. For example, the hiragana "あ" is pronounced only as "a," and the katakana "ア" is also pronounced only as "a." On the other hand, most kanji characters do not correspond to a specific sound. For example, the kanji "男 (male)" is pronounced as "otoko" or "dan" depending on the context.

Compared to the other characters, kanji generally have more strokes and are more complicated in form. For example, the number of strokes of the kanji "鬱 (depression)" is as many as 29. Most kanji are divided into two or more components: left and right or up and down. For example, the kanji "男 (male)" is a combination of "田 (paddy)" and "力 (force)."

Japanese students are required to learn 1,026 kanji in elementary school and 1,110 in junior high school. However, Uno *et al*. [1] found that 6.1% of children with learning disabilities (LD) had difficulty acquiring kanji writing, which was higher than for the acquisition of hiragana (1.6%) and katakana (3.8%). Furthermore, learning kanji writing may be a major cause of learned helplessness in children with LD [2].

Wakamiya (2017) [3] suggested that some brain functions that are involved in visual information pro-

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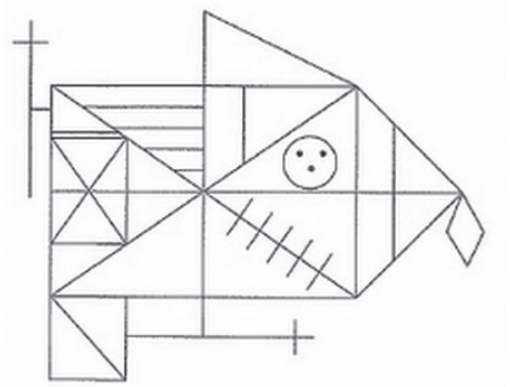

Fig. 1. Rey–Osterrieth complex figure

cessing may be related to writing and the perception of quantity, and that deficits in these functions cause LD. In particular, he focused on the large variety of characters used in Japanese orthography and their morphological complexity and assumed that they place a heavy burden on morphological perception and recognition.

The Rey–Osterrieth complex figure (ROCF) test (Fig. 1) is often used as a test of visual information processing in case studies of children with LD who have difficulty acquiring kanji [4−10]. In the ROCF test, Osterrieth's (1944) [11] scoring system (hereinafter referred to as "the accuracy scale") is generally used, which evaluates the accuracy of the morphology and position. Based on this accuracy scale, the factors that hinder the acquisition of kanji writing have been identified as impaired figure recall [4,7] and impaired visual cognition and figure recall [5]. However, no impairments of visual cognition or figure recall were found when the accuracy scale was used in another study [8,9].

On the other hand, Hashimoto *et al*. (2006) [6] used the organizational scoring system (hereinafter referred to as "the drawing strategy scale") that was devised by Chervinsky, *et al*. (1992) [12], which is a scale for evaluating the composition strategy in terms of how many components of the figure are drawn together. This drawing strategy scale evaluates planning among executive functions [13]. By using this scale, they were able to identify that it is difficult for a child with attention-deficit hyperactivity disorder (ADHD) and developmental coordination disorder (DCD) to acquire kanji writing because of the impaired use of composition strategies that promote recall. Usually, kanji is acquired through visual copying that combines the overall picture and the components of the character (e.g., the kanji "男" is learned as both the "田" and "力" components), but children with LD just copy the entire character as the figure. Separately, Onishi and Kumagai (2019) [10] reported that four children who had LD and difficulty acquiring kanji writing all showed impaired use of the composition strategy, which suggests the need for learning guidance that takes into account the composition strategy for children who have LD and difficulty acquiring kanji writing. Onishi and Kumagai (2019) [10] considered the composition strategy and reported the learning effect of giving guidance by color-coding each stroke of the kanji so that the components can be easily recognized.

In fact, a unified view of the factors that hinder the acquisition of kanji writing has not been established, and there are different interpretations depending on the evaluation scale that is used. To consider effective support for these children, it is necessary to understand what visual information processing factors affect their learning of kanji writing.

Therefore, the purpose of this study was to identify the hindering factors in children with LD who have difficulty acquiring kanji writing by evaluating their ROCF using both the accuracy and drawing strategy scales, which specifically focus on the aspects of visual recognition/recall and composition strategy. This study is the first to employ both scales when investigating the factors that influence the acquisition of kanji writing in children with LD.

As per Onishi and Kumagai (2019) [10], who considered the composition strategy and the learning effect, we will confirm the effect of considering the composition strategy on the figure recall performance by color-coding the components of the Rey complex figure.

Many studies have reported executive dysfunction in children with ADHD and autism spectrum disorder (ASD) [14−15]. Some of these studies used the Rey's complex figures [15−17]. Furthermore, McGee *et al*. (1989) [18] reported that children with reading disabilities (RD) and attention deficit disorder (ADD) had lower recall performance in the ROCF test than children with RD alone. Oka (2017) [19] stated that ASD and ADHD are associated with cognitive dysfunctions including executive dysfunction, and the cognitive traits become more complicated in cases with LD. Therefore, we will also examine the effect of the presence or absence of ADHD or ASD on the accuracy scale and the drawing strategy scale.

Methods

Participants

Sixty-eight elementary school children (boys = 54, girls = 14; second grade (7 to 8 years of age) = 13, third grade (8 to 9 years) = 22, fourth grade (9 to 10 years) = 15, fifth grade (10 to 11 years) = 12, sixth grade (11 to 12 years) = 6) who met the test conditions (1) to (4) (see below) were retrospectively selected from medical

charts. The test conditions were as follows:

(1) Children from second to sixth grade who were native Japanese speakers and attend the X medical facility.

(2) Children with an intelligence quotient (IQ) of 85 or higher on the Wechsler Intelligence Scale for Children-Fourth Edition's Full-Scale IQ, the second edition of the Kaufman Assessment Battery for Children's cognitive comprehension scale, or the Tanaka–Binet Intelligence Scale-V.

(3) Children whose writing grades in kanji were in the 25th percentile or less in the Screening Test of Reading and Writing for Japanese Primary School Children [20].

(4) Children who had been diagnosed with LD by a doctor.

Procedure

The ROCF test was conducted face-to-face on the first day of occupational therapy in the occupational therapy room. A therapist explained how to perform the test, and the participant copied a sample figure on A4 size paper with a pencil. After the copying was completed, the therapist collected the sample figure and the copy. After 3 minutes, the therapist handed another sheet of A4 paper to the participants and instructed them to recall (remember and draw) the copied figure.

After 1 week or more, the ROCF test was performed again in the same setting and using a similar process (Fig. 2) although the components of the drawing were coded in different colors. Regarding the color coding of each component of the figure, we took care not to intersect the lines of the same color, and confirmed that even a person with color weakness can recognize the components.

The participants were instructed not to rotate the paper during the test. If a mistake was made, the use of an eraser was prohibited but drawing a double line and redrawing was allowed. The therapist used an iPad to record a video only during the copying process. The video was employed for the scoring when using the drawing strategy scale.

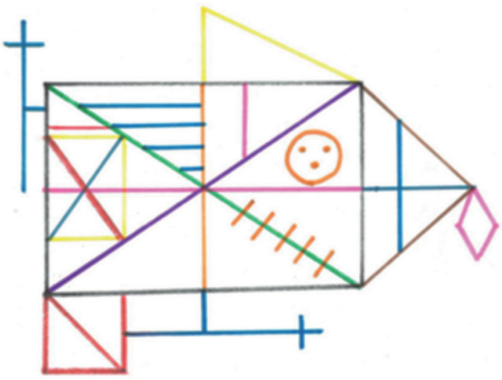

Fig. 2. Rey–Osterrieth complex figure (with color-coded settings for each component)

Evaluation of the participants' performance in the ROCF test

Accuracy scale

The copying and recall were evaluated using Osterrieth's scoring system, which divides the ROCF into 18 units and evaluates the accuracy of their morphologies and positions. For example, if a large rectangular unit is drawn correctly in terms of morphology and position, 2 points will be given to the unit, but if either the morphology or position is wrong, 1 point will be given. If it is wrong in terms of both morphology and position, 0.5 points will be given. In short, the score is determined depending on how accurately the figure is drawn. The maximum scale score is 36 points.

Drawing strategy scale

Only the task of copying is evaluated when using Chervinsky's organizational scoring system, which divides the ROCF into six sections and evaluates how many components of each section are drawn. For example, in the first section, if the participant draws a large rectangle with diagonal, horizontal, and vertical lines inside it, he/she will be awarded 15 points. If he/she draws only a rectangle and moves on to another section, he/she will be given only 5 points. In other words, the score is determined by how many components of the figure are included in the drawing. The scale score was calculated using the scoring method of Hattori (2004) [21] with a maximum of 54 points.

Statistical analysis

The ROCF scale scores of the 68 participants were normalized to standard *z*-scores in reference to Hattori (2004) [21]. To evaluate the factors related to the visual information processing in the ROCF test of the children with learning disabilities who have difficulty acquiring kanji writing, in terms of both the accuracy and drawing strategy scales, a two-factor analysis of variance was performed among the participants for the color-coding factors (with or without color coding) and evaluation scale factors (Table 1); that is, the copying-drawing strategy, copying-accuracy, and recall-accuracy. The Bonferroni test was used as the post-hoc test.

In addition, 68 study participants were grouped according to their diagnosis of ADHD and ASD. The test results and IQ were compared by one factor variance analysis. The Bonferroni test was used as the post-

Table 1. The combination of the task content and evaluation scale factors in the Rey–Osterrieth complex figure test

	Scale	
	Drawing strategy	Accuracy
Copying	○	○
Recall		○

hoc test. The R (version 3.5.1) free statistical analysis software was used for the statistical analysis. The significance level was set to 5%.

Ethical considerations

This study was conducted with the approval of the Research Ethics Committee of the institution to which the first author belongs. The relevant tests were agreed upon by the participants and their parents.

Results

Breakdown of the participants' diagnoses

All 68 eligible children were diagnosed with LD. Of these, 12 were diagnosed with LD alone, ,6 with at ADHD, 22 with ASD, one with DCD and 27 with combined ADHD and ASD (Fig. 3).

Relationship between the figure's color-coding factors and evaluation scale factors

The basic statistics of the *z*-score for the figure's color-coding and evaluation scale factors were calculated (Table 2). To investigate the factors that are related to the visual information processing of the children with learning disabilities who have difficulty acquiring kanji writing, a two-factor analysis of variance was performed for the color-coding factors (with or without color coding) and evaluation scale factors (copying-drawing strategy, copying-accuracy, and recall-accuracy). A significant interaction was found (Fig. 4), which suggested that the relationships between the factors were strong ($F(2, 134) = 28.93$, $p < .01$, $\eta_p^2 = .30$).

In the test of the simple main effect of the col-

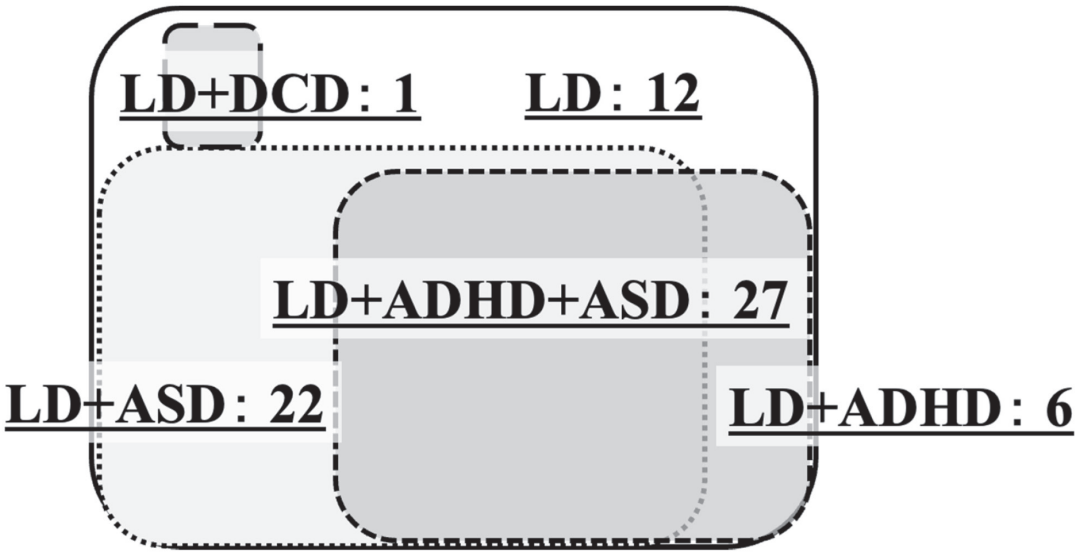

Fig. 3. Breakdown of the diagnoses of the 68 participants. LD = learning disabilities alone; DCD = developmental coordination disorder; ADHD = attention deficit hyperactivity disorder; ASD = autism spectrum disorder.

Table 2. Average value and standard deviation of the z-scores for each factor of the visual information processing and figure's color coding

	Copying-drawing starategy		Copying-accuracy		Recall-accuracy	
	M	*SD*	*M*	*SD*	*M*	*SD*
Without color code	-1.06	1.43	-0.24	1.12	-0.96	1.07
With color code	0.66	1.32	-0.07	1.10	0.00	0.96

M = mean; *SD* = standard deviation.

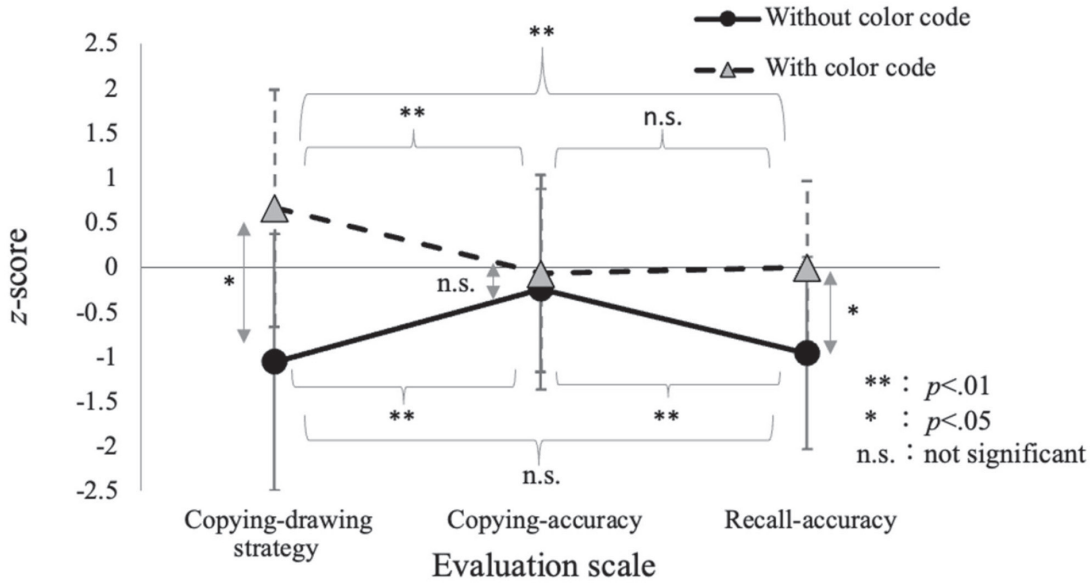

Fig. 4. Average z-score for each of the color-coding factors and evaluation scale factors of the figures

or-coding factors, the copying-drawing strategy and recall-accuracy were significant at the 1% level (F (1, 67) = 63.83, η_p^2 = .49; F (1, 67) = 98.20, η_p^2 = .59). In the simple main effect test of the evaluation scale factors, both with and without color coding were significant at the 1% level (F (2, 134) = 11.29, η_p^2 = .14; F (2, 134) = 12.03, η_p^2 = .15).

The multiple comparison that involved the Bonferroni test indicated that the z-score of copying-accuracy was significantly higher than that of the copying-drawing strategy and recall-accuracy at the 5% level in the condition without color coding. In the color-coded condition, the z-score of the copying-drawing strategy was significantly higher at the 5% level than the copying-accuracy and recall-accuracy.

The effects of ADHD and ASD comorbidity

Of the 68 study participants, 67 excluding one both with LD and DCD were analyzed. There were 12 children in the LD only group, 6 in the LD with ADHD group, 22 in the LD with ASD group, and 27 in the LD with ADHD and ASD group. The test results and IQ were divided into the 4 groups and compared by one factor variance analysis. (Table 3). A significant difference at 5% was found only for the copying-drawing strategy under the condition without color coding (F (3,63) = 3.03, p<.05, η^2= .13). Bonferroni's multiple comparison results showed no significant difference at the 5% level, but there was a significant tendency at the 10% level. The LD with ADHD and ASD group tended to have a lower z-score than the LD only group, and the LD with ASD group (Table 3).

Discussion

To clarify the factors that are related to the visual

Table 3. Differences in the evaluation results depending on the children's diagnoses

		LD (1) (n=12)		LD+ADHD (2) (n=6)		LD+ASD (3) (n=22)		LD+ADHD+ASD (4) (n=27)				
	Scale	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*η2*	*Post hoc*
IQ		95.83	7.32	101.50	12.53	100.73	13.39	100.96	10.92	0.66		
Without color coding	Copying-drawing strategy	-0.58	1.17	-0.67	1.10	-0.72	1.35	-1.70	1.52	3.03 *	0.13	(1) > (4)† , (3) > (4)†
	Copying-accuracy	0.06	1.31	0.12	0.91	-0.29	1.13	-0.41	1.13	0.69		
	Recall-accuracy	-1.09	1.02	-0.46	0.63	-1.19	1.24	-0.85	1.06	0.88		
With color coding	Copying-drawing strategy	0.62	1.34	0.66	1.33	0.88	1.38	0.54	1.35	0.27		
	Copying-accuracy	-0.27	1.37	0.28	1.06	-0.04	1.10	-0.06	1.03	0.33		
	Recall-accuracy	-0.09	1.07	0.82	0.70	-0.27	1.07	0.07	0.83	2.15		

LD, learning disabilities alone; ADHD, attention deficit hyperactivity disorder; ASD, autism spectrum disorder; IQ, intelligence quotient; M, mean; SD, standard deviation.
* p<.05. † p<.10.

information processing of children with learning disabilities who have difficulty acquiring kanji writing, their ROCF were evaluated using both an accuracy scale and drawing strategy scale. A two-factor analysis of variance of the figure's color-coding factors and evaluation scale factors revealed that the interaction was significant with a large effect size ($\eta_p^2 = .30$).

In the normal test method without color coding, the *z*-score for copying-accuracy was significantly higher than for the copying-drawing strategy and recall-accuracy. This suggests that children with learning disabilities who have difficulty acquiring kanji writing are not unable to accurately copy (copying-accuracy) the morphology and position of the figures but that they have difficulty copying all of the components of the figures (copying-drawing strategy), efficiently committing them to memory, and hence remembering them (recall-accuracy). This may correspond to "the impaired use of composition strategies that promote recall" as described by Hashimoto *et al*. (2006) [6]. The results suggest that many of the 68 children could not perceive the components of the figure as a unit and that they found it difficult to efficiently remember them because they tended to copy by piecing together the details. When writing kanji, such children do not copy the kanji "男" by perceiving the components of "田" and "力"; they copy it as a simple figure instead. Since the copied kanji cannot be efficiently memorized, it becomes more difficult to remember as the number of character strokes increases.

On the other hand, the test of the simple main effect for the color-coding factors of the figure found no significant difference in the copying-accuracy, whereas the copying-drawing strategy and recall-accuracy with color coding were significantly higher. The multiple comparisons indicated that there was no significant difference between copying-accuracy and recall-accuracy in the color-coding condition. This finding suggests that the color coding of the figure's components makes it easier to perceive them and that it compensates for the disability in using the composition strategy that promotes the recall of the figure. Therefore, when learning kanji writing, it may also be easier to memorize the components of a character by using color coding.

In this study, the children who visited the facility to which the first author belongs first experienced the without color-coding condition and then the color-coding condition, which means that the influence of iterative learning on the effect of the color coding of the figure cannot be denied, and that there is a limit to the generalization of the results. However, the test of the simple main effect of the color coding of the figure found no significant difference in the copying-accuracy. It is therefore considered that the influence of the color coding of the figure is larger than the influence of iterative learning. Finally, the results also suggest that it is important to support the use of the composition strategy when visually copying kanji during learning support for children with learning disabilities who have difficulty acquiring kanji writing.

Comparing by diagnoses, a significant difference was found at the 5% level among the 4 groups. However, no significant difference was found at the 5% level in the post-hoc test. Although, a significant tendency was observed at the 10% level. These findings suggested that children with ADHD and ASD tended to have inferior results when attempting the copying-drawing strategy. Okamaki (2017) stated that ASD and ADHD are associated with cognitive dysfunctions including executive dysfunction. Our results also suggested that children with LD combined with ADHD and ASD had lower performance on the drawing strategy scale without color-coding that required more executive function. It was suggested that the performance of the drawing strategy scale without color-coding may deteriorate. In contrast, a significant difference was not found among the four groups in the drawing strategy scale with color coding. The color coding of the components of the figure compensated for executive function deficits (impairments in the use of the composition strategy to promote the recall of the figure). The children with LD combined with ADHD and ASD may need special support for composition strategies.

Limitations of this research and future issues

In this study, all of the research participants experienced the first ROCF test in a non-color-coded condition and completed the second ROCF test in a color-coded condition. This order was used because it was difficult to counterbalance the conditions due to the ethics of the clinical work. Therefore, there is a limit to the generalization of the results.

All the participants were children who attended one medical facility. Many of the children had ADHD or ASD, suggesting that characteristics other than LD also affect their performance. Moreover, the number of participants was limited because this study was limited to children with LD who had difficulty acquiring kanji writing. It is necessary to increase the number of participants in future studies to further investigate the effects of learning disabilities alone and combined with other diagnoses.

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■ORIGINAL ARTICLE

Types of Grasping Chopsticks and Their Functionality in Typically Developing Preschool Children

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Abstract: Objective: In Asia, chopsticks are popular eating utensils, and the use of chopsticks is closely related to food culture. Therefore, the type in which children grasp chopsticks and the functionality of these grasping patterns are important for occupational therapists. The purpose of this study was to investigate the various types of grasping chopsticks in typically developing preschool children and compare the functionalities of these types.
Methods: We investigated various types of grasping chopsticks in 102 typically developing preschool children. There were 72 preschool children who performed four types of chopstick operation tasks: two pick-up and carry tasks, a scoop-up and carry task, and a cut task. These task scores were compared between the traditional and untraditional grasping types.
Results: Within the 102 participants, we found the traditional and four untraditional grasping types. There was no significant difference between the traditional and untraditional grasping types in the "pick-up and carry" and "scoop-up and carry" task scores ($p>0.05$). For all grasping types, the "cut task" score was low.
Conclusion: There were no differences in functionality between traditional and untraditional grasping types. Furthermore, we found that functionality was affected by food shape. These results may provide insights on interventions during meals, especially for children who are learning how to use chopsticks.

Keywords: typically developing children, preschool, chopsticks, meal, activity of daily living

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Introduction

In Asia, chopsticks are popular eating utensils, and the use of chopsticks is closely related to food culture. Therefore, using chopsticks is not only a skill but also an important occupation throughout an individual's lifespan. The traditional type of grasping chopsticks involves grasping one stick (movement stick) with the thumb, index, and middle finger, while the other (static stick) is grasped with the thumb and ring finger (Figure 1). This is regarded as the proper method for using chopsticks. Social meals lead to better communication among peers; however, those with improper chopstick grasps may feel uncomfortable around others [1]. Therefore, the traditional type of grasping chopsticks is recommended for appearance and etiquette. However, with decreased opportunities to acquire table manners, the types of grasping chopsticks have become diverse, and the number of those who use the traditional grasping type has gradually decreased [2, 3]. In addition, there is an increasing number of adults who cannot grasp chopsticks using the traditional type [4, 5], which may be regarded as a loss of Japanese tradition [3].

The method by which chopsticks are grasped is considered to be a basic skill acquired during early childhood in Japan [2]. However, there are individual differences in how chopsticks are grasped and handled, and a few children acquire the traditional type of grasping chopsticks [6, 7]. Continuous practice is necessary to acquire the traditional grasp type, and this type may be introduced at home to children at approximately 2

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years old when fine motor skills are developed enough to grasp chopsticks [8]. Therefore, studies have focused on various types of grasping chopsticks during early childhood; however, they were based on existing grasp patterns [4, 7]. Furthermore, to our knowledge, no studies have assessed various types of grasping chopsticks in early childhood.

Chopsticks have two functions: The first is a "basic function" to pinch, support, and carry, and the second is an "additional function" to cut, scoop, and flake [3]. Several studies have shown that the traditional grasp type has better functionality than other types [1, 2, 9]. However, these studies did not assess grasping types in early childhood, and only a few were examined for functionality. Additionally, no studies have examined the effects of food shape or dish position on chopstick functionality.

Using chopsticks is an important occupation for children's development in Japan and other Asian countries. Occupational therapists involved in nursery care and child rearing often intervene during meal times. Therefore, it is necessary for occupational therapists to be knowledgeable in the various types of grasping chopsticks and their functionality under various situations. In this study, we clarified various types of grasping chopsticks during early childhood and examined the functionality of several grasping patterns by performing tasks using different types of food and dish positions. The purpose of this study was to investigate the various types of grasping chopsticks in typically developing children, categorize these types by using video observation (Part I), and to compare their functionality under several conditions (Part II).

Materials and Methods

Design

Two studies were conducted. Part I was observational. Types of grasping chopsticks were investigated in typically developing children and categorized according to finger position. Part II was the experiment. Chopstick operation tasks were performed to compare the functionality of the traditional and untraditional grasping types.

This study was approved by the ethics committee of Nagoya University, School of Health Sciences, in accordance with the Helsinki Declaration (15−610).

Part I

Participants

A total of 102 healthy children between ages 5 and 6 participated in Part I of the study. There were 56 boys (54.9%) and 46 girls (45.1%). Participants were recruited by convenience sampling from a preschool that received comprehensive community support from our research group in Aichi Prefecture. We selected a preschool with an equal amount of indoor and outdoor activities. We excluded children who were diagnosed with developmental disorders and obvious impairments in fine motor skills. The first author conveyed the nature of the study to all participants and their parents and provided written informed consent to the parents.

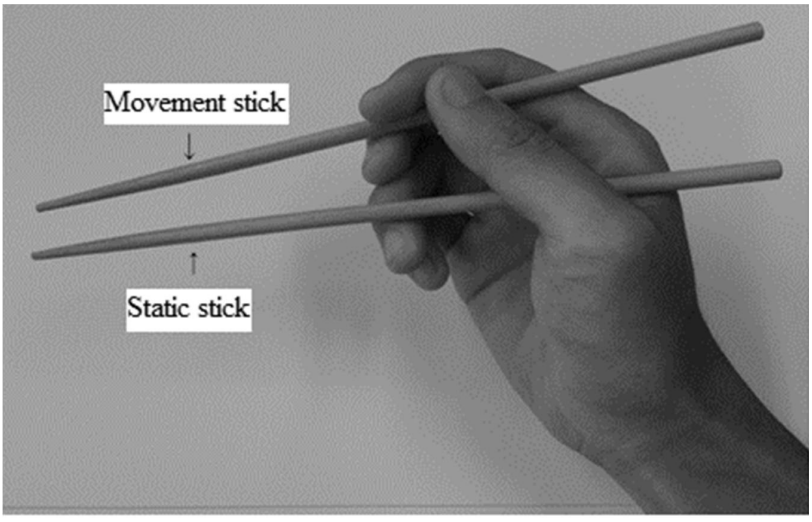


Figure 1. Traditional type of grasping chopsticks

The movement stick is grasped with the thumb, index, and middle fingers, while the static stick is grasped with the thumb and ring finger.

Measures and Procedure

The participants were observed during lunch and instructed to use chopsticks according to their usual way. Since we focused on the usual way of using chopsticks, participants used their own chopsticks during the research. For this reason, the shape, width, and length of chopsticks varied. Motions of picking up and bringing food to the mouth using chopsticks were recorded five times per participant using two video cameras (NV-GS300, Panasonic, Tokyo, Japan). The cameras were set in front and near the non-dominant hand side of the participants to observe finger positions.

Date Analysis

First, we used the video recordings to create still images of each participant picking-up food and bringing food to the mouth and observed the various chopstick grasping types. Based on a previous study [3], we defined the traditional grasping type (pincers-pinching) as follows: the movement stick is grasped with the thumb, index, and middle fingers, while the static stick is grasped with the thumb and ring finger. All other grasping types were regarded as untraditional. Untraditional grasping types were categorized according to finger position similarities.

Results

The majority of participants (98) were right-handed, and only four participants were left-handed. The traditional grasping type was used by 17 participants, whereas 85 used untraditional types. The untraditional grasping types were divided into four categories (untraditional type I, n=37; type II, n=28; type III, n=3; type IV, n=17; Figure 2).

Part II

Participants

Participants in Part II of the research included 72 healthy children between ages 5 and 6 who usually ate with chopsticks. There were 42 boys (58.3%) and 30 girls (41.7%). Participants were recruited by convenience sampling from three preschools in the Aichi and Gifu prefectures. As in Part I, we selected three preschools where there were equal amounts of indoor and outdoor activities. These preschools received comprehensive community support from our research group. Children diagnosed with developmental disorders or obvious fine motor skill impairments were excluded. The first author conveyed the nature of the study to all participants and their parents and provided written informed consent to the parents.

Procedure

All participants were asked to perform four experimental tasks. Four types of food were used in the tasks and placed in a dish on a table. To investigate the effect of dish position on functionality, the dishes were placed in four positions: (a) near the dominant hand side and near the body, (b) near the dominant hand side and far from the body, (c) near the non-dominant hand side and near the body, and (d) near the non-dominant hand side and far from the body (Figure 3). A tall plastic container was also placed as a food destination. We used this container based on the assumption that food would be delivered to the mouth. For each type of food, the participants were asked to perform the tasks in the order of (a) to (d). Participants were instructed to perform each task for 30 seconds using their own chopstick-grasping types. The details of the four tasks are as follows.

1. Tofu pick up and carry task (tofu task): Tofu (2.5 by 2.5 by 2.5 centimeters) was picked up from a dish and placed in a container in front of the participant.

2. Soybean pick-up and carry task (soybean task): Soybeans were picked up from a dish and placed in a container in front of the participant.

3. Rice scoop up and carry task (rice task): Rice was scooped up from a dish and placed in a container in front of the participant.

4. Flour dough cut task (flour dough task): Elongated flour dough was placed on a dish and cut at 1 cm intervals using chopsticks. Red lines were drawn on the dough to indicate 1 cm intervals.

Measures

During the tasks, the motions of the participants were recorded using two video cameras (NV-GS300, Panasonic, Tokyo, Japan). The cameras were set in front and near the non-dominant hand side of the participant. The number of "pick-up and carry," "scoop-up and carry," and "cut" motions were counted, and each counted number was defined as the task score. Task scores were measured by two researchers and determined based on their agreement.

Data Analysis

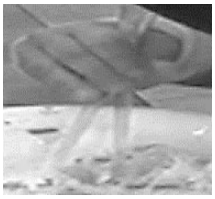
From the video recordings, the chopstick grasping types were divided into traditional and four untraditional types based on the Part I results, and the average task scores were calculated for each grasping type. Dunnett's multiple comparison test was used to compare task scores between the traditional and untraditional types. The control and experimental groups used traditional and untraditional grasping types, respectively. The task scores of each grasping type were compared among the tofu, soybean, and rice tasks using multiple comparison

Type I: The fingers used for the movement and static sticks are the same used during the traditional type. However, the finger position is different.

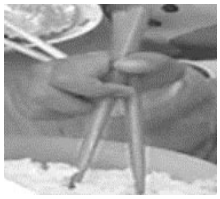
[A] The middle finger is above the movement stick.

[B] The middle finger is under the movement stick.

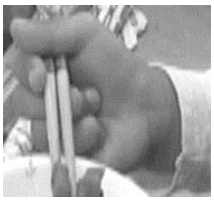
Type II: The fingers used for the movement stick are the same used during the traditional type. However, the finger positions are different.



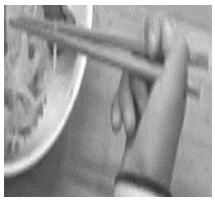
[C] The static stick is grasped with the thumb, ring, and little finger.



[D] The static stick is grasped with the thumb.

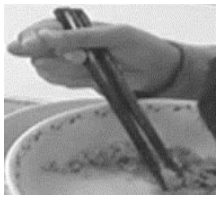


[E] The movement stick is grasped with the pulp of the index finger.

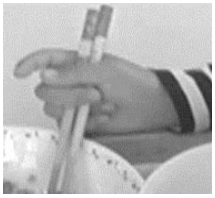


[F] The movement stick is grasped by rolling the index finger.

Type III: The fingers used for the static stick are the same used in the traditional type. However, the finger positions are different.

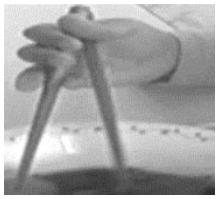


[G] The movement stick is grasped with the thumb and index finger.

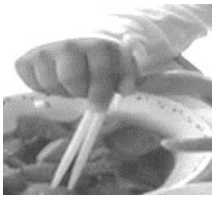


[H] The index finger is extended.

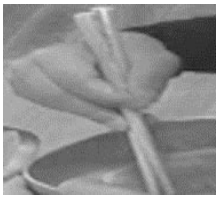
Type IV: Different fingers are used to hold the movement and static sticks than those used in the traditional type.



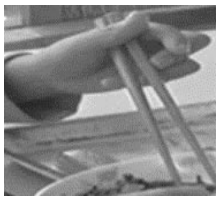
[I] The movement stick is grasped with the thumb, index, middle, ring, and little fingers, and the static stick is grasped with the thumb.



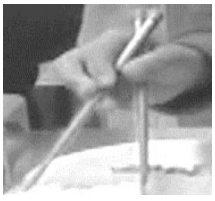
[J] The ring and little finger are flexed.



[K] The movement stick is grasped with the thumb and index finger, and the static stick is held with the thumb, middle, and ring fingers.



[L] The index finger is extended.



[M] The index finger is not extended.

[N] The ring and little finger are extended.

Figure 2. Categorized untraditional types of holding chopsticks

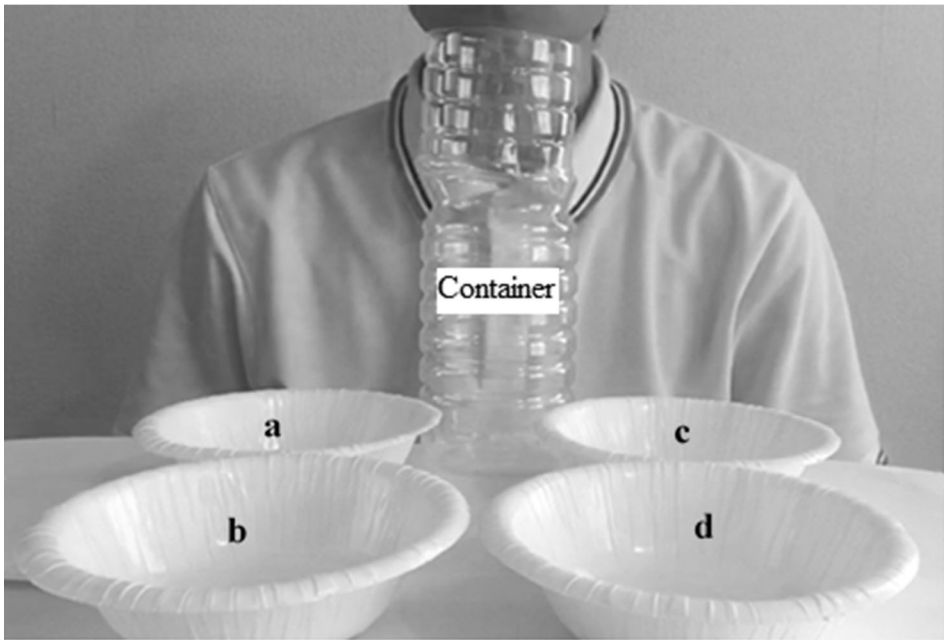


Figure 3. Experimental setting for a right-handed participant

The dishes were placed in four positions: (a) dominant hand side and near the body, (b) dominant hand side and far from the body, (c) non-dominant hand side and near the body, and (d) non-dominant hand side and far from the body. A container was placed in front of each participant.

Bonferroni-Dunn's test. This analysis was performed for each of the four positions of the dish: dominant hand side; the mean of the results from positions (a) and (b), non-dominant hand side; the mean of the results from positions (c) and (d), near the body; the mean of the results from positions (a) and (c), far from the body; the mean of the results from positions (b) and (d). The threshold for significance was set at $p < 0.05$. All statistical analyses were conducted using the IBM SPSS version 24.0.

Results

A total of 69 participants were right-handed, and three participants were left-handed. The number of participants using each grasping type was as follows: traditional type, n=15; type I, n=24; type II, n=23; type III, n=2; type IV, n=8. In this study, only two participants were classified as type III. Therefore, we decided to exclude type III participants from the subsequent statistical analysis.

For the tofu, soybean, and rice tasks, there were no significant differences between the average task scores of the traditional and four untraditional grasping types at all dish positions (Table 1). However, for the flour dough task, the average task score of the traditional type was significantly higher than that of types II and IV at dish position (b) ($p<0.05$).

For the traditional type and type II, the average task score was significantly higher in the tofu, soybean, and rice tasks, respectively, at all dish positions ($p<0.05$) (Table 2). For type I, except for the tofu and soybean tasks at the non-dominant hand side dish position, the average task score was significantly higher in the tofu, soybean, and rice tasks, respectively ($p<0.05$). For type IV, the average task scores of both the tofu and soybean tasks were significantly higher than those of the rice task at all dish positions ($p<0.01$), although, there were no significant differences in the average task score at all dish positions between the tofu and soybean tasks.

Discussion

In a previous study by Mukai *et al*, they reported that 55.6% of children aged 6 to 7 years old used the traditional type of holding chopsticks [8]. This previous study defined the traditional type of holding chopsticks only in terms of the fingers used to holding the movement and static sticks and this is different from our study. We defined the traditional type of holding chopsticks in terms of the fingers used to hold the sticks and the finger position. In this study, the traditional type of

Table 1. Comparisons of average task scores between each grasping type

	Tofu pick-up and carry task				Soybean pick-up and carry task			
	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
Traditional type (n=15)	13.8±3.4	12.5±3.3	14.5±3.3	12.3±3.0	10.4±3.2	10.1±2.6	11.7±2.9	10.5±3.0
Type I (n=24)	14.8±3.4	13.0±3.2	14.3±3.3	12.9±3.0	11.5±3.7	11.2±3.4	12.7±3.8	11.6±4.0
Type II (n=23)	12.7±3.5	11.5±3.2	12.7±3.3	11.2±2.7	10.7±2.8	9.0±2.3	10.7±2.9	9.3±2.5
Type III (n=2)	12.0±1.4	12.0±0.0	17.0±0.0	12.5±2.1	12.5±0.7	9.5±0.7	11.0±0.0	11.0±1.4
Type IV (n=8)	11.8±2.9	11.0±1.8	11.1±2.2	11.6±2.0	10.3±2.8	9.1±2.8	11.9±2.3	11.0±3.5

	Rice scoop-up and carry task				Flour dough cut task			
	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
Traditional type	7.2±2.7	5.9±2.3	7.4±2.3	6.1±2.5	1.9±1.5	2.8±1.5	2.4±1.6	2.2±1.3
Type I	7.3±2.8	5.8±2.5	7.3±2.8	6.0±2.6	1.7±1.0	1.9±1.1	2.2±1.3	2.0±1.1
Type II	5.9±2.1	5.2±2.1	6.2±2.7	5.3±2.1	1.8±1.2	1.7±1.1*	2.1±0.9	2.2±1.2
Type III	8.5±0.7	5.5±0.7	7.5±2.1	5.0±1.4	1.5±0.7	2.0±1.4	1.5±2.1	3.0±4.2
Type IV	7.1±2.0	6.1±1.7	6.9±2.0	5.4±1.6	1.8±0.9	1.1±1.0**	1.6±1.1	1.9±0.8

(a)–(d) indicates dish positions: (a) dominant hand side and near the body, (b) dominant hand side and far from the body, (c) non-dominant hand side and near the body, and (d) non-dominant hand side and far from the body. Dunnett's multiple comparison was used. The control group included those who used the traditional grasping type, and the experimental groups included those who used grasping types I, II and IV.
*: $p<0.05$, **: $p<0.01$

Table 2. Comparisons of average task scores among tofu, soybean, and rice tasks

		Tofu	Soybean	Rice	P^A	P^B	P^C
Traditional type	(a, b)	13.1±3.4	10.2±2.9	6.6±2.6	.001	.000	.000
(n=15)	(c, d)	13.4±3.3	11.1±3.0	6.7±2.4	.010	.000	.000
	(a, c)	14.1±3.3	11.0±3.1	7.3±2.5	.000	.000	.000
	(b, d)	12.4±3.1	10.3±2.8	6.0±2.4	.015	.000	.000
Type I	(a, b)	13.9±3.4	11.3±3.5	6.5±2.7	.000	.000	.000
(n=24)	(c, d)	13.6±3.2	12.1±3.9	6.6±2.8	.101	.000	.000
	(a, c)	14.5±3.3	12.1±3.7	7.3±2.8	.001	.000	.000
	(b, d)	12.9±3.1	11.4±3.7	5.9±2.5	.048	.000	.000
Type II	(a, b)	12.1±3.4	9.8±2.7	5.5±2.1	.001	.000	.000
(n=23)	(c, d)	12.0±3.1	10.0±2.7	5.8±2.5	.004	.000	.000
	(a, c)	12.7±3.4	10.7±2.8	6.0±2.4	.006	.000	.000
	(b, d)	11.3±2.9	9.2±2.4	5.2±2.1	.000	.000	.000
Type III	(a, b)	12.0±0.8	11.0±1.8	7.0±1.8	-	-	-
(n=2)	(c, d)	14.8±2.9	11.0±0.8	6.3±2.1	-	-	-
	(a, c)	14.5±3.0	11.8±1.0	8.0±1.4	-	-	-
	(b, d)	12.3±1.3	10.3±1.3	5.3±1.0	-	-	-
Type IV	(a, b)	11.4±2.4	9.7±2.8	6.6±1.9	.150	.000	.002
(n=8)	(c, d)	11.4±2.0	11.4±2.9	6.1±1.9	1.000	.000	.000
	(a, c)	11.4±2.5	11.1±2.6	7.0±2.0	1.000	.000	.000
	(b, d)	11.3±1.9	10.1±3.2	5.8±1.7	.416	.000	.000

Tofu, tofu pick-up and carry task; soybean, soybean pick-up and carry task; rice, rice scoop-up and carry task. (a)–(d) indicate dish positions; (a, b) dominant hand side, (c, d) non-dominant hand side, (a, c) near the body, (b, d) far from the body. Task scores were compared among the tofu, soybean, and rice tasks using the multiple comparison Bonferroni-Dunn's test. A compared tofu and soybean task scores, B compared tofu and rice task scores, and C compared soybean and rice task scores.

holding chopsticks was observed in 17 out of 98 participants (17.3%) in Part I and in 15 out of 69 participants (21.7%) in Part II. However, if we include the subjects who were classified as type I, which corresponds to the traditional type of holding chopsticks according to the definition of the previous study [8], the number of participants becomes 54 out of 98 (55.1%) in Part I and 39 out of 69 (56.5%), which is almost the same ratio as the previous study.

There were no differences in the average task score between each grasping type, except for dish position (b) of the flour dough task. Mukai stated that when carrying soybean or tofu, individual dexterity and proficiency in using chopsticks have a greater impact than differences in the type of holding chopsticks [10]. During early childhood meals, children repeatedly carry food by pinching using chopsticks [7]. Therefore, even if a participant may grasp chopsticks using an untraditional type, its functionality may be developed through repeated practice during meals.

In contrast, cutting is not commonly performed during early childhood [7]. The average task scores of the flour dough task for each grasping type were low compared to those of the other tasks. Since there are few learning opportunities during early childhood to use the "cut" task, this functionality may be low regardless of the grasping type. However, the dish position may partially affect the functionality of the "cut" operation. At dish position (b), participants manipulated the chopsticks by extending the elbow joint. When the movement of the extensor muscles at the elbow joint is dominant, it may be difficult to continuously open and close chopsticks because the flexor muscle movements are suppressed. On the other hand, the traditional grasping type involves high muscle activity in the short thumb abductor muscle, short thumb flexor, and dorsal interosseous muscle due to the continuous opening and closing motion with the movement stick [11]. Furthermore, in the traditional type, the finger positions on the chopsticks are stabilized during operation [10]. Therefore, the traditional type may have higher functionality than types II and IV in the "cut" operation. However, there were no significant differences in average task scores between the traditional and untraditional types at dish position (d), despite the dish being positioned far from the body. We were unable to determine the cause of this discrepancy. In addition, since we did not provide detailed instruction on the sitting posture and chair position of the participants when they performed the task, there may be individual variations in the effects of the elbow extension movements described above. Therefore, we concluded that the functionality of the "cut" operation is low for the traditional and untraditional grasping types.

The average scores of the tofu and soybean tasks were significantly higher than those of the rice task. Rice must be scooped carefully because it easily falls apart. In addition, the tofu and soybean tasks involve a one-unit operation in which opened chopsticks are closed, while the rice task involves a two-unit operation in which a scooping motion is performed while closing opened chopsticks. Therefore, complexity in food shape and difficulty in chopstick operations may affect functionality.

For the traditional type, types I and II, the average scores of the tofu task were significantly higher than those of the soybean task. Tofu has a larger contact area with chopsticks than soybeans. Therefore, picking up tofu may be easier than picking up soybeans. In addition, types I and II have similar elements to the traditional type because the fingers used for grasping sticks are the same. For type IV, it may be difficult to operate both the movement and static sticks with stability because it has very little similarity to the traditional type. Therefore, for type IV, the functionality of picking up tofu is similar to that of picking up soybeans, despite the former being easier to perform.

Although a child may use untraditional types for grasping chopsticks, its functionality does not differ from that of the traditional type. Since food shape may affect the functionality of chopsticks, it is important to prepare "easy-to-pinch" foods that facilitates eating, especially when the child is learning how to use chopsticks. In the future, a larger study using the motion analysis method may be used to investigate the force quality and quantity in different joint segments during chopstick use.

Limitations

In this study, since only two participants were classified in type III, we were unable to draw any conclusions regarding its functionality. In addition, participants were recruited from a limited area in Japan. In future studies, a larger sample size should be used.

Although we only used the type of grasping chopsticks to define the control and experimental groups in Part II, the functionality of chopsticks might be influenced by the child's age, sex, and frequency of chopstick use. Furthermore, we did not indicate the seating posture and non-dominant hand position during the tasks, which may have partly influenced the task results.

Conclusions

There was no difference in the functionality of the "pick-up and carry" and "scoop-up and carry" operations between the traditional and untraditional grasping

types. The “cut” operation had low functionality for traditional and untraditional grasping types. In traditional and untraditional grasping types, the “pick-up and carry” operation is more functional than the “scoop-up and carry” operation. In the “pick-up and carry” tasks, types I and II had similar functionality to the traditional type for all food sizes used in this study. Since using chopsticks is an important occupation in Asia, occupational therapists must knowledgeable in the various types of grasping chopsticks and their functionality under various situations.

Declaration of Interest

The authors report no conflict of interest.

Acknowledgements:

We would like to express our gratitude to the preschool staff members and all the participants.

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■ORIGINAL ARTICLE

Development of the Perfect O Sign Quantification Tool

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Abstract: Objective: The perfect O sign is often evaluated in carpal tunnel syndrome but there are no clear criteria. The purpose of this study is to develop a tool for quantifying the perfect O sign and to investigate the values of the perfect O sign in healthy subjects using this method.
Methods: Participants are healthy 20- to 30-year-old volunteers (n = 13) without any clinical symptoms of carpal tunnel syndrome. Surface electromyogram was used to measure the amplitude of the abductor pollicis brevis (APB), first dorsal interosseous muscle (FDI), flexor digitorum superficialis (FDS), and extensor digitorum communis (EDC) while performing the perfect O sign in three different wrist positions: neutral, dorsiflexion, and palmar flexion. The roundness of the perfect O sign in healthy subjects was measured by approximating a circle using 7 points in the photo captured by a smartphone and imported to a personal computer.
Results: The FDI/APB ratio was significantly lower in the dorsiflexion position than that in the palmar flexion position, and the FDS/APB ratio had a significantly lower dorsiflexion position than that of the other two wrist positions. Based on these results, a device was developed that holds the wrist in the dorsiflexion position. The mean roundness of the perfect O sign using the device in 13 healthy volunteers was 80.46 ± 9.47%.
Conclusions: Dorsiflexion of the wrist can minimize the effect of other muscles while performing the perfect O sign. The perfect O sign can be quantified by calculating the roundness.

Keywords: carpal tunnel syndrome, perfect O, quantification, roundness

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Introduction

In patients with carpal tunnel syndrome, paralysis of the abductor pollicis brevis (APB) prevents thumb opposition [1], which causes functional disabilities in tip pinch in combination with sensory impairment [2−4]. When affected individuals attempt to make a circle with their thumb and index finger, it becomes elliptical. Bunnell reported this finding and called it the “round O,” and other researchers have called it the “perfect O sign” [5−8]. As this physical finding is simple and takes only a few seconds to obtain, it is widely used to evaluate the function of thumb opposition in the clinical setting [9]. The perfect O sign is expressed as positive or negative according to the examiner’s subjective decision as to whether it looks round or not—there are no clear criteria [9]. For precise evaluation of patient disability and clinical treatment, the perfect O sign must be quantified.

Some patients with carpal tunnel syndrome can make the perfect O sign, even if there are atrophies of the thenar muscles. Compensatory movements may occur by muscles that are not impaired, such as intrinsic muscles other than the median nerve–innervating, extrinsic flexor, or extensor muscles. Some patients may use those muscles and adjust them with assistance from the wrist positions to perform the perfect O sign.

The purpose of this study is to develop a tool

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to quantify the perfect O sign. The amplitude of the abductor pollicis brevis (APB; responsible for palmar abduction of the thumb), first dorsal interosseous muscle (FDI; an intrinsic muscle innervated from the ulnar nerve), flexor digitorum superficialis (FDS; an extrinsic muscle belonging to the forearm flexor muscle group), and extensor digitorum communis (EDC; an extrinsic muscle belonging to the forearm flexor muscle group) was measured using a surface electromyogram while the patient performed the perfect O sign in three different wrist positions: neutral, dorsiflexion, and palmar flexion to determine the optimal wrist position for evaluation of the perfect O sign that minimizes the effect of compensatory movement using muscles other than the APB, including intrinsic and extrinsic muscles and wrist positioning. The secondary purpose is to investigate the values of the roundness of the perfect O sign in healthy subjects using this method.

Methods

Participants

Thirteen healthy subjects between 20 and 30 years of age participated. No participants had clinical symptoms of carpal tunnel syndrome or any APB muscle atrophy, pain, contracture, morphological abnormalities, or any history of traumas or surgeries of the wrist and fingers. This study was approved by the ethics committee of Kyoto University Hospital. All participants provided written informed consent before study participation.

Protocol

Healthy participants were instructed to make the perfect O sign with the thumb and index finger in three different wrist positions: 80° dorsiflexion position, 70° palmar flexion position, and neutral position with immobilization by orthoses. The forearm rotation was neutral and elbow flexion was 90°. The sensors of a surface electromyograph (TeleMyo2400, Noraxon, USA) were attached to the APB, FDI, FDS, and EDC. The average amplitude of four muscles, including during the perfect O sign, was recorded in each position for 3 s (Fig. 1). The subjects were instructed to touch the tips of their thumb and index finger together without any strength (as in the tip pinch) while making the perfect O sign. The amplitude ratio of APB compared to the other muscles, the FDI/APB ratio, FDS/APB ratio, and EDC/APB ratio in three different wrist positions was calculated.

Creating a device to take digital pictures of the perfect O sign

We developed a device to take digital pictures of the perfect O sign. We achieved standardized pictures by making the position of each joint and the photographic angle constant. In particular, the dorsal side of the upper arm was supported by an L-shaped plate attached to the proximal part of the testing platform, the elbow was held in a 90° flexion position, and the forearm was immobilized in the neutral position with Velcro tape. The wrist joint was held in the optimal position by two bars from both the dorsal and the palmar respectively at the distal of the forearm, and another bar that can push around the neck and head of the third metacarpal from either dorsal or palmar side. Of the three different wrist positions, the

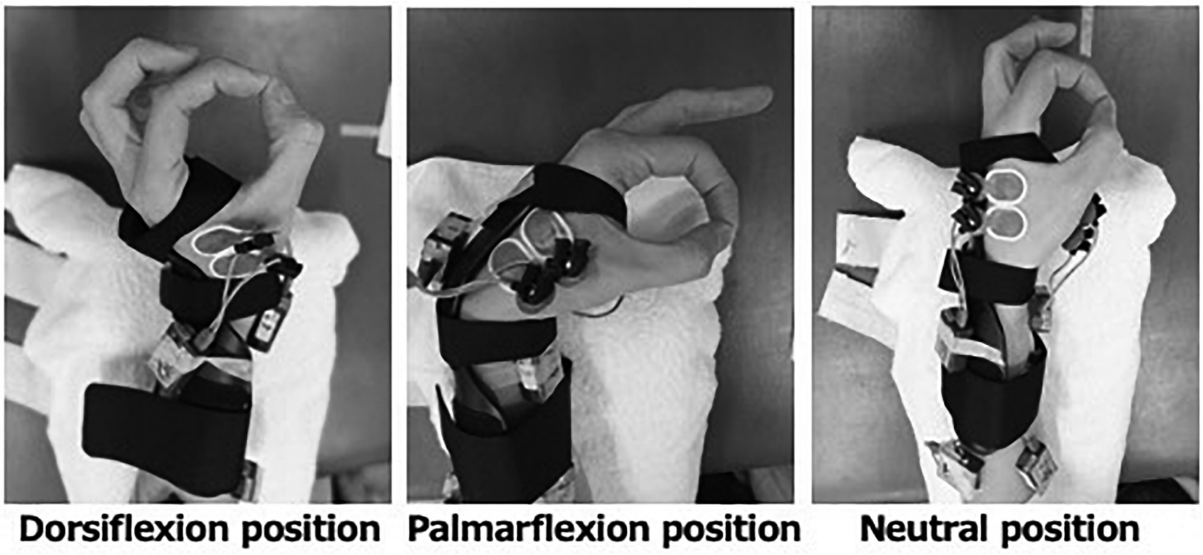


Fig. 1 Measurement of the amplitude of four muscles, APB, FDI, FDS, and EDC, using surface electromyogram in three different wrist positions immobilized by orthoses.

optimal wrist position was determined from the results of the amplitude ratio of each muscle described above. The bar that pushed the metacarpal was designed to be short enough to not interfere with the points taken to approximate the perfect O as a circle. The smartphone holder was attached to the bar immediately above the testing platform where subjects made the perfect O sign, which was set horizontal to the table so that the photographic angle is constant.

Analyzing the roundness of the perfect O sign

In the picture of the perfect O sign, seven points were marked: 1) the palmar contact point between the index finger and the thumb, 2) the interphalangeal crease of the thumb, 3) the palmophalangeal crease of the thumb, 4) the proximal palmar crease (PPC) on the first web, 5) the palmophalangeal crease of the index finger, and 6) the proximal and 7) distal interphalangeal crease of the index finger (Fig. 2). The roundness was calculated using ImageJ software (National Institutes of Health, USA). The seven points on the picture imported to a personal computer were assigned as the vertexes of a polygon and used to approximate the polygon into a circle and obtain the roundness.

Analyzing the roundness of the perfect O sign in a carpal tunnel syndrome patient

The roundness of the perfect O sign in a single patient with carpal tunnel syndrome diagnosed by clinical symptoms and electromyograph was measured as described above.

Verifying the validity of the tool

To evaluate the reliability of the measurement of the roundness of the perfect O sign using this tool, we calculated the intra- and inter-rater reliability. For the former, the roundness of the perfect O sign made by healthy subjects in three pictures was measured five times by four raters and the interclass correlation coefficient (ICC) (1, *k*) was calculated. For the latter, the roundness of the perfect O sign in six pictures was measured once by four raters and the ICC (2, *k*) was calculated. ICC values larger than 0.9 indicate that the reliability of the

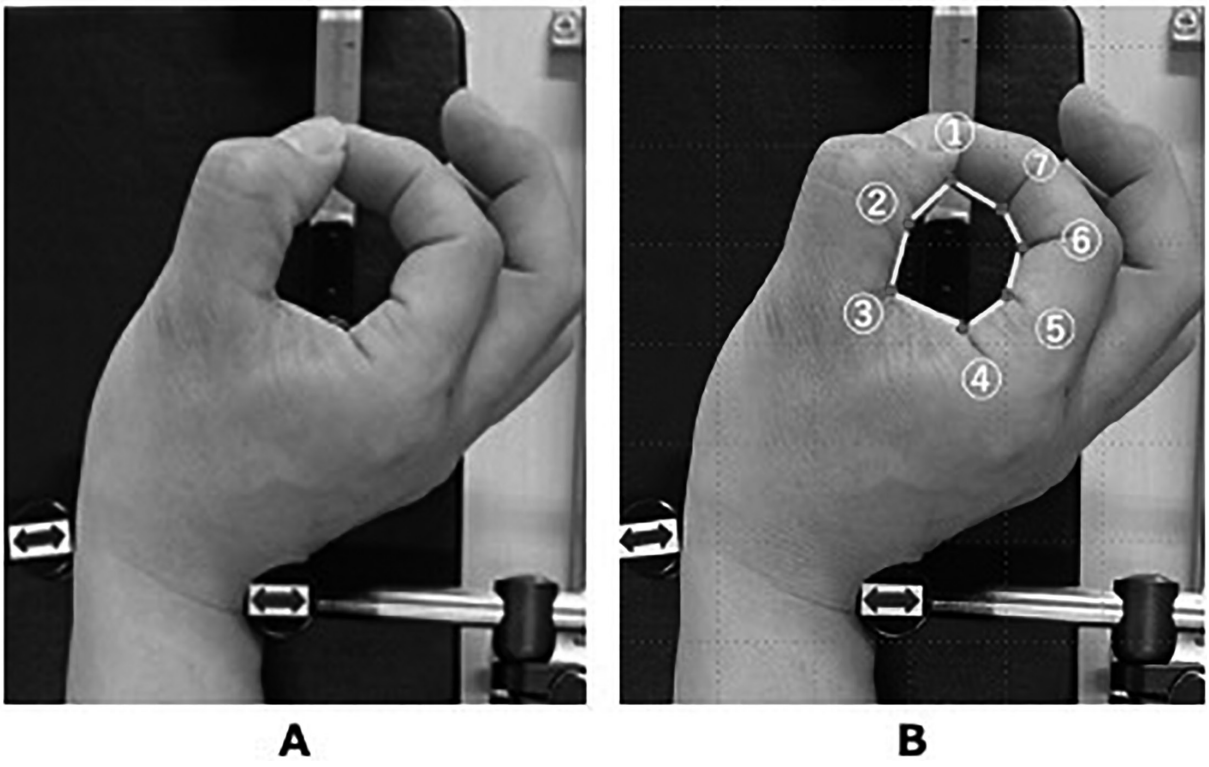


Fig. 2 The seven points to approximate the shape of the perfect O sign to a circle.
A) Performing the perfect O sign
B) Dotting the seven points
1) The palmar contact area between the thumb and the index finger
2) The interphalangeal crease of the thumb
3) The palmophalangeal crease of the thumb
4) The proximal palmar crease on the first web
5) The palmophalangeal crease of the index finger
6) The proximal interphalangeal crease of the index finger
7) The distal interphalangeal crease of the index finger

measurement is excellent; values between 0.75 and 0.9 are good, 0.5 to 0.75 are moderate, and less than 0.5 are poor [10].

Statistical analysis

Data were compared using an analysis of variance (ANOVA). When a significant difference was detected, the Bonferroni *post hoc* test was applied. Differences were considered statistically significant at $p < 0.05$. All statistical analyses were performed with JMP pro software version 15.10.0 (SAS Institute Inc., Cary, NC, USA). Regarding the sample size, assuming a 40% difference in the average and standard deviation among groups with a 95% confidence interval and statistical power of 90%, it was estimated that we would need at least 13 subjects according the results of Rainodi et al [11]. The sample size was calculated with JMP pro software version 15.10.0 (SAS Institute Inc., Cary, NC, USA).

Results

The amplitude of FDI and APB was almost constant compared to those of FDS and EDC (Fig. 3).

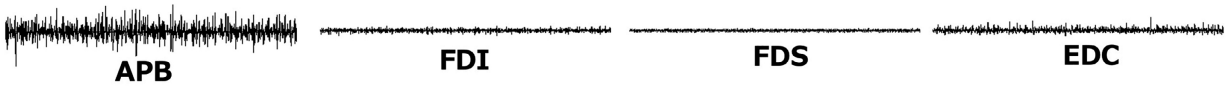
The amplitude ratio of APB to the other muscles revealed that the FDI/APB ratio was significantly lower ($p = 0.0271$) in the dorsiflexion position than that in the palmar flexion position, and the FDS/APB ratio was significantly lowest ($p = 0.0457$) in the dorsiflexion position among the three wrist positions (Fig. 3). The EDC/APB ratio in the palmar flexion position was significantly lower ($p < 0.001$) than that in the neutral position, but there was no significant difference between the palmar flexion and the dorsiflexion positions. Based on these results, the dorsiflexion position was considered to be the most optimal testing position for the perfect O sign among the three different positions.

Based on the results of the amplitude ratio of APB, a device was developed to keep the wrist in the dorsiflexion position during evaluation of the perfect O sign (Fig. 4).

The roundness of the perfect O sign in healthy subjects measured with this tool was 82.08 ± 7.92% (Fig. 2). Using the same method, the roundness of the perfect O sign in a single patient with carpal tunnel syndrome diagnosed by clinical symptoms and electromyograph was measured, and it was 40.20% (Fig. 5). The measurement reliability using this tool was demonstrated to be excellent by ICC (1,1) and ICC (2,1) values of 0.951 and 0.971, respectively.

Discussion

The perfect O sign is constructed of two semicircles. One is formed by the palmar side of the flexed distal interphalangeal (DIP), proximal interphalangeal



Amplitude (mV)	Dorsiflexion	Palmar Flexion	Neutral
APB	20.18±11.42	20.89±11.87	20.68±9.81
FDI	7.01±2.73	8.33±4.16	7.38±3.61
FDS	4.07±2.63	6.00±3.65	5.01±2.62
EDC	22.94±13.27	10.75±5.69	13.49±8.03

Muscle Ratio	Dorsiflexion	Palmar Flexion	Neutral	p
FDI/APB	0.71(0.37)†	1.23(0.77)†	0.84(0.32)	*<0.05*
FDS/APB	0.97(0.52)†	1.4(0.94)†	1.56 (1.1)†	*<0.05*
EDC/APB	1.58(1.01)	0.93(0.6)†	1.61(1.72)†	*<0.001*

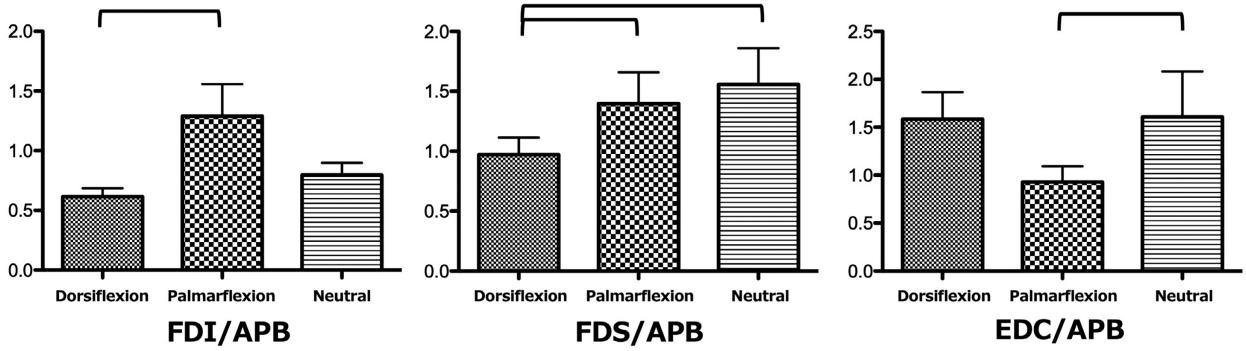


Fig. 3 The waveforms of the APB, FDI, FDS, and EDC, those amplitude and the amplitude ratio of the FDI, FDS, and EDC to the APB in three different wrist positions. The lower values indicate the reduced influence of the muscle to the APB. The bucket in the graph and † in the table indicate significant differences.

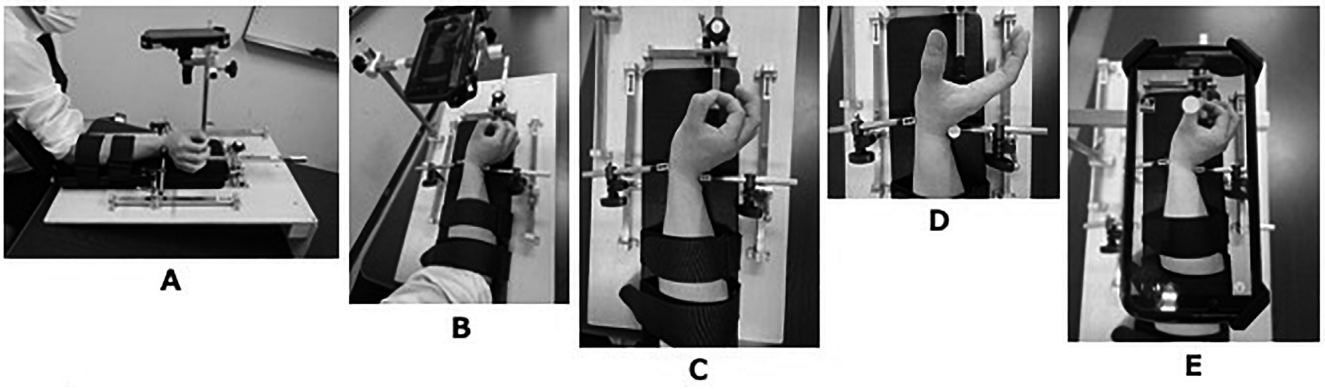


Fig. 4 The developed device.
A, B) The full image of the device when taking photos with a smartphone camera.
C) The view from directly above.
D) The method to immobilize the wrist in the dorsiflexion position. The two blocks attached to the bars hold the proximal of the wrist from the dorsal and the palmar side, and the other block pushes the third metacarpal from the distal to the proximal direction.
E) The image through a smartphone camera.

Fig. 5 Measurement of the roundness of the perfect O sign in a patient with carpal tunnel syndrome.

(PIP), and metacarpophalangeal (MP) joint of the index finger, and the other is formed by the palmar side of the flexed interphalangeal (IP) and MP joints of the thumb. In addition, the thumb is flexed and the MP and carpometacarpal (CM) joints are internally rotated when observed in the plane on the radial side of the index finger [12]. Some patients with carpal tunnel syndrome can make a perfect O sign despite the thenar muscle atrophy. Some wrist positions can allow the patient to make the perfect O sign using assistance from muscles that are not impaired, such as intrinsic muscles other than the median nerve–innervating, extrinsic flexor, or extensor muscles. When the APB is paralyzed, it is possible to make a perfect O sign with compensatory movements using extrinsic and other intrinsic muscles with adjustments to the wrist joint. To minimize the influence of muscles other than the APB in the perfect O sign, the wrist position was evaluated so as to reduce compensatory movement. Compensatory movement was initially evaluated using the results of surface electromyogram of muscles in different wrist positions to eliminate the effect of muscles other than the APB. Many intrinsic and extrinsic muscles which are not innervated by lower median nerve contribute to the compensatory movement. In this experiment, the forearm flexor (FDS), extensor (EDC), and ulnar nerve–innervating muscle (FDI) were selected to detect the wrist position that minimizes compensatory movements by muscles other than the APB as the optimal testing position because of using surface electromyography. Force produced by muscles depends on the muscle weight and average length of muscle fibers [13], [14]. The muscles analyzed in this study included both the intrinsic and extrinsic muscles, which have different muscle weights and muscle fiber lengths, in addition to individual differences among subjects. Therefore, we employed a comparison using

the ratio not the amplitude itself. That is, we determined the wrist position in which the APB was relatively less affected by other muscles that assist to make the perfect O sign as optimal. In the dorsiflexion wrist position, the FDI/APB ratio and FDS/APB ratio were significantly lower although the EDC/APB ratio was not. There was no significant difference in the EDC/APB ratio between dorsiflexion and palmar flexion. These results revealed that the dorsiflexion wrist position is where the amplitude of these muscles other than the APB was minimized during the perfect O sign. Therefore, the optimal testing position of the wrist is the dorsiflexion position. The dorsiflexion position is thus recommended when evaluating the perfect O sign in clinical practice, even when not using the device developed herein. The forearm rotation was set in the neutral position and the elbow joint was set at 90° flexion. Because the extrinsic muscle length varies in forearm rotation and the picture of the perfect O sign is taken in a constant direction, we fixed the forearm and elbow position.

Li and Nimbarte reported that when the median nerve is blocked at the wrist, compensatory increases in the ranges of motion at the PIP and DIP of the index finger and the MP joints of the thumb [15]. They described that the compensatory movement was created by the extrinsic muscles of the thumb and index finger as theses extrinsic muscles are located in the forearm and should not be impaired by the nerve block at the wrist, and the robust output was likely augmented by the muscle spindles and Golgi tendon organs of the extrinsic muscles of the thumb and index finger [15]. In the dorsiflexed position of the wrist the FDS is stretched and the outputs by the muscle spindles and Golgi tendon organs easily produced, leading to decreasing the muscle amplitude. As Li and Nimbarte described, the flexor pollicis longus (FPL) can contribute to the formation of the perfect O sign [15]. The flexor pollicis longus muscle exist deeper than the FDS muscle and in the current study we did not evaluate the FPL amplitude using surface electromyography.

As for the roundness, the number of points required to approximate the shape of the perfect O sign to a circle was considered. Seven points that are easy to identify on the picture to approximate the shape of the perfect O to a circle were assigned. It is sometimes difficult to identify the palmar point on the palmophalangeal crease of the thumb and the proximal palmar crease in the first web. Although these two points were changed, the roundness was similar. The values of the healthy volunteers and the patient with carpal tunnel syndrome were compared, and a difference was identified.

Previous researchers have investigated the thumb opposition motion using different methods [16–22]. Kerkhof et al. used dynamic computed tomography (CT) to quantify thumb opposition kinematics [16]. Kuroiwa et al. used a three-axis gyroscope to measure thumb pronation and the palmar abduction angle [17–19]. Other researchers used a motion capture system to detect the thumb opposition motion [10–22]. All of these methods require special equipment, however, such as CT, sensors, or a motion capture system. In addition, they take time and cannot be utilized in outpatient clinics.

With this tool, the perfect O sign can be used as an objective finding based on a quantitative examination that does not take a great deal of time and is not a complicated or invasive procedure. As a result of these advantages, it is possible to follow the natural course of the APB weakness observed in carpal tunnel syndrome without patient stress. The improvement in opposition function was also evaluated by comparing before and after carpal tunnel release surgery, and by comparing the opposition function among various surgery techniques, such as tendon transfers. In addition, this method was employed to evaluate the disease severity of carpal tunnel syndrome. If severity can be determined by the cutoff value of the roundness, this tool could be used diagnostically as a non-invasive alternative to electromyogram.

There are several limitations in this study. First, unlike needle electromyogram, surface electromyogram does not indicate precise muscle amplitude. Not all of the muscles that may be involved in thumb opposition and compensatory movements while making the perfect O sign were evaluated. The opponens pollicis (OP) is the muscle responsible for volar abduction and pronation of the thumb and is innervated by the median nerve. Many variances of innervation in the thenar muscles, such as Riche-Cannieu anastomosis (RCA), exist, and the high prevalence of the thenar muscles innervated by a motor branch of the ulnar nerve or both the ulnar nerve and the median nerve has been reported, especially in the APB range (4.9–82.6%) and the OP range (16.4–60.8%) [23–26]. This may be one of the explanations for the discordance between the findings of electromyogram that show severe neuropathy and the absence of thenar muscle atrophy or thumb opposition dysfunction. It is reasonable to evaluate both the OP and the APB when determining the optimal wrist position for evaluation of the perfect O sign. Surface electromyography could not be used to evaluate the OP because it lies in a deeper layer immediately dorsal to the APB. Nevertheless, the contribution of the APB is speculated to be greater than that of the OP in thumb opposition because it has a larger lever arm as a result of its origin and insertion.

Similarly, the muscle belly of the FDS exists close enough to the surface to be palpable, and it can be

evaluated by surface electromyography. The flexor digitorum profundus that belongs to the same group of forearm flexor muscles as the FDS exists in a deep layer, it cannot be evaluated by surface electromyography. It was impossible to measure the amplitude of muscles such as the lumbrical muscles and flexor pollicis brevis muscles by surface electromyography. It was also impossible to use needle electromyogram for healthy volunteers because it is an invasive method that could potentially involve infection and pain.

Second, the number of subjects in this study was small. Although some significant results were obtained with a small number of volunteers, it is recommended that a larger number of subjects be used and that the validity of this tool be examined in future research.

The third limitation is the possibility that an orthosis hindered the excursion of the muscles when we measured the amplitude using surface electromyography to determine the optimal wrist position for evaluation of the perfect O sign. To minimize this effect, a volar support part of the orthosis was designed as its overhang toward the thenar was small enough to not hinder the excursion of the thenar muscles, including the APB, and the band over the first web was designed to be as narrow as possible so as to not hinder the excursion of the FDI. Despite this, there remains the possibility of an obstacle to muscle excursion other than the thenar muscles and FDI.

Lastly, the roundness of the perfect O sign was only obtained in a single patient with carpal tunnel syndrome. This was merely a reference value for the disease. There is some possibility that amplitude of each muscle when a healthy person forms the perfect O sign differ from those of a carpal tunnel syndrome patient. The effect of limb and wrist position in cases of carpal tunnel syndrome may be different. A larger amount of data should be collected in the future so as to enable verification of the difference between subjects with and without carpal tunnel syndrome.

Conclusion

The optimal wrist position for evaluating the perfect O sign was examined, and a quantification tool for the perfect O sign was developed based on the results. The optimal wrist position for the perfect O sign was determined to be dorsiflexion. The roundness of the perfect O sign in healthy subjects obtained using this tool was 82.08 ± 7.92%. In the future, we will conduct research with an increased number of subjects both with and without carpal tunnel syndrome, and demonstrate the validity of this tool.

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■CASE REPORTS

Effect of Perceptive Exploration Activity on Spoon Manipulation by Paralyzed Upper Extremity with Sensory Disturbance in a Patient with Stroke Hemiparesis: A Single-Subject Research Design

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Abstract: Introduction: Functional use of a paralyzed upper extremity in patients with hemiparesis after stroke depends on the specificity of the task. Further, task specificity-dependent upper extremity use is an important factor in the recovery of upper extremity function. The purpose of this study was to investigate the usefulness of a perceptive exploration activity in consideration of the specificity of the task for Japanese male patient in his 70s and monitor its effect on spoon manipulation using the affected arm.
Methods: A single-subject research design was implemented in the ABAB trial. The facilitation of selective movement of the paralyzed upper extremity and self-care skill training were provided during baseline A and A' as occupational therapy (OT). In addition to the OT, 10 minutes of perceptive exploration activity was added during the interventions B and B'. The required time (RT) and number of errors (NOE) in task performance were monitored as the outcome of the therapeutic effect. Goal Attainment Scaling (GAS) and Fugl-Meyer Assessment (FMA) were also adopted to evaluate individual goals and changes in upper extremity function.
Results: RT and NOE in task performance were decreased with interventions B and B' compared to baselines A and A'. GAS score improved in interventions B and B', and FMA showed a gradual improvement within each phase.
Conclusion: Spoon manipulation using the paralyzed upper extremity with sensory disturbance was improved by perceptive exploration activity. Current therapy suggests that perceptive exploration activity may be effective in improving movement skills in the manipulation of tools.

Keywords: hemiparesis, paralyzed upper extremity, spoon manipulation, perceptive exploration activity, ABAB trial

(*Asian J Occup Ther* **18**: 111−115, 2022)

Introduction

Restoration of functional use of the paralyzed upper extremity is one of the goals of occupational therapy (OT) in patients with stroke hemiparesis because paralyzed upper extremities often cause difficulty in manipulating tools for everyday items by problems such as sensory disturbance and motor control [1]. In addition, approximately 50% of stroke patients experience sensory disturbance, which negatively affects the functional use of the upper extremities [2].

The functional use of the upper extremities is supported by the corticospinal system [3]. For upper extremity function supported by the corticospinal system depends on the specificity of the task, and the exploration of perceptual information and motor control are important factors for the recovery of upper extremity function [4]. Therefore, the exploration of perceptual information and motor control that depends on the specificity of the task is a hypothesis that improves the functional use of the paralyzed upper extremity. The purpose of this study was to monitor the effects of perceptive exploration activity performed.

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Method

Subject

The patient, a male in his 70s, diagnosed with a cerebral infarction in the left middle cerebral artery inferior trunk area participated in this study.

This study was initiated on day 127 of the illness. Brunnstrom's stages were right upper extremity IV, finger V. The paralyzed upper extremity had had sensory disturbance and therefore was not used in activities of daily living (ADLs).

ADLs were required the setting and watching of the environment. The Functional Independence Measure had 81 scores. Eating was performed by adjusting the environment of the dining table and manipulating the spoon of the non-paralyzed upper extremity. The spoon manipulation of the paralyzed upper extremity was not appropriate. He spilled most of the food because of the poor fundamental movement of scooping.

Research Design

In this study, the ABAB trial was conducted after obtaining informed consent from the patient. At baselines A and A', OT comprised facilitating selective movement of the paralyzed upper extremity and self-care skill training was provided for 40 minutes a day, five days a week. For interventions B and B', a specific intervention for 10 min was added to OT.

Specific Intervention (Fig. 1a)

Spoon manipulation using the paralyzed upper extremity was found to be difficult for scooping the food, so the task of stirring soybeans was selected. This task is considered as a perceptive exploration activity that scoops changes in the sense of resistance to soybeans as an aggregate, and the movement to scoop is a fundamental movement skill of the hand [5].

In the therapy, the paralyzed upper extremity of the patient was guided, and the hand shaping and soybean movement were adjusted based on the change in the sense of resistance provided by the soybeans as an aggregate.

Outcome Measurements

1) Efficiency of spoon manipulation by the paralyzed upper extremity (Fig. 1b, c)

Measurements of evaluation task were taken in daily sessions, measuring the required time (RT) and the number of errors (NOE) based on the beans spilled from the spoon.

2) Goal Attainment Scaling: GAS

GAS was measured at the end of each phase, and the change in score was calculated [6].

3) Fugl-Meyer Assessment: FMA

The FMA was used to measure movement, sensation, range of motion, and pain in the upper extremity at the end of each phase.

Data analysis

For the analysis, RT and NOE measured in each period were compared by 2 standard deviation (2SD) bands, Kruskal-Wallis H-test for analysis of variance, and Mann-Whitney U-test with Bonferroni correction for multiple comparison and was considered statistically

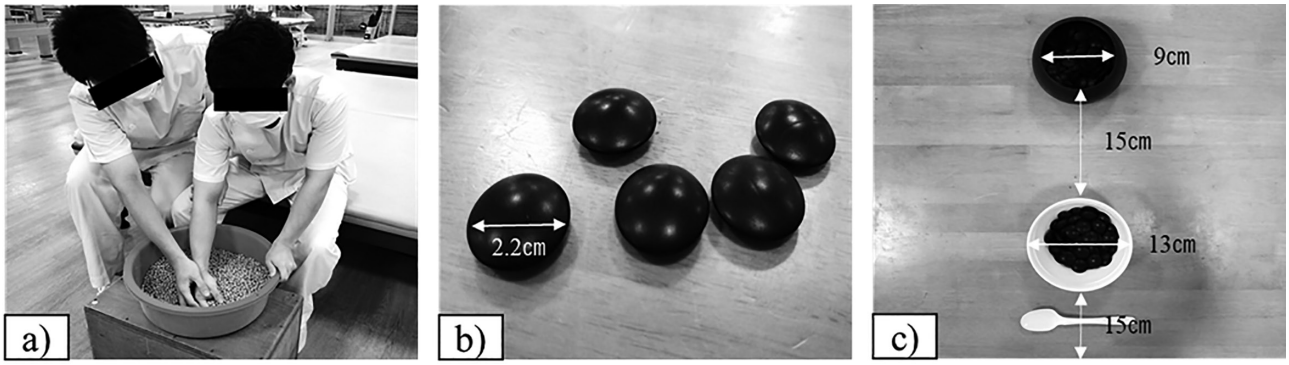

Fig. 1. a) Reproduction of therapy scene by perceptive exploration activity.
b) Go stones. The surface is smooth, is 2.2 cm in diameter, and has a clear weight.
c) Evaluation task. Because there is no evaluation task for utensils manipulation so far, it was decided independently with reference to previous research in Japan. The setting on the table controlled the distance from the edge in front of the table to the Japanese bowl and the distance from the Japanese bowl to a different bowl to 15 cm. The Japanese bowl containing the Go stone is 13 cm in diameter and 6.8 cm in depth. A different bowl is 9 cm in diameter and 6.8 cm in depth. The evaluation task was to move the Go stones placed in the Japanese bowl to a different bowl placed in front of the former as quickly as possible by manipulating the spoon using the paralyzed upper extremity.

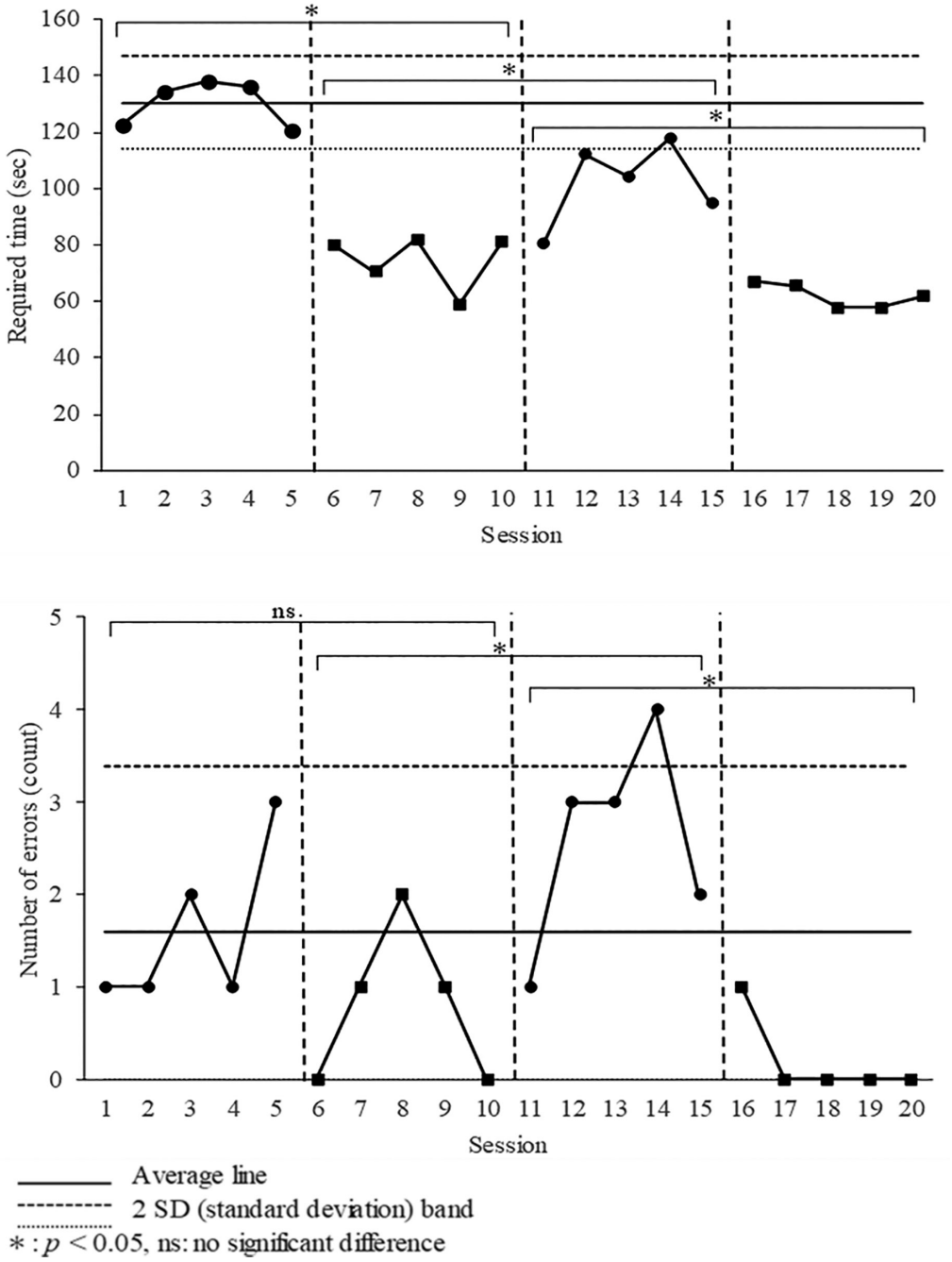

Fig. 2 Changes in required time and number of errors in task performance

significant at $p < 0.05$.

In addition, the correlation coefficient of RT, NOE and FMA were calculated using the Spearman's rank correlation coefficient.

Results

RT and NOE by 2SD bands showed a decrease in interventions B and B' (Fig. 2). Table 1 shows the changes in outcomes during each phase. Intervention B's RT was reduced relative to baseline A ($p = 0.013$), but NOE was not significantly different ($p = 0.124$). A comparison of intervention B and A' showed an increase in both RT and NOE ($p = 0.026$, $p = 0.031$). A comparison of baseline A' and intervention B' showed a decrease in both RT and NOE ($p = 0.013$, $p = 0.016$). GAS improved with interventions B and B'. In addition, the spoon manipulation at the B and B' stages has smoothly changed the process of scooping food and eating it to the mouth. The FMA showed a gradual improvement in

Table 1. Effect of interventions on the main outcome measures

		Pre	Baseline A	Intervention B	Baseline A'	Intervention B'
Task performance	Required time (sec)	-	130.5±8.3	74.7±9.8	102.0±14.7	61.8±4.3
	Number of errors (count)	-	1.6±1.6	0.8±0.8	2.6±1.1	0.2±0.4
GAS	Goal 1: Spoon manipulation of the paralyzed upper extremity in eat	-1	-1	0	0	+1
	Goal 2: Shortening required time in task performance	-1	-1	+2	0	+2
	Goal 3: Reduction of number of errors in task performance	-1	-1	+1	-1	+2
	Calculated goal attainment scores	36	36	64	45	73
FMA	Upper-extremity movement (/66)	52	54	54	58	59
	Reflex (/4)	4	4	4	4	4
	Flexor synkinesis (/12)	9	10	10	11	12
	Extensor synkinesis (/6)	6	6	6	6	6
	Flexor-extensor synkinesis mixed (/6)	4	4	4	5	5
	Selective movement (/6)	3	3	3	5	5
	Normal reflex activity (/2)	2	2	2	2	2
	Hand joint (/10)	7	7	7	7	7
	Finger function (/14)	13	14	14	14	14
	Coordination and speed (/6)	4	4	4	4	4
	Upper-extremity sensory (/12)	2	2	3	4	4
	Superficial sensation (/4)	2	2	3	4	4
	Sense of position (/8)	0	0	0	0	0
	Upper-extremity range (/24)	19	21	21	22	22
	Upper-extremity pain (/24)	19	22	22	22	22

The required time and number of errors in the task performance indicate the mean value ± standard deviation.
GAS: Goal Attainment Scaling, FMA: Fugl-Meyer Assessment.

each phase.

The correlation coefficient between FMA and RT was -0.6 and NOE was -0.3; hence, a negative correlation was observed.

Discussion

The paralyzed upper extremity of the patient before the intervention had sensory disturbance, and therefore spoon manipulation was not practical. One underlying mechanism may be disorders of the central nervous system affecting tool manipulation of upper extremity function, which is associated with motor and sensory function [7].

Therefore, perceptive exploration activity was performed in this study to facilitate the perceptive exploration function of the paralyzed upper extremity. Our observation is consistent with previous studies suggesting perceptive exploration of the hand is an active movement that brings consistency between hand movements and sensations, and reactions based on somatosensory input are the basis for acquiring movement skills [8, 9]. In terms of the corticospinal system in the functional use of the hand, the recruitment of corticospinal neurons is activated during hand movement based on perceptive exploration and regulates fine control of the hand [10]. Therefore, it would be reasonable to assume that our intervention improved spoon manipulation and GAS score.

In addition, from the result of negative correlation between spoon manipulation and FMA, the effect of recovery of the motor function of the upper extremity on spoon manipulation cannot be ruled out. Therefore, it is a future task to verify the function that greatest effect on spoon manipulation.

Conclusion

It has been shown that perceptive exploration activity may be effective in improving movement skills in tool manipulation of the paralyzed upper extremity with sensory disturbance.

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■ORIGINAL ARTICLE

Relationship between Driving Risk, Attention Function, and Driving Characteristics of Healthy Middle-aged and Older Female Drivers in the Fukui Prefecture in Japan

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Abstract: Problem Statement: There is a need to determine whether a brain-injured person can return to driving from the viewpoint of a healthy individual's driving abilities and characteristics. Accordingly, this study investigated the attention function and driving characteristics of healthy middle-aged and older female drivers in a region with a high level of automobile dependence, and examined their relationship with traffic violations and accidents.
Methodology: Participants were 81 healthy female drivers, with a mean age of 64.4 ± 8.4 years, whose incidences of traffic violations and accidents, attention function, and driving characteristics were examined. Attention function was evaluated using Trail Making Test Part A, Trail Making Test Part B, and Symbol Digit Modalities Test. Participants were divided into two groups according to whether they had been involved in traffic violations or accidents. Statistical comparisons were performed.
Results: Drivers who experienced violations and accidents exhibited reduced attention function in the Trail Making Test Part A assessments. Trail Making Test Part B and Symbol Digit Modalities Test were unrelated to driving risk. Driving characteristics showed differences between the two groups.
Conclusion: In addition to attention function, potential personality changes and awareness of disease after brain damage may affect the driving function of people with brain damage, in addition to their driving characteristics and personality traits from before the brain damage. In the future, we aim to conduct a survey of drivers with brain diseases to help determine criteria for whether a person with a brain injury can return to driving.

Keywords: middle-aged and older, female driver, traffic violations and accidents, visual attention, driving characteristics

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Introduction

For many people, driving automobiles (hereinafter, driving) is an essential part of daily life. Although a decline in cognitive function from higher brain dysfunction resulting from brain injuries significantly affects driving [1, 2], it has been reported that 40–80% of people who suffer brain injuries ultimately return to driving [3−6]. Whether a driver can return to driving after a brain injury greatly affects the maintenance of life, especially in automobile-dependent areas; hence, there is often conflict over the support that should be given to patients to facilitate a return to driving. There is a need to assess whether someone who has suffered a brain injury is more likely to commit traffic violations (hereinafter referred to as violations) or cause traffic accidents (hereinafter referred to as accidents). However, there is no international consensus on a standardized assessment of an individual's capacity to drive after suffering a brain injury [7]. While no clear safety standards, such as specific test parameters and values, have

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been established in Japan either, common assessments include cognitive function tests and road assessments. It has been reported that 90% of the information used in driving is visual information, and cognitive function tests are essential to assess visual attention function. While attention function tests are highly valuable in determining an individual's fitness to drive [8, 9], it is not clear what level of attention function would allow a person who has suffered brain injury to drive as safely as a healthy person. There have been no studies comparing and verifying the attention functions of healthy drivers. In addition to cognitive function, driver gender and personal driving characteristics affect cognitive and decision-making processes in driving [10]. According to the statistics on traffic violations and accidents in Japan [11, 12], the accident rate is higher for women than for men when standardized by distance traveled, with an increasing trend observed especially in middle-aged and older drivers. Several studies have focused on the influence of driver personality characteristics on behavior at the wheel among healthy drivers of different ages [13, 14]. Several studies on patients with brain disease have investigated their driving skills from the perspective of attention function and operating skills [8,15–17], but few studies have considered gender or driving characteristics [18]. It is believed that comprehensive judgment is necessary for brain-injured people to resume driving [19], but t but no specific criteria for comprehensive judgment for driving have been established. To date, no studies have examined attention functions and driving characteristics based on female drivers' violation or accident experience.

This study aims to fill this research gap by investigating the attention function and driving characteristics of healthy middle-aged and older female drivers in a car-dependent area, to examine the relationship between these two variables and traffic violations and accidents, and to compare the driving functions of healthy drivers and drivers with brain diseases in the future.

The study protocol was approved by the Nittazuka Medical Welfare Center Ethics Review Committee (NE: 2019−35).

Material and Subject

Participants and Basic Attributes

Of the healthy individuals who participated in the "Health Checkup Project" held at commercial facilities in Fukui, which comes under the Fukui Prefecture in Japan, we recruited individuals who were: between 50 and 80 years, in possession of a regular automobile license, and driving on a daily basis. This prefecture has the highest automobile ownership rate in Japan and is a typical automobile-dependent region [20]. Those with a history of brain disease or brain trauma were excluded from the investigation. As women accounted for approximately 80% of the 115 participants, we decided that only data from female participants would be analyzed in the study.

Participant age, gender, and driving records were investigated based on a self-administered questionnaire.

Presence or Absence of Violations or Accidents

A self-administered questionnaire was used to investigate whether the participants were involved in traffic violations or accidents in the past three years. In terms of violations, which included those cited by the police, participants were asked to choose all applicable instances from a list that included the following options (1) stop sign violation, (2) over speeding, (3) ignoring traffic light, (4) use of mobile phone, (5) not wearing seatbelt, and (6) other. If (6) was selected, the participants were asked to describe the violation in detail. Accidents were limited to those caused by negligence, and we investigated the circumstances surrounding the accident and whether there was property damage. Similarly, we investigated the incidence of personal injuries suffered and the specific matter of the accident.

Attention Function

The Trail Making Test Part A (TMT-A) (A4 vertical version), the Trail Making Test Part B (TMT-B) (A4 vertical version), and the Symbol Digit Modalities Test (SDMT) were performed to determine the time taken for TMT-A and TMT-B and calculate the SDMT achievement rate. All of these tests require the visual attention function. While TMT-A primarily requires the selection function, TMT-B primarily requires the conversion function, and SDMT requires the distribution function. These tests are often used to judge driving aptitude. In the present study, the cutoff values were set to 54 s for TMT-A [21], 150 s for TMT-B [21], and 37.3% for SDMT [22]. In addition, to evaluate as many participants as possible while the "Health Checkup Project" was being held, the time limits for TMT-A and TMT-B were set to 90 s and 180 s respectively, and the evaluation was aborted if it was not completed within the time limit. If the evaluation was not completed within the time limit, the time taken for evaluation was regarded as 90 s for TMT-A and 180 s for TMT-B. The evaluations were performed without informing the participants about the time limit.

Driving Characteristics

A self-administered questionnaire based on a four-point Likert scale was used to investigate how

Table 1. Questionnaire about Driving Characteristics

Please answer about your driving. How applicable are the following statements to you usually? Choose the one that best applies to you and mark the number to the right of each sentence with a circle. Please answer honestly. Please answer with intuition without thinking too deeply. 1: Not applicable at all, 2: Not very applicable, 3: Quite applicable, 4: Very applicable				
1) I struggle to switch lanes in a traffic jam *	1	2	3	4
2) I prefer buses and trains over cars when there is not much difference in the amount of time it takes to arrive at the destination	1	2	3	4
3) I keep a good distance between cars without worrying about being interrupted *	1	2	3	4
4) I make sure to slow down and stop appropriately	1	2	3	4
5) I look at the signal ahead and slow down or speed up in advance	1	2	3	4
6) Cars are a means of transportation, so I think it's only necessary to move *	1	2	3	4
7) I cannot be focused on driving when I have worries and problems	1	2	3	4
8) I'm always worried about running over pedestrians	1	2	3	4
9) I avoid parking in no-park areas, even for a short time	1	2	3	4
10) I am confident in the width of the car	1	2	3	4
11) When traveling by car, I prefer a wide, well-maintained road with as much traffic light as possible, rather than a back road	1	2	3	4
12) I want to be as close to the front as possible even after a lane switch	1	2	3	4
13) I carefully check safety when switching lanes and at intersections	1	2	3	4
14) I adjust the speed so that I will not get caught in the previous signal	1	2	3	4
15) I think that the car is a status symbol (a cool car)	1	2	3	4
16) I drive fast or neglect to drive according to my mood	1	2	3	4
17) I am worried about causing a car accident	1	2	3	4
18) I always keep the speed limit	1	2	3	4
19) I overtake the car when overtaken	1	2	3	4
20) I overtake a lower grade car	1	2	3	4
21) I sounds the horn when the preceding car is late to start, such as when the traffic light turns green.	1	2	3	4
22) I switch lanes when given the slightest space	1	2	3	4

*: Reverse queitions

participants drove and used their cars (Table 1). The questionnaire consisted of 18 questions from the Driving Style Questionnaire (DSQ) [23] and four moral factor questions concerning driving characteristics [24]. The Driving Behavior Questionnaire (DBQ), developed by Reason [25], is often used internationally as a questionnaire for driving behavior. However, since there is no Japanese version of the DBQ, the DSQ was used in this study. Emotional factors, including anger and aggression while driving, affect driving behavior (moral) [26], so a moral factor was added. The DSQ consists of eight principal components [23]: I. Confidence in driving skills (Questions 1 and 10), II. Passivity for driving (Questions 2 and 11), III. Hasty driving (Questions 3 and 12), IV. Meticulous driving (Questions 4 and 13), V. Prepared for traffic signals (Questions 5 and 14), VI. Car that is a status symbol (Questions 6 and 15), VII. Unstable driving (Questions 7 and 16), and VIII. Worried driving (Questions 8 and 17). Questions 9 and 18 were added as false discovery scales to check if they were answered from the perspective of social desirability [23]. Driving characteristics were ultimately classified into nine categories with the addition of IX. Moral problems (Questions 19, 20, 21, and 22) (Table 2).

Table 2. Category of the Driving Characteristics

Category		Question number
I	Confidence in driving skills	1,10
II	Passivity for driving	2,11
III	Hasty driving	3,12
IV	Meticulous driving	4,13
V	Prepared for traffic signals	5,14
VI	Car that is a status symbol	6,15
VII	Unstable driving	7,16
VIII	Worried driving	8,17
IX	Moral problems	19,20,21,22
	False discovery scales	9,18

The driving characteristics were classified into categories I to IX. False discovery scales were not included in the categories.

For all questions, we calculated the number of people who responded, "very applicable to quite applicable" and the number of people who responded, "not applicable at all to not very applicable." However, as Questions 1, 3, and 6 were reverse questions, their response values were also reversed.

Method

We provided participants with written explanations about the purpose of the research and the methodology through which personal information would be handled before obtaining their oral consent to participate.

Analysis based on the Presence or Absence of Traffic Violations or Accidents

The participants were divided into the No Violation/Accident Group (hereinafter, NVA Group) or Violation/Accident Group (hereinafter, VA Group) according to whether they had been involved in traffic violations or accidents. Basic attributes, attention functions, and driving characteristics were compared between the two groups.

Analysis based on the Attention Function Results

Participants were divided into two groups according to the mean and standard deviation (SD) values of TMT-A and TMT-B: good attentional function group (hereinafter, Good Group) and poor attentional function group (hereinafter, Poor Group). The former comprised participants whose scores for both TMT-A and TMT-B were less than the mean + SD, and the latter included those whose scores for one or both the tests were higher than the mean + SD. Basic attributes and driving characteristics between the two groups were compared.

Statistical Analysis

Subsequently, the two groups were compared using a t-test, a test of difference in population ratio, and a χ^2-test. SPSS statistics 25 and Bell Curve for Excel software (Social Survey Research Information Co, Ltd, Tokyo, Japan) were used as the statistics software; the significance level was set to 5%.

Results

Analysis based on the Presence or Absence of Traffic Violations or Accidents

1) Basic Attributes

Table 3 shows the basic attributes of the participants. There were 81 participants, with a mean age of 64.4 ± 8.4 years and a mean driving experience of 36.7 ± 8.6 years. The number of participants (proportion), mean age, and mean number of years of driving experience according to NVA/VA Groups were 63 participants (77.8%)/18 participants (22.2%), 64.4 ± 8.5 years/64.4 ± 8.3 years, and 36.8 ± 9.0 years/36.2 ± 7.5 years, respectively. Comparison of mean age and mean number of years of driving experience between the two groups showed no significant differences. The VA Group included 10 participants with experience of violations, seven participants with experience of property damage accidents, and one participant with experience of violation and property damage accident. No participant reported

Table 3. Profile of the Participants

	All participants (n=81) Mean (SD)	NVA group (n=63) Mean (SD)	VA group (n=18) Mean (SD)	p
Age	64.4 (8.4)	64.4 (8.5)	64.4 (8.3)	n.s.
Driving experience (years)	36.7 (8.6)	36.8 (9.0)	36.2 (7.5)	n.s.
Traffic violations (n=10)			Stop sign violation	5*
			Overspeeding	2
			Not wearing seatbelt	2
			Trespassing violation	2
			Ignoring traffic signals	1
			Use of mobile phone	0
Property damage accidents (n=7)			Collisions	5*
			Scratches	3
Traffic violations and Property damage accidents (n=1)			(Stop sign violation and Collision)	
Personal injury accidents (n=0)				

Statistics: T-Test was performed. n.s.: not significant

*: One of them is experiences both stop sign violation and collision.

Table 4. Attention Function Examination

	Cut-off	All participants (n=81) Mean (SD)	NVA group (n=63) Mean (SD)	VA group (n=18) Mean (SD)	p
TMT-A (seconds)	54	36.0 (11.3)	35.1 (10.4)	38.6 (13.9)	n.s
Below the cut-off values (%)			3.2	11.1	<.05
*Time limit over (%)			0	5.5	
TMT-B (seconds)	150	89.3 (31.7)	88.1 (31.9)	93.3 (31.3)	n.s.
Below the cut-off values (%)			4.8	11.1	n.s.
*Time limit over (%)			3.1	0	
SDMT (%)	37.3	46.9 (8.8)	47.0 (8.9)	46.4 (8.4)	n.s.
Below the cut-off values (%)			19	22.2	n.s.

TMT-A: Trail Making Test part A, TMT-B: Trail Making Test part B, SDMT: Symbol Digit Modalities Test
*Time limit: TMT-A 90 seconds, TMT-B180 seconds
Statistics: T-Test and Hypothesis Testing for the Difference in the Population Proportions were performed.
n.s.: not significant

Table 5. Driving Characteristics

	Category	Questions	All participants (n=81) (%)	NVA Group (n=63) (%)	VA Group (n=18) (%)	p
I	Confidence in driving skills	I struggle to switch lanes in a traffic jam	45.7	39.7	66.7	<.05
		I am confident in the width of the car	38.3	38.1	38.9	n.s.
II	Passivity for driving	I prefer buses and trains over cars when there is not much difference in the amount of time it takes to arrive at the destination	17.3	14.8	27.8	n.s.
		When traveling by car, I prefer a wide, well-maintained road with as much traffic light as possible, rather than a back road	61.7	57.1	77.8	n.s.
III	Hasty driving	I keep a good distance between cars without worrying about being interrupted	61.7	61.3	61.1	n.s.
		I want to be as close to the front as possible even after a lane switch	8.6	9.5	5.6	n.s.
IV	Meticulous driving	I make sure to slow down and stop appropriately	74.1	75.4	77.8	n.s.
		I carefully check safety when switching lanes and at intersections	84.0	84.1	83.3	n.s.
V	Prepared for traffic signals	I look at the signal ahead and slow down or speed up in advance	46.9	41.3	66.7	n.s.
		I adjust the speed so that I will not get caught in the previous signal	27.2	25.4	33.3	n.s.
VI	Car that is a status symbol	Cars are a means of transportation, so I think it's only necessary to move	46.9	42.6	55.6	n.s.
		I think that the car is a status symbol (a cool car)	6.2	4.8	11.1	n.s.
VII	Unstable driving	I cannot be focused on driving when I have worries and problems	8.6	4.8	22.2	<.05
		I drive fast or neglect to drive according to my mood	8.6	6.3	16.7	n.s.
VIII	Worried driving	I'm always worried about running over pedestrians	32.1	25.8	55.6	<.05
		I am worried about causing a car accident	50.6	42.9	77.8	<.01
IX	Moral problems	I overtake the car when overtaken	3.7	1.6	11.1	n.s.
		I overtake a lower grade car	4.9	3.2	11.1	n.s.
		I sounds the horn when the preceding car is late to start, such as when the traffic light turns green.	2.5	1.6	5.6	n.s.
		I switch lanes when given the slightest space	2.5	0.0	11.1	<.01

Statistics: χ^2 Test was performed. n.s.: not significant

any personal injury accidents. The survey revealed that five participants had stop sign violations and two had speeding violations. In addition, two participants were caught not wearing a seatbelt, two had trespassing violations, and one was reprimanded for ignoring traffic signals. None of the participants had a traffic violation for using a mobile phone while driving. Property accidents comprised five participants with collisions and three with minor damage on their vehicle.

2) Participants' Attention Function

Table 4 shows the time taken for TMT-A and TMT-B, as well as the SDMT achievement rate of each group. The ratio of participants below the cutoff values in the NVA/VA Groups was 3.2%/11.1% for TMT-A, 4.8%/11.1% for TMT-B, and 19.0%/22.2% for SDMT. The percentages of participants who were unable to complete the assessments within the time limit were 0%/5.5% for TMT-A and 3.1%/0% for TMT-B. Although the VA Group did not differ significantly from the NVA Group in the TMT-A time, the VA Group had

a significantly higher percentage of participants below the cutoff value ($p<0.05$). There were no significant differences between the two groups in terms of TMT-B and SDMT.

3) Driving Characteristics

Table 5 shows the proportion of responses to questions related to driving characteristics.

A significantly greater proportion of participants responded "very applicable to quite applicable" for Category IV ("I carefully check safety when switching lanes and at intersections" [84%] and "I make sure to slow down and stop appropriately" [74.1%]), followed equally by Category II ("When driving, I prefer wide, well-maintained roads with as many traffic signals as possible, rather than back roads" [61.7%]) and Category III ("I keep a good distance between cars without worrying about being interrupted" [61.7%]). The least frequent response was recorded for Category IX ("Moral concerns"), with less than 5% for all four questions.

The analysis of traffic violations/accidents and driving characteristics showed that the five questions that elicited significant differences in responses between the two groups were: "I struggle to switch lanes in a traffic jam" ($p<0.05$) in Category I; "I cannot be focused on driving when I have worries and problems" ($p<0.05$) in Category VII; "I am always worried about running over pedestrians" ($p<0.05$) and "I am worried about causing a car accident" ($p<0.01$) in Category VIII; and "I switch lanes when given the slightest space" ($p<0.01$) in Category IX. The VA Group had a significantly greater proportion of participants who responded "very applicable to quite applicable." There were no differences between the two groups in terms of questions from Categories II, III, IV, V, and VI. Furthermore, there were no significant differences between the two groups in terms of responses to the two questions added as false discovery scales.

Analysis based on the Attention Function Results

Table 6 shows the results of the analysis of attention function results and driving characteristics.

The time required for TMT-A/TMT-B for all participants was 36.0 ± 11.3/89.3 ± 31.7 s. The Good Group consisted of 58 participants aged 62.7 ± 8.4 years and required 30.6 ± 7.1 s to complete the tests. The Poor Group consisted of 23 participants aged 68.6 ± 6.8 years and required 49.6 ± 8.2 s to complete the tests. The Good Group was significantly younger than the Poor

Table 6. Attention Functions and Driving Characteristics

Category		Questions	Good group (n=58) (%)	Poor group (n=23) (%)	p
I	Confidence in driving skills	I struggle to switch lanes in a traffic jam	50.0	34.8	n.s.
		I am confident in the width of the car	29.3	60.9	<.01
II	Passivity for driving	I prefer buses and trains over cars when there is not much difference in the amount of time it takes to arrive at the destination	13.8	26.1	n.s.
		When traveling by car, I prefer a wide, well-maintained road with as much traffic light as possible, rather than a back road	53.4	82.6	<.05
III	Hasty driving	I keep a good distance between cars without worrying about being interrupted	63.8	56.5	n.s.
		I want to be as close to the front as possible even after a lane switch	8.6	8.7	n.s.
IV	Meticulous driving	I make sure to slow down and stop appropriately	74.1	73.9	n.s.
		I carefully check safety when switching lanes and at intersections	82.8	87.0	n.s.
V	Prepared for traffic signals	I look at the signal ahead and slow down or speed up in advance	48.3	43.5	n.s.
		I adjust the speed so that I will not get caught in the previous signal	27.6	26.1	n.s.
VI	Car that is a status symbol	Cars are a means of transportation, so I think it's only necessary to move	46.6	47.8	n.s.
		I think that the car is a status symbol (a cool car)	6.9	4.3	n.s.
VII	Unstable driving	I cannot be focused on driving when I have worries and problems	12.1	0.0	n.s.
		I drive fast or neglect to drive according to my mood	10.3	4.3	n.s.
VIII	Worried driving	I'm always worried about running over pedestrians	29.3	39.1	n.s.
		I am worried about causing a car accident	51.7	47.8	n.s.
IX	Moral problems	I overtake the car when overtaken	3.4	4.3	n.s.
		I overtake a lower grade car	5.2	4.3	n.s.
		I sounds the horn when the preceding car is late to start, such as when the traffic light turns green.	1.7	4.3	n.s.
		I switch lanes when given the slightest space	1.7	4.3	n.s.

Statistics: χ^2 Test was performed. n.s.: not significant

Group. An analysis of driving characteristics by attention function showed that the two questions that elicited significant differences in response between the two groups were: Category I: "I am confident in the width of the car" ($p<0.01$) and Category II: "When traveling by car, I prefer a wide, well-maintained road with as much traffic light as possible, rather than a back road" ($p<0.05$). The Poor Group had a significantly greater proportion of participants who responded "very applicable to quite applicable." There were no differences between the two groups regarding questions from Categories III to IX and false discovery scales.

Discussion

Attention Function and Driving Risk

As the percentage of participants below the cutoff value in TMT-A showed differences between the two groups, we inferred that reduced selective attention increased driving risk. However, TMT-B and SDMT were found to be unrelated to driving risk. All accidents experienced by study participants were collision and scratch accidents; there were no serious accidents that resulted in personal injuries. In a study of elderly drivers over 65 years old, Horikawa *et al*. [27] reported that TMT-A results were related to mild collision and scratch accidents, and that TMT-B results were unrelated to accidents, which is consistent with our results. As such, TMT-A can be regarded as an indicator that predicts the risk of violations or minor accidents. In contrast, a report by Kobayashi *et al*. [22] that showed the importance of SDMT, cited the results of Track Tests, which were different from those discussed in the present study that examined violations and accidents. At present, there are no methods or clear criteria for objectively evaluating driving risk from the perspective of attention function [27], and further studies are needed.

Driving Characteristics and Driving Risk

Driving characteristics, which recognized differences based on the presence or absence of violations or accidents, were addressed by questions contained in four categories (I, VII, VIII, and IX). As participants in the VA Group agreed that they frequently struggled to switch lanes during traffic jams and worried about causing a car accident and hitting a pedestrian, it was evident that they were more anxious about driving than participants in the NVA Group. Many participants in the VA Group also mentioned that they cannot concentrate on driving when they have anxiety or worries, which suggests how psychologically vulnerable they may be. Pêcher *et al*. [28] reported that negative emotions, such as anxiety and depression, enhance driving safety. Although negative emotions can be a compensatory measure to enhance safety, they may have acted as a factor impeding driving concentration among individuals in the VA Group in our study. In addition, many participants in the VA Group mentioned that they switch lanes when given the slightest space, suggesting hasty driving. As it has been reported that hasty drivers struggle with emotional control, such as managing their irritation and impatience, and are prone to make situational judgments [29], we conceived that participants in the VA Group were more easily affected by other drivers and the surrounding environment and tended to lose their cool while driving.

Previous studies on the driving aptitude of persons with brain injury [18, 30] have suggested that incidences of traffic violations and accidents are affected by the driving characteristics and personality of the driver, regardless of brain injury. The present study also showed that driving characteristics are related to traffic violations and accidents, implying that in the future, it may be important to consider a driver's pre-brain injury driving characteristics and personality when determining whether the individual can resume driving. Furthermore, Anstey *et al*. [31] clearly distinguished "driving ability" from "driving behavior," mentioning that "driving ability" is determined by an individual's cognitive and physical functioning, whereas "driving behavior" is determined by an individual's driving abilities and self-monitoring abilities. In other words, it is possible that the ability to accurately monitor one's own driving abilities affects driving risk. We feel that it is necessary to evaluate the personality changes and disease awareness of an individual after experiencing a brain injury, while remembering that brain injuries not only reduce cognitive functioning, but also cause personality changes and reduce disease awareness.

Importantly, in our study, the two groups showed no differences in terms of responses to all questions from Categories II, III, IV, V, and VI.

In particular, most participants agreed with the questions included in Categories II, III, and IV. In other words, the driving characteristics of the female drivers in this study included meticulous and safe driving, passivity for driving, and worried driving. According to a survey of female drivers in their 20s to 50s [3], they are highly anxious, lack confidence and leeway in their driving, and have a strong perception that their driving is safe. This is consistent with the characteristics of the female drivers in this study. However, female drivers tend to drive in a self-centered manner without realizing that they are causing inconvenience to other vehicles [3], and it is possible that they generally perform safety checks such as improper deceleration and stopping.

We believe that the fact that only a few participants

agreed with "I think that the car is a status symbol (a cool car)" supports the results of a previous study [32] that suggested female drivers had less interest in automobiles themselves and were less likely to engage in risky driving compared to male drivers. Moreover, given that only a few participants agreed with "I prefer buses and trains over cars when there is not much difference in the amount of time it takes to arrive at the destination," it is evident that there was relatively little use of public transportation among the participants. We believe this is due to the low convenience level of public transportation and overdependence on automobiles due to the participants living in an automobile-dependent zone.

Attention Function and Driving Characteristics

The group with poor attention function was older than the Good Group, more confident in their sense of vehicle width, and less likely to use narrow roads. Older people tend to rate their own driving ability highly [33, 34], which may lead to their confidence in their sense of vehicle width. In general, female drivers also tend to have more accidents at narrow intersections [12], and drivers with impaired attention functions and older drivers may be more reluctant to drive on narrower roads. No significant differences were found for the other questions, suggesting that there are few differences in driving characteristics by attention function.

Limitations of the Study

In the present study, since TMT-A and TMT-B assessments were made with a time limit given the circumstances of the testing environment, we were unable to accurately measure the time taken by participants who could not complete the assessment within the time limit. As there was one participant from the VA Group who could not complete TMT-A in time and two participants from the NVA Group who could not complete TMT-B in time, it is necessary to be careful when interpreting the results of attention function. Furthermore, it is unclear whether driving characteristics are factors that cause violations or accidents or whether they are characteristics resulting from experiences of driving violations or accidents. For this reason, there is a limitation to discussing the relationship between driving characteristics and driving risk. Moreover, previous studies have suggested that cognitive functioning, driving characteristics, and accident trends vary depending on gender [32,35,36]. Hence, it would be necessary to also verify the gender differences when examining the criteria for persons with brain injury to resume driving.

Conclusion

This study unfolded in three main moves: 1) we investigated the attention function and driving characteristics of healthy middle-aged and elderly female drivers in a region with a high level of automobile dependence, 2) we examined the relationship between these two variables and traffic violations and traffic accidents, and 3) we conducted basic research to compare the driving functions of healthy drivers and drivers with brain diseases. The results showed that subjects in the VA Group more frequently demonstrated driving characteristics, such as reduced attention function in the TMT-A assessments, reduced confidence in driving skills, unstable driving, worries about driving, and moral problems, than subjects in the NVA Group. Furthermore, analysis of attention functions and driving characteristics showed that there was little possibility of differences in driving characteristics depending on attention functions. In addition to attention function, potential personality changes and awareness of disease after brain damage may have affected the driving function of people with brain damage, in conjunction with their driving characteristics and personality from before the brain damage. In the future, it will be necessary to investigate potential personality changes and pathology after brain injury, in addition to driving characteristics and personality before brain injury, as a driving function of drivers after brain injury, and to clarify their relationship with traffic violations and accidents.

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Declaration of interest

There are no conflicts of interest regarding the publication of this paper.

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■CASE REPORTS

Effect of Home-Visiting Support Combining the Canadian Occupational Performance Measure with a Behavioral Reinforcement-based Checklist to Enable Occupation in a Client with Schizophrenia: A Case Study

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Abstract: Introduction: Few reports describe the occupational therapy practice of reinforcing the daily life behaviors hoped for by clients with schizophrenia in community mental health services. We outline a therapeutic process to enable bathing hoped for by a client with schizophrenia through the combined use of the Canadian Occupational Performance Measure (COPM) and a checklist as a cognitive aid.
Methods: The study was divided into a baseline phase and intervention phase based on the single-system design. The interventions were focused on occupation based on the COPM and positive feedback by using the checklist. Assisted bathing, advice, suggestions and prompting of voluntary activities were conducted in the baseline phase.
Results: The frequency of bathing per week increased significantly in the intervention phase compared to baseline phase by binomial test ($p = 0.03$). Although bathing performance score and satisfaction score in the COPM assessment decreased from 10 and 9 (20th week) to 6 and 4 (34th week), respectively, the assessment was influenced by the client's further positive inquiries into ways of bathing.
Conclusion: Bathing hoped for by a client with schizophrenia was enhanced, and further positive inquiries into activities of daily life in a personal context were initiated. The findings suggest that in community-dwelling clients with schizophrenia, a client-centered approach combining COPM and a checklist as a behavioral reinforcement-based cognitive aid is sufficiently appropriate for promoting client participation in activities.

Keywords: enabling occupation, COPM, behavioral reinforcement, schizophrenia, single-system design

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Introduction

Effective approaches focused on the personal context are important to address the diversity of psychosocial difficulties of schizophrenia [1]. Behavioral reinforcement typified by the token economy has been described as one of the evidence-based psychosocial treatments in schizophrenia since being effective to improve adaptive behavior such as personal hygiene and social interactions by using tokens based on material rewards or social rewards (e.g., praise and encouragement) [2]. However, previous research had a bias toward inpatients and institutionalized users, and few practical studies and specific methodologies in daily life with less restrictive for community-dwelling consumers have been reported [3]. We addressed this issue through this study of home-visiting support combining behavioral

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reinforcement and the Canadian Occupational Performance Measure (COPM) for a community-dwelling client with schizophrenia. The COPM is useful for focusing on a client's occupation and has been shown significant effects on clients' self-perceived level of performance and satisfaction with the performance in the previous study [4, 5].

The purpose of this study was to outline the behavioral reinforcement approach process combined with the COPM for a client with schizophrenia. Approval by the institution's research ethics committee (approval number: 2020−002B) and signed informed consent from the client were obtained in this study.

Case

The client was a man in his 50s with schizophrenia. He was living at home with family and clinic follow-up despite residual psychiatric symptoms. After bereaving his parents' deaths, he could not keep himself clean by not bathing due to his obsession with a deviant lifestyle in the absence of supporters although he continued to live alone by eating out or eating prepared food. Worsening mental condition and poor hygiene had alienated him from his workshop community.

Our home-visiting support team had the request of his clinic. The immediate goals shared with him in home-visiting support were to keep clean by himself and participate again in his workshop activities.

Method

Therapy Process

The home-visiting support period was divided into two phases (Table 1).

Baseline phase: 1st to 20th week

During this phase, the nursing staff provided assisted bathing to improve his poor hygiene and prompt his attendance at the workshop to overcome alienation from his community based on observational assessment, and his voluntary participation in these activities was expected.

Intervention phase: 21st to 34th week

Due to behavioral reinforcement, the "Checklist of Activity of Daily Living" (checklist; Figure 1) based on behavioral activation was created with him and introduced to record his daily activities [6]. The staff provided positive feedback on his actions and records on the checklist. Before beginning this phase, the COPM approach was conducted to determine only the occupation "Bathing" by him to collaborate with staff among all personal and meaningful occupations (looking at a favorite picture, taking a trendy vitamin or nutritional supplement, etc.). Sharing the meaning of bathing through the COPM was carried out by the occupational therapist with recording its performance and satisfaction scores. Attending the workshop was not assessed by COPM as he had not voluntarily mentioned it.

Procedure

A single-system design with the advantage to ex-

Table 1. Experimental Procedure and Changes in Outcomes in Each Phase.

	Baseline phase (1st to 20th week)	Intervention phase (21st to 34th week)
Interventions	• Assisted bathing • Advising on methods of keeping the client clean • Suggesting and prompting voluntary bathing and attending the workshop	• Sharing personal context and meaning of bathing based on COPM assessment • Recording on the checklist • Positive feedback based on the checklist records
Frequency per week of attending (times)	0.8 (SD = 0.4, range: 0–1)	1.4 (SD = 0.5, range: 1–2)
Range of working time per week (minutes)	10–60	60–180
COPM assessment about bathing		
Importance score (range: 1–10)	6 (20th week)	8 (34th week)
Performance score (range: 1–10)	10 (20th week)	6 (34th week)
Satisfaction score (range: 1–10)	9 (20th week)	4 (34th week)
Meaning and context (remarks)	"Bathing, for me, is meant to keep me clean." "It was nice to have the home-visiting supporting staff come in and help me stay clean and show me all sorts of ingenious ways to keep me clean."	"I've come to believe that bathing is not just about keeping myself clean." "When I was a student, I used to take a long soak in the bath every day." "The original meaning of bathing for me was to warm up, so I want to soak more properly in the bath."

COPM: The Canadian Occupational Performance Measure; the checklist: The Checklist of Activity of Daily Living; SD: standard deviation. Values are mean, n, or score.

Mr. X's Checklist of Activity of Daily Living

Day		/ ( )	/ ( )	/ ( )	/ ( )	/ ( )	/ ( )	/ ( )
Meal	Breakfast							
	Lunch							
	Dinner							
Water intake								
Excretion								
Time of sleeping								
Bathing		○						
Working			○ (90 min)					

Fig. 1. The Checklist of Activity of Daily Living. This checklist was created with the client and introduced to him. One checklist sheet was used per week and was modified to fit the client's needs. As shown in the figure, the client drew a circle to indicate that a task was done or wrote a description of what he did in the appropriate column.

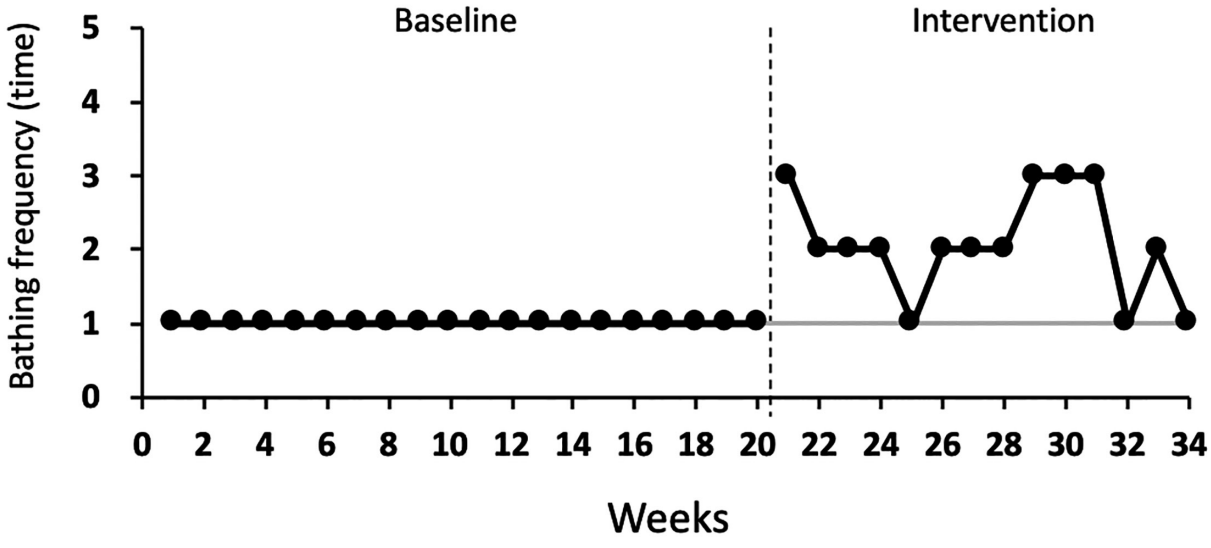

Fig. 2. Frequency per week of bathing. Baseline phase: 1st to 20th week; Intervention phase: 21st to 34th week. Bathing behaviors included bed-bath, some body washing, full-body showering and bathing. The solid gray line indicates the celeration line in the baseline phase. Assisted bathing in the baseline phase was conducted mainly by the staff. In intervention phase, however, the client conducted voluntary bathing by himself. The increase in bathing frequency per week in the intervention phase compared to the baseline phase was statistically significant ($p = 0.03$).

amine causality between the intervention and changes in the target behavior was selected as an outcome to test effectiveness in the combined approach using the COPM and checklist (Table 1). Bathing and attending the workshop were as target behaviors, and the implementations per week of their activities were recorded by the client on the checklist. Bathing behaviors included bed-bath, washing parts of the body, showering, and bathing, whether passively or voluntarily. Reliability of counting the target behaviors was ensured when observing his implementation in daily life through the multidisciplinary collaboration of our team staff, home helpers and workshop staff.

Data Analysis

The split-middle method and the binomial test were adopted to compare bathing behavior per week in each phase [7]. The outcomes of attending the workshop were calculated only by averages and ranges of values as the number of attendance behaviors could not be increased at his discretion due to acceptance by the workshop and holidays. A p-value <0.05 was considered to indicate statistical significance.

Results

The client's frequency of bathing per week increased significantly in the intervention phase compared with the baseline phase ($p = 0.03$, Figure 2). The number of attendances per week and working time in the workshop also increased due to participation in cleaning or cooking assistance (Table 1).

His meaning of bathing was shared in the COPM assessment (Table 1). The performance and satisfaction scores for bathing decreased in the intervention phase (34th week) compared to those before introducing the checklist (20th week) (Table 1). We shared with him that, based on his remarks, these decreasing scores were influenced by his further positive inquiries into ways of bathing (Table 1).

Discussion

Engaging in daily occupations is an important aspect of the mental health and quality of life of people with schizophrenia [8]. The results in the baseline phase indicate that the behaviors of the client with schizophrenia were difficult to change by only suggesting and prompting voluntary behaviors. Although COPM scores decreased due to the exploration of more personally contextualized bathing, the client's remarks and the improvement of performance demonstrated the effect of the COPM approach with promoting a positive awareness of the desire to enable personal and meaningful occupation.

Focusing on involvement in activities of an individual with mental illness is important to achieve independence in the community, and aids may be helpful [9]. Visualization with the checklist as a cognitive aid based on behavioral reinforcement techniques helped the client to realize his execution status. Preferable behaviors based on the client's exploration of meaningful occupations (bathing in this case) may be self-reinforcers and lead to maintenance or alteration without intervention [10].

To validate the effectiveness of this therapeutic approach in a future study, more sophisticated evidence design (e.g., washout of interventions based on the consent of the individual and well-considered ethics), modeling and formulation of the interventions, and an increase in the number of subjects are desirable.

Conclusions

The current home-visiting support combining the COPM approach and the behavioral reinforcement-based checklist as a cognitive aid was sufficiently appropriate for promoting engagement to activities by a community-dwelling client with schizophrenia.

Acknowledgements

We thank the client for his participation and the home-visiting support team staff, the home helpers and the workshop staff for their cooperation in this study.

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■ORIGINAL ARTICLE

Oculomotor Rehabilitation Program for a Patient with Brain Injury in an Acute Care Hospital: A Single-Case Experimental Design

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Abstract: Statement of the problem: We conducted a systematic review on oculomotor rehabilitation for patients with brain injuries; however, an appropriate study design was not used and was inadequate for the evaluation of effect. Thus, in this study, we aimed to verify the benefits of our previously developed oculomotor rehabilitation program for patients with brain injury hospitalized in an acute care hospital.
Methods: This report presents the case of a 50-year-old female patient hospitalized in an acute care hospital for disturbed consciousness and limb dysfunction due to subarachnoid hemorrhage and cerebral stroke. The patient showed abducens nerve palsy of the right eye and right-sided gaze palsy. She received our oculomotor rehabilitation program. An ABAB design was used: Phase A involved basic rehabilitation only, and Phase B involved basic rehabilitation plus the oculomotor rehabilitation program. The program comprised training to promote pursuit, fixation, saccade, and vergence. Starting from day 40 of admission, the patient completed five 20-min sessions per week for 4 weeks forming Phases A1, B1, A2, and B2. The oculomotor range of the right eye was measured during each phase.
Results: The patient did not exhibit fluctuation of vital signs or any adverse events following the oculomotor rehabilitation program. The mean expanded mobility ranges were 1.49 mm in Phase A and 4.91 mm in Phase B ($p < 0.05$).
Conclusion: Implementation of the oculomotor rehabilitation program promoted shortening of the extraocular muscles, resulting in improvement of the oculomotor mobility range.

Keywords: oculomotor, rehabilitation, stroke, acute period

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Introduction

Oculomotor disorder is a serious disorder that reduces the quality of life, as it causes double vision, inhibition of gait and independent daily living, and cosmetic issues for patients [1]. Approximately 37% of patients with oculomotor disorder experience some forms of ocular deviation as a result of brain injury [2]; therefore, acute-phase hospitals encounter many stroke patients with oculomotor disorder. Although surgery has been shown to be an effective treatment for oculomotor disorder [3], it is highly invasive and many patients with this disorder who are admitted to acute care hospitals require monitoring, as one eye must be covered with a patch to block light. Covering the eye may help reduce discomfort; however, a paralyzed eye may be overlooked [4], and disuse of the extraocular muscle may affect the prognosis.

Recently, we conducted a systematic review on oculomotor rehabilitation for patients with brain injuries [5], and based on the findings of the review and after discussing with four experts (a neurologist, a rehabilitation specialist, a physiotherapist, and an occupational therapist [mean duration of clinical experience, 30.5 ± 0.5 years]), we developed a program that can be imple-

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mented in rehabilitation hospitals for stroke patients [6]. In that report, we showed the efficacy of the program in a patient with left thalamic hemorrhage. The patient did not undergo surgery, had stable status, and was admitted to the rehabilitation hospital. We assessed the effect of the oculomotor rehabilitation program. However, an appropriate study design was not used and was inadequate for the evaluation of effect. In addition, we showed the efficacy of the program in subacute patients, including those with subarachnoid hemorrhage [7]. In that study, as for the subjects, time passes after the onset or underwent surgery, therefore the state is stable. The oculomotor rehabilitation program is not very invasive, but it may be effective for a patient who admitted to an acute care hospital and underwent surgery. By using an appropriate study design, assessment of the effect of the oculomotor rehabilitation program in brain injury inpatients in an acute care hospital who had undergone surgery seems to be significant. This single-case study aimed to test the benefits of this oculomotor rehabilitation program for brain injury inpatients in an acute care hospital using an ABAB design.

Methods

Participant

The participant was a 50-year-old, right-handed female patient. She had a history of vertebral artery dissection and is currently living with her husband and two daughters. She performed all housework. On presentation, she chiefly complained of double vision and was urgently transported to our hospital due to a sudden-onset headache. Plain head computed tomography (CT) was performed on the day of onset, which showed subarachnoid hemorrhage, and a diagnosis of subarachnoid hemorrhage due to rupture of vertebral artery dissection was made. The patient remained oriented and capable of communicating during transportation, but her consciousness gradually declined (World Federation of Neurological Surgeons classification Grade V). Although no clear signs of limb paralysis were noticeable, abducens nerve palsy of the right eye was observed. On the day of admission, coil embolization was performed, and the patient was placed on an artificial ventilator. On day 2 of admission, she underwent ventricular drainage. Head magnetic resonance imaging on day 3 revealed elevated signals in the middle cerebellum, left cerebellar hemisphere, and left side of the outer medullar oblongata (Figure 1a, b), indicating profound brain edema; therefore, external decompression was performed on the same day. From day 8, the patient initiated physiotherapy, occupational therapy, and speech and hearing therapy. She was extubated on day 15 of admission and transferred from the intensive care unit to the general hospital ward. Normal-pressure hydrocephalus was identified by plain head CT examination performed on day 30 of admission, and ventriculoperitoneal (VP) shunt placement was performed on day 36. By this time,

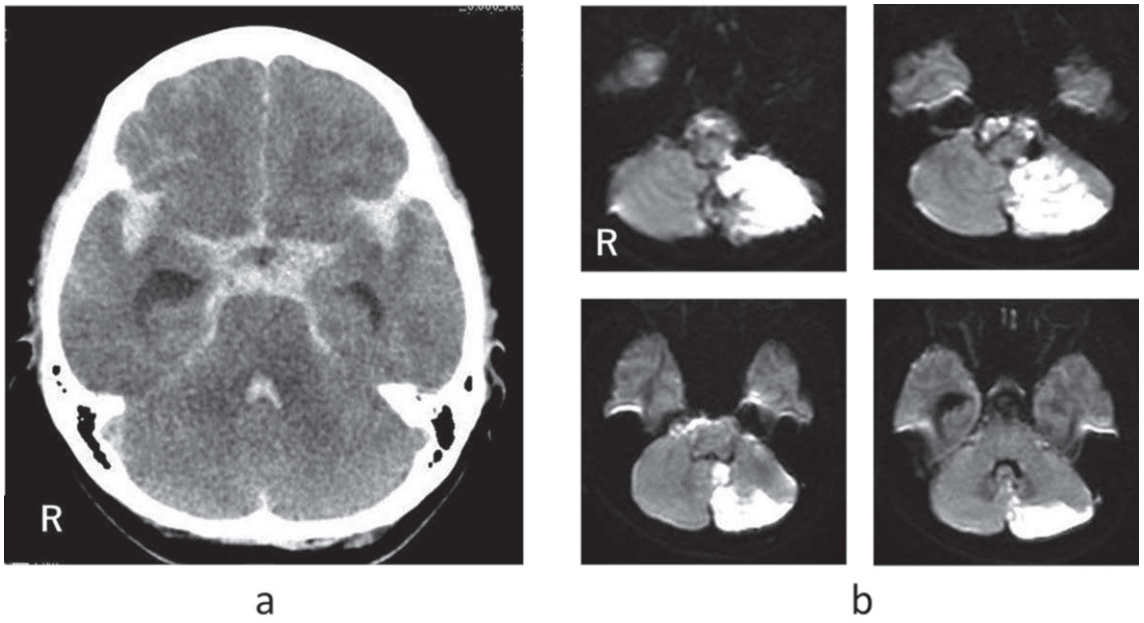

Fig. 1. Radiography results that led to the diagnosis. (a) Plain head computed tomography scans taken on the day of onset showing subarachnoid hemorrhage. (b) Diffusion-weighted head magnetic resonance image taken on day 3 of admission showing elevated signals in the middle cerebellum and left cerebellar hemisphere and on the left side of the outer medulla oblongata.

the patient's consciousness level had improved, and she was capable of communicating. The oculomotor rehabilitation program was initiated on day 40 of admission. Informed consent for inclusion in this case report was obtained from the patient in writing.

Rehabilitation assessment

Neurological and neurophysiological findings

On day 8 of admission, when rehabilitation started, the patient's consciousness was extensively disturbed, with a Glasgow Coma Scale (GCS) rating of eyes (E) of 1 point, verbal (V) intubated, and motor (M) score of 1 point, and she did not respond to stimulation. By day 15 of admission, artificial ventilation was no longer required, and the GCS rating had improved to E3, V2, and M4 and to E4, V4, and M6 after VP shunt placement. Although her respiratory condition was stable, she had remarkable sputum production requiring frequent aspiration. She could maintain a bed-up seated position for approximately 30 min without any changes to vital signs, but experienced dizziness upon changing her head position. The attending physician had instructed not to compress the external decompression site of the left occipital region and had prohibited extensive flexion of the neck because of vertebral artery dissection.

On day 40 of admission, the patient was capable of undergoing detailed neurological and neurophysiological assessment. Although the volume of her voice was low and she appeared confused, she was capable of making ordinary conversation. Her limbs were hypotonic and showed strong proximal paralysis, with Brunnstrom recovery stages of III–V–III for the right side and II–V–II level for the left. Ataxia was noted in the left upper and lower limbs, as well as in the trunk. The presence of sensory disorder was difficult to examine, and thermal hypoalgesia of the right upper and lower limbs was suspected. The patient exhibited profoundly impaired orientation; her Mini-Mental State Examination score was 20 points. Routine activities required full assistance. The bed-up sitting position could be maintained using cushions, but both sitting and standing required full assistance. The patient required tube feeding for meals, had a balloon placed for urination, and used diapers for defecation. All other self-care duties required full assistance.

Ocular motility disorder

Assessments were performed on day 40 of admission. When viewed from the front, the right eye showed strabismus. There was no vertical deviation. Covering one eye and evaluating the horizontal ocular motility revealed remarkable restriction of the abduction of the right eye. With binocular vision, we identified conjugate deviation to the left and gaze palsy toward the right. The possible duration of gaze toward the right was approximately 1 s, and nystagmus was evident. Pursuit was relatively smooth, with no overshoot or undershoot, and the convergence reflex was maintained. Diplopia was observed in all directions, and the patient complained of strong discomfort.

Oculomotor rehabilitation program

In our previous systematic review [5], we highlighted the utility of pursuit, fixation, saccade, and vergence exercises performed for 20−60 min per day, 2−6 times per week, for 3−10 weeks. The rehabilitation program that was developed from these findings can be performed at bedside, without the need to establish a special environment [6]. During training, the patient was placed in the supine or bed-up sitting position, and the illumination of the room was bright. A therapist presented a target object 30 cm in front of the patient and asked the patient to follow these steps: 1) Perform three sets of pursuit motions by following the object in all eight directions with the eyes at a speed at which the patient can (pursuit); 2) perform three sets of fixing the gaze for 10 s at the limit of the mobility range of the eye in all eight directions (fixation); 3) perform three sets of holding the target object that serves as a marker outside the patient's field of view and, then, rapidly bring it to above her face into her field of view to attract the gaze as it moves in eight directions randomly (saccade); and 4) perform three sets of following the object as it is moved slowly toward the patient 10 times to induce convergence (vergence). The tasks were performed with the right eye closed, left eye closed, and with binocular vision, so as to prevent symptoms that tend to appear, which would mask the paralyzed eye. Each session lasted 20 min, and patients attended six sessions per week for a total of 8 weeks. They were allowed to rest if fatigue or dizziness was experienced during training and to massage the area around the eyes if needed. For the present case, we modified the program and used five 20-min sessions for 1 week to evaluate the utility of the program for patients hospitalized in acute care hospitals (Figure 2).

Study design

Our participant was in the acute phase; therefore, oculomotor spontaneous recovery was more likely to be caused. We used an ABAB design to inspect the effect of this program. Phase A involved basic rehabilitation only, and Phase B involved the oculomotor rehabilitation program in addition to basic rehabilitation. Basic rehabilitation comprised lower-limb function training and sitting/standing training, which were performed during physiotherapy. Upper-limb function training and

Oculomotor Rehabilitation Program

Frequency: 20 minutes per day

Program

1. Pursuit exercises

Instruct the patient to look at a pen held 30 cm above his face as a marker, and encourage him to follow its movements with his gaze. Move the pen slowly, and within a range that the patient's eyes are capable of following. Perform this exercise randomly in eight directions, first with the right eye covered, then the left eye covered, and finally with both eyes open. Perform three sets of exercises in all eight directions.

2. Fixation exercises

Position the pen that serves as a marker at the maximum range of motion, of which the patient is capable and instruct him to focus his gaze on the pen and maintain it for 10 seconds. As in the pursuit exercise, perform this exercise randomly in eight directions, first with the right eye covered, then the left eye covered, and finally with both eyes open. Perform three sets of exercises in all eight directions.

3. Saccade exercises

Hold the pen that serves as a marker outside the patient's field of view, then rapidly bring it to 30 cm above his face into his field of view to attract his gaze. As in the pursuit exercise, perform this exercise randomly within the field of view, first with the right eye covered, then the left eye covered, and finally with both eyes open. Perform three sets 10 times each.

4. Vergence exercises

Hold a pen 30 cm above the subject's face and move it rapidly to a position close to his face to encourage the convergence reflex. Bring the pen close enough to the face to ensure that adduction movements of both eyes following the pen appear, adjusting the distance while keeping these under observation. Perform this exercise with both eyes open and perform three sets 10 times.

Note: Massage the orbicularis oculi muscle before and after these exercises.
Note: Take breaks as needed, taking account of vertigo and fatigue.

Fig. 2. Details of the oculomotor rehabilitation program. During training, the patient was placed in a supine or bed-up sitting position, and the therapist presented the target object to promote pursuit, fixation, saccade, and vergence of the eyes. Each session lasted 20 min. The patient was allowed to massage around the eyes as needed and to rest during training whenever dizziness or eye fatigue was experienced. This figure was adapted from Watabe *et al*. [6]

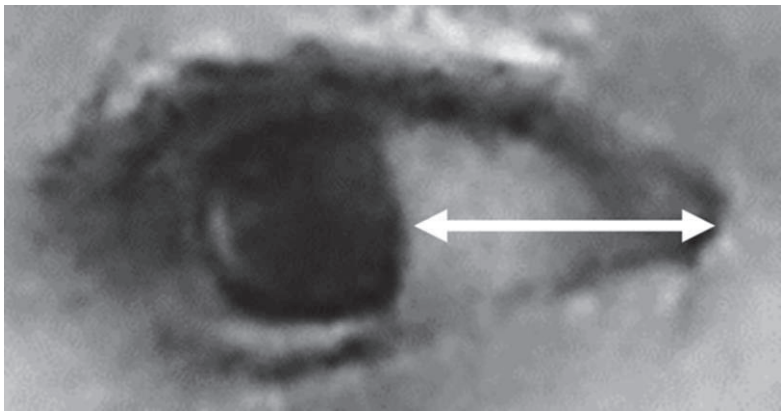

Fig. 3. Measurement of the abduction range of the eye. The abduction range was defined as the distance from the inner eyelid to the inside margin of the pupil during maximum abduction of the eye. Footage recorded using a video camera was analyzed using the HAS-XViewer software (DITECT Co., Ltd.) to calculate the abduction range.

daily-life movement training were performed during occupational therapy. Communication and swallowing training were performed during speech and hearing therapy. Each therapy was performed for 20 min per day for five times per week. The exercises presented in Figure 2 were performed during oculomotor rehabilitation training for 20 min per day with breaks in between for five times a week. Each phase lasted 1 week, and the program continued for a total of 4 weeks from day 41 of admission, through A1, B1, A2, and B2. Ocular motility and range of right-eye motility were evaluated during each intervention.

The ocular motility analysis software HAS-XViewer (DITECT Co., Ltd., Tokyo, Japan) was used to measure the range of ocular motility. In this study, we analyzed the abduction range of the right eye, which showed the greatest level of impairment, by filming the right eye during maximum abduction movement using a 30-fps video camera (Sony Corp., Tokyo, Japan). Filming was conducted as follows: 1) placing a video camera 50 cm in front of the patient's face; 2) placing a pillow under the patient's head in a bed-up position, 70° sitting position; 3) fixing the patient's head and neck; and 4) slowly moving the target object left and right in front of the patient and instructing her to follow the object with her eyes. The steps were repeated to take three measurements. Recorded footage was analyzed using the HAS-XViewer software, and the mean result of the three measurements was used for the analysis. The abduction range was defined as the distance from the inner eyelid to the inside margin of the pupil during maximum abduction (Figure 3).

The abduction range of the right eye was measured before and immediately after the first intervention. In addition, we determined the celeration lines of Phases A1 and A2 using central partitioning and, then, extended them to Phases B1 and B2, respectively. In Phases B1 and B2, the upper numbers of the extended celeration lines were examined by binomial distribution. The significance level was set at $p < 0.05$.

Results

The patient did not exhibit fluctuation of vital signs or any adverse events, such as exacerbation of dizziness following the oculomotor rehabilitation program. All

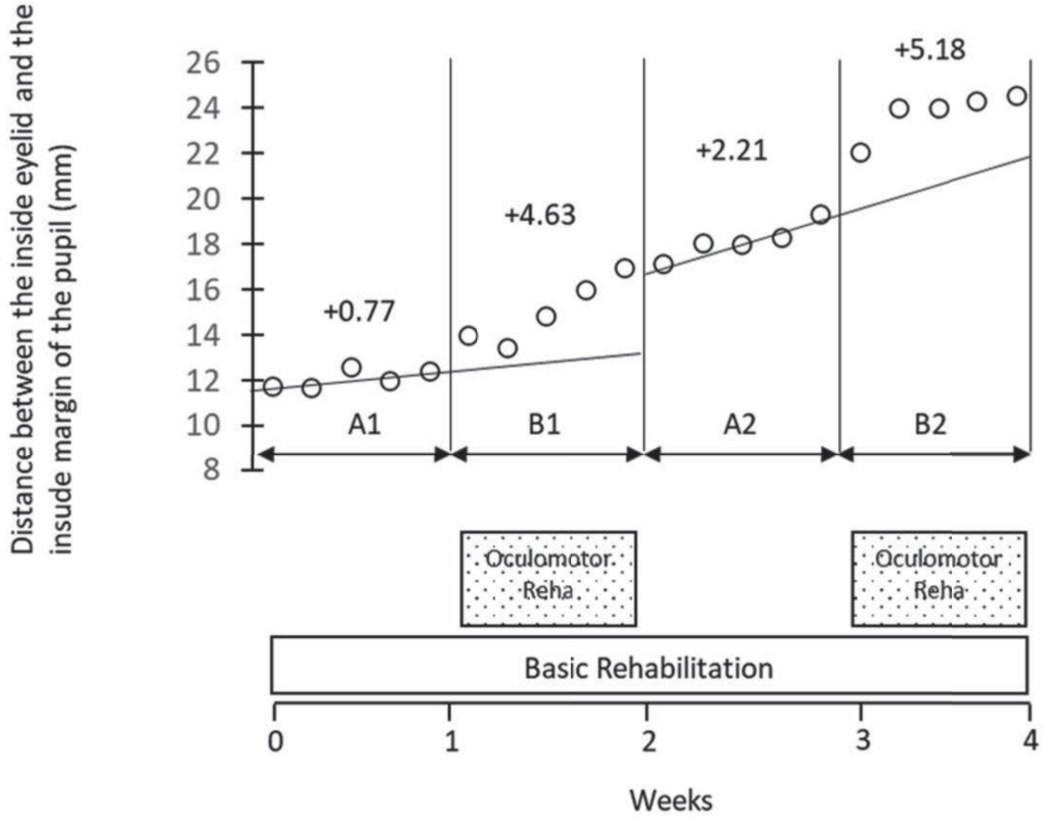

Fig. 4. Abduction range in relation to the phase of the program. The abduction ranges of the right eye were 11.76 mm before Phase A1, 12.53 mm before Phase B1, 17.16 mm before Phase A2, 19.37 mm before Phase B2, and 24.55 mm immediately after Phase B2. The mean expansions of the abduction range were 1.49 mm in Phase A and 4.91 mm in Phase B. Comparison with the extended celeration line and examination by binomial distribution reveals that the ocular motility range expanded more when the patient engaged in the oculomotor rehabilitation program than when she did not ($p < 0.05$).

scheduled sessions were completed. The abduction ranges of the right eye were 11.76 mm before Phase A1, 12.53 mm before Phase B1 (PreB1), 15.74 mm immediately after the first oculomotor rehabilitation session, 17.16 mm before Phase A2, 19.37 mm before Phase B2, and 24.55 mm after Phase B2. The abduction range increased by 3.21 mm after the first oculomotor rehabilitation session in PreB1. The mean expansions of the abduction range in Phases A and B were 1.49 and 4.91 mm, respectively. The upper numbers of Phase B were compared using the extended celeration line with binomial distribution and revealed that the ocular motility range expanded more in Phases B1 and B2 (i.e., when the oculomotor rehabilitation program was included) than in Phases A1 and A2 (i.e., when only basic rehabilitation was completed) ($p < 0.05$) (Figure 4). With respect to the ocular motility at the end of Phase B2, when observed from the front, the strabismus and abduction range of the right eye improved. During joint movement of both eyes (binocular vision), we observed that the gaze palsy toward the right had improved and the patient was capable of maintaining the gaze toward the right for 10 s. Diplopia disappeared in the frontal view, with only slight diplopia remaining during rightward gaze (Figure 5). The patient reported that the double vision had disappeared and there was less discomfort.

Discussion

Mechanism underlying the oculomotor disorder

In addition to the subarachnoid hemorrhage caused by the rupture of the vertebral artery, this patient had infarct lesions from the middle cerebellum to the left hemisphere and in the left side of the outer medulla oblongata. Subarachnoid hemorrhage in the vertebral artery region has been reported to be associated with abducens nerve palsy [8,9]. As this patient had exhibited abducens nerve palsy toward the right even before the onset of cerebral infarction, we believe that the abducens nerve had been compressed by a hematoma in the vertebral artery region. Conjugate deviation to the left was not consistent with the patient's lesion (which was on the left side). Horizontal gaze paralysis is caused by injury to the paramedian pontine reticular formation (PPRF), which is located at the back of the pons [10]. We hypothesized that the patient had experienced temporary circulatory disturbance to the back of the pons due to compression caused by the hematoma from the subarachnoid hemorrhage, brain edema, compression of the back of the pons by normal-pressure hydrocephalus, or a combination of these, which led to the horizontal gaze paralysis. No other symptoms, such as smooth pursuit disorder caused by injuries to the cerebellar hemisphere, skew deviation, or ocular lateropulsion due to damage of the medullar oblongata, were observed. Based on the aforementioned, we predicted that the oculomotor disorder would improve with aspiration of the hematoma and consequent improvement of the impaired circulation.

We considered that one-eye masking and compensatory approaches could promote the shortening and disuse of the extraocular muscle and inhibit the recovery

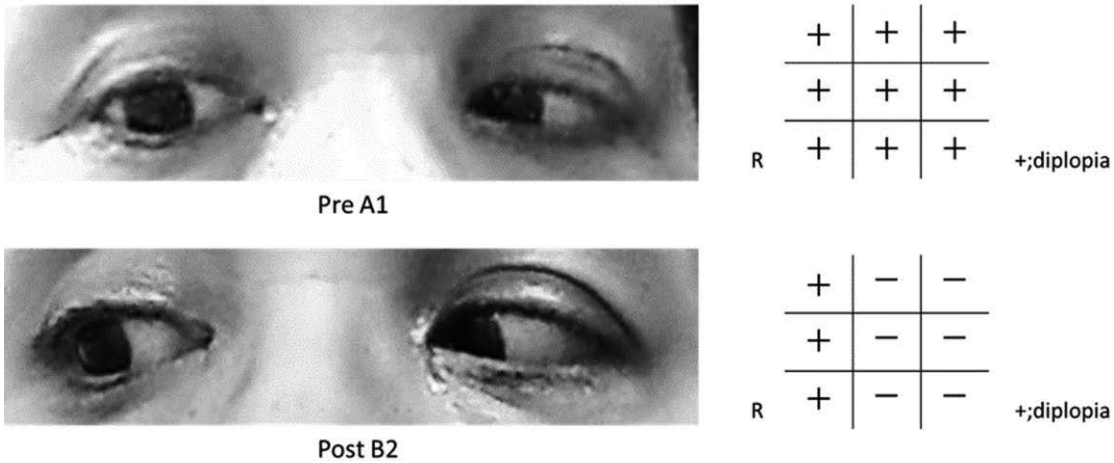

Fig. 5. Improvement in abduction due to the prorestriction of abduction of the right eye. deviation to the left and gaze palsy toward the program, the strabismus and abduction range During joint movement of both eyes (binocular the patient is capable of maintaining the gaze frontal view, with only slight diplopia remainB2, after Phase B2.
gram. Prior to the intervention, we observed remarkable When binocular vision was used, we identified conjugate right. Diplopia was observed in all directions. After the of the right eye improved when observed from the front. vision), the gaze palsy toward the right has improved and toward the right for 10 s. Diplopia has disappeared in the ing during rightward gaze. Pre A1, before Phase A1; Post

process. Therefore, we planned proactive treatment of the oculomotor disorder to prevent secondary irreversible changes due to disuse and improve the patient's symptoms. Oculomotor disorder improved after 4 weeks of intervention, confirming our hypothesis and the appropriateness of the treatment.

Characteristics of the oculomotor rehabilitation program

Our previous review [5] identified nine reports on the benefits of the oculomotor rehabilitation program in multiple patients; however, only three randomized controlled trials have described the effects of interventions involving computer programs. Despite the large number of patients who experience oculomotor disorder, research performed to date has been insufficient to develop rehabilitation programs for this condition.

The oculomotor rehabilitation program that we developed is novel and does not require special tools or skills. Similar to general mobility range training for the limbs, the program primarily involves pursuit and fixation work, which are expected to prevent muscle atrophy in the direction of movement and prevent shortening of the antagonistic muscle, as well as saccade to cope with sudden changes in the line of sight and vergence, which trains the reflexes. This is the same for one-eye-masked training, not just binocular vision. Once a patient has adapted to a certain level to oculomotor disorder, symptoms tend to appear, which mask the paralyzed eye [4]. Therefore, it is necessary to prevent disuse of the paralyzed eye by carrying out training while the healthy eye is covered, rather than training with binocular vision alone.

As the intervention described in this report is conducted with the patient in the supine or bed-up sitting position for 20 min, this program can be applied to acute-phase patients with low tolerability. While adverse events of eye fatigue and dizziness are possible, our patient could complete the program without presenting such symptoms. This finding provides significant evidence concerning the efficacy of the performed eye-movement rehabilitation program.

In cases with direct injury to oculomotor centers, such as the horizontal oculomotor center of the PPRF and medial longitudinal fasciculus [10], or vertical oculomotor centers, such as the rostral interstitial nucleus of the medial longitudinal fasciculus in the midbrain reticular formation [11], a robust treatment to promote nerve reorganization is needed. Nevertheless, the 20-min intervention of the current program may not be sufficient to achieve clinical improvement in such cases. Our rehabilitation program was applied to a single patient. This was a limitation of the present study. Future studies examining the applicability of this oculomotor rehabilitation program should include a larger number of patients in an acute phase.

To our knowledge, no study has yet reported on the use of this oculomotor rehabilitation program for brain injury patients hospitalized in an acute care hospital where they had just undergone surgery and had low endurance. Thus, we believe that this program is safe and easy to implement in clinical practice and applicable to other patients. Examination of the lesion led us to expect that the present patient would achieve full recovery, and preventing disuse of the extraocular muscle—which would have led to its shortening or atrophy—produced favorable results.

Acknowledgments

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Ethics approval

This study was conducted with the approval of the Ethics Committee of the School of Nursing and Rehabilitation Sciences, Showa University (Approval No. 477). Furthermore, the patient and her family members provided consent to the study and reporting the case.

Conflict of interest

The authors have no conflicts of interest directly relevant to the content of this article.

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■RAPID COMMUNICATIONS

Practicality of Using a Ladle for Sock Folding in Hemiplegic Patients

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Abstract: Purpose: Folding socks can be difficult for patients who rely on only one hand. We hypothesized that through the following procedure, patients could easily fold their socks even with just one hand. First, place the rounded part of a ladle between the leg and the chair. Then, stack the pair of socks on top of each other. Put your finger through the opening of the upper sock and hold up the lower sock. Finally, place the sock on the tip of the handle, and pull your fingers down. The aim of this study was to compare how hemiplegic patients fold socks using the flip and tuck method through the folding motion with and without a ladle, to demonstrate the effectiveness of this technique in folding socks.
Method: Forty hemiplegic patients participated in this study. After being instructed on how to fold a sock with and without a ladle, participants performed the folding motion using the flip and tuck method with one hand. After the experiment, it was determined whether the participants had successfully folded the socks, and the ease of folding was subjectively evaluated. Moreover, the folding time was measured using the captured video footage.
Results: When the ladle was used, all participants succeeded in folding the socks. The motion was easier and the folding time was significantly shorter when using a ladle than when not using a ladle.
Discussion: Using a ladle to fold socks is a practical method for hemiplegic patients.

Keywords: sock folding, hemiplegia, ladle

(*Asian J Occup Ther* **18**: 141−145, 2022)

1. Introduction

There are several ways of folding socks, including the square, single-fold, roll, military, fold and tuck, and flip and tuck methods [1]. Among these, the flip and tuck method, which folds back only the elastic grip part of the cuff, is considered a quick and easy way to combine a pair of socks [2]. The flip and tuck method is performed as follows. First, lay both socks on a flat surface with one sock on top of the other. Then, hold one cuff and flip it inside out while tucking both socks approximately halfway into the cuff [1]. The flip and tuck method is a two-handed maneuver, which can affect the daily lives of patients, such as those diagnosed with orthopedic diseases or hemiplegia, who have to rely on using just one of their upper extremities. Although folding socks with one hand is possible, learning the technique requires repeated practice. Furthermore, as we have shown, some patients are unable to learn the technique even with practice. Hence, we considered how everyday objects could be used to make folding socks easier. We hypothesized that with the following novel method, patients would easily be able to fold their socks even with just one hand. First, place the rounded part of a ladle, [3], between the thigh and surface of the seat. Then, stack the pair of socks on top of each other. Put your finger through the opening of the upper sock and hold up the lower sock. Finally, place the sock on the tip of the handle, and pull your fingers down.

The aim of this study was to compare the sock folding motions (folding motions) of hemiplegic patients using the flip and tuck method, both with (folding motion with a ladle) and without (folding motion without a ladle) a ladle, to demonstrate the effectiveness of

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utilizing this method for folding socks.

2. Methods

Participants

Forty patients with hemiplegia due to cerebral infarction or cerebral hemorrhage (20 men and 20 women, including 10 men paralyzed on their left side, 10 men paralyzed on their right side, 10 women paralyzed on their left side, and 10 women paralyzed on their right side) participated in this study. The mean age was 73 ± 11 (range, 48–91) years. Intelligence was tested using the Revised Hasegawa's Dementia Scale [4]. The median score of the participants was 26/30 (range, 16–30 points). All participants were in the chronic phase of their illness, regularly used daycare facilities, and had no experience of folding socks following the onset of their medical condition.

This study was approved by the Ethics Committee of Tohoku Medical School (approval number 373; approval date, February 18, 2021) in accordance with the Declaration of Helsinki. Written consent was obtained from all the participants after providing a detailed explanation of the study.

Equipment

The experiment was performed in a seated position, and the seat surface was set at a height where the participant's hip and knee joints bent at 90°. A regular, commercially available ladle was used (Fig. 1) and placed on the seat surface on the non-paralyzed side of the patients. Ankle-length socks were placed on the non-paralyzed thigh.

The folding motion was captured using myoVIDEO (NORAXON USA Inc., Scottsdale, Arizona, USA) at 30 frames per second with a webcam (c920r, Logitech Co. Ltd., Lausanne, Switzerland) from two directions (from the non-paralyzed side and the front) and was simultaneously recorded. The video footage was analyzed.

Folding instructions provided to participants

The procedure using the ladle is shown in Fig. 2 (a). Hold the ladle that is placed on the seat surface and position the rounded part between the thigh and seat (1) (2). Put your fingers in the opening of the sock (3). Hold the sock at the bottom (4). Cover the tip of the handle of the ladle with the center part of the sock you are holding (5). Finally, lower your fingers and turn the rubber part inside out (6)–(8).

The procedure without the use of a ladle is shown in Fig. 2 (b). Put your finger in the opening of the sock (1) (2). Hold the sock at the bottom (3). Turn it inside out and press it against the thigh (4). Finally, while pressing against the thigh, turn the rubber part inside out gradually (5)–(8).

Procedure

After the participants were taught how to fold socks both with and without a ladle, they were allowed to practice until they were satisfied. Subsequently, they were instructed to perform the folding movements using the flip and tuck method using only their non-paralyzed hand.

After the experiment, it was determined whether the participants successfully folded the socks, and the ease of folding was subjectively evaluated. The folding time was then measured using the captured video footage.

Analysis

Success or failure of folding socks

The finished state after folding with and without a ladle was compared. Cases where the folded socks were placed on a desk and one of the sock toes could be lifted without separating the left or right of the pair of socks

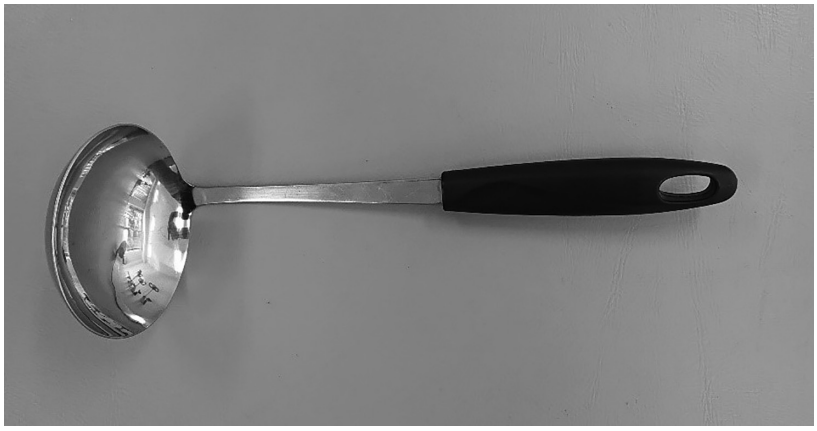

Fig. 1. Ladle used

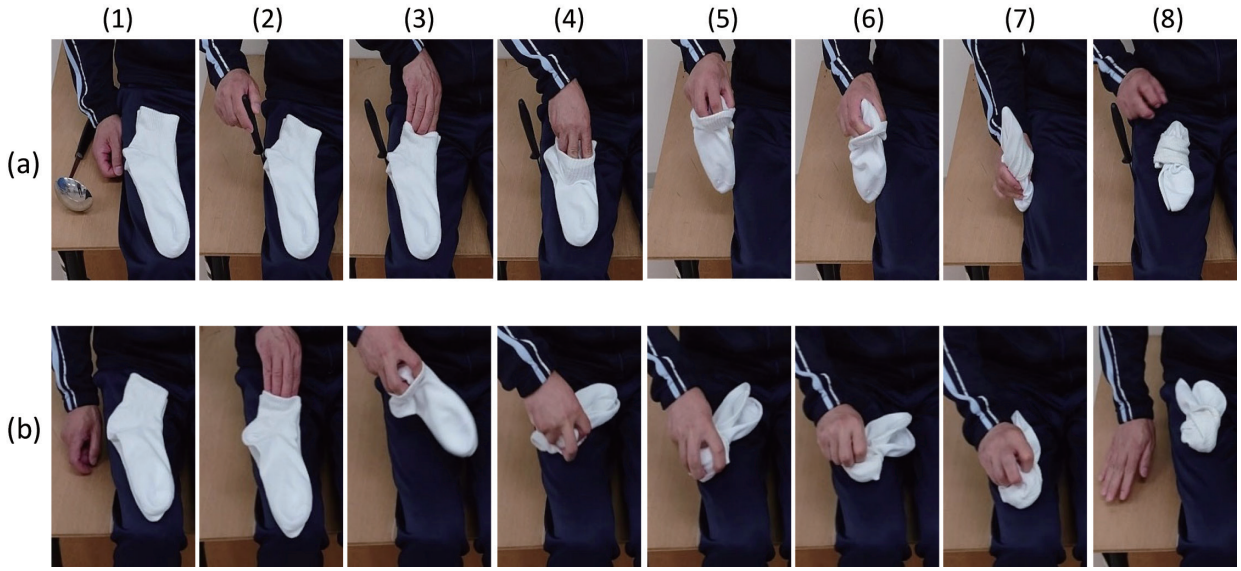

Fig. 2. Folding procedure

The figure shows the folding procedure using the right hand. The upper row (a) shows folding with a ladle, and the lower row (b) shows folding without a ladle. When using one's left hand, place the ladle on the outside of the left thigh, and follow the same procedure as that for the right hand. The numbers in the figure correspond to those in the text.

were deemed a success, whereas cases where the left and right socks were separated were regarded as a failure. The success rate was analyzed using the chi-squared test with a significance level of 5% or less.

Subjective evaluation of ease of folding

Participants evaluated the ease of folding on three scales: whether it was easier to fold the socks with a ladle, whether it was the same as without, and whether it was more difficult. Participants were also asked whether they experienced pain or discomfort when using the ladle.

Comparison of folding time

When a ladle was used, the time from when the participants touched the ladle to when they turned the socks inside out was measured. Accordingly, when a ladle was not used, the time from when the participants touched the socks to when they turned them inside out was measured. The recorded times were then compared. A Wilcoxon signed-rank test was used for statistical processing, and the significance level was set to less than 5%. Participants who failed to fold socks were excluded from the comparison.

3. Results

Success or failure of folding socks

Table 1 shows the participants' success or failure in folding the socks. All participants succeeded when a ladle was used. Fifteen participants (eight with left-side hemiplegia and seven with right-side hemiplegia) failed when a ladle was not used. Of the 15 unsuccessful individuals, 6 had the dominant hand on the paralyzed side and 9 had the nondominant hand on the paralyzed side. The success rate was significantly higher when participants used the ladle than when they did not ($p < .01$).

Subjective evaluation of ease of folding

Thirty-five participants stated that using a ladle was easier when folding the socks, three participants expressed that it was the same with or without a ladle, and two participants said that it was more difficult to use a ladle. Hence, 87.5% of the participants stated that folding with a ladle was easier than folding without a ladle. No participant complained of pain or discomfort due to using the ladle.

Comparison of folding time

Data from 25 participants were used for the comparison. Table 1 shows the median folding times (interquartile ranges). The median times when using and when not using a ladle were 11.1 (9.3–14.2) and 18.1 (13.6–22.9) seconds, respectively. Using a ladle resulted in significantly faster folding times than without using a ladle ($p < .01$).

Moreover, the median times when using and not

Table 1. Success or failure of folding socks and folding time

	With a ladle	Without a ladle	p value
Success or failure of folding socks			
Success	40	25	<.01
Failure	0	15	
Folding time (seconds)	11.1 (9.3−14.2)	18.1 (13.6−22.9)	<.01

Folding time is expressed in terms of median (interquartile range)

using a ladle for participants who failed to fold socks were 13.5 (12.9–16.4) and 27.3 (19.1-35.4) seconds, respectively.

4. Discussion

In this study, folding socks with and without a ladle using one hand was compared. Participants were able to successfully fold the socks with a ladle, the task was easier, and took significantly less time when using a ladle than when not using a ladle. These results suggest that folding socks using a ladle is more practical for hemiplegic patients.

To turn the elastic part of the socks inside out without using a ladle, the elastic part must be gradually turned over while pressing the socks against the thigh (Fig. 2b). In contrast, when a ladle is used, the elastic part of the socks is turned over all at once by placing the sock on the handle of the ladle and then pulling it down with the fingers (Fig. 2a). Thus, to fully turn over the elastic part of the socks, it is necessary to repeatedly turn over the section incrementally while pressing against the thigh when a ladle is not used, whereas when a ladle is used, one's fingers are used to pull down the elastic part all at once. Thus, no repeated action is needed. It is presumed that when a ladle was used, the time required to complete the task was shortened because there were no repeated actions. In addition, an extended time suggests an increased difficulty in an action [5]. Hence, the fact that using a ladle resulted in a shorter folding time than when it was not used suggests that folding with a ladle is less difficult. Therefore, as the difficulty level when a ladle was used was low, there were no failures, and this resulted in the subjective evaluation that the method made folding the socks easier.

To fold socks with the flip and tuck method using both hands, the following procedure can be performed. First, both the left and right socks are stacked on top of each other. Then, both thumbs are placed in one of the sock openings. Then, using one's index, middle, and ring fingers as support, the elastic part is turned inside out by turning one's thumbs outward [6]. In this way, when folding socks with the flip and tuck method, the folding motion becomes easier when a form of physical support is used. When the socks were folded with a ladle, the tip of the handle acted as this support, suggesting that this method made it easier for participants to turn the socks inside out because of the support. Furthermore, because the ladle is inserted in a fixed position between the thigh and seat surface, the support provided by the ladle does not move. Therefore, it is presumed that the openings of the socks could be turned inside out all at once when a ladle was used.

Limitations and Future Directions

The participants in this study were limited to patients with chronic hemiplegia who were eligible to attend daycare facilities. In addition, hemiplegic patients with severe brain dysfunction were excluded. Therefore, it is unclear whether this method has a similar efficacy in patients in the acute phase or with severe higher brain dysfunction. Using this method of folding may also be effective for patients who have to rely on only one side of their upper body because of orthopedic disease. The ladle used in this study was metal. Whether the results would likely be similar with a plastic, silicone, or wooden ladle, has not yet been verified. In the future, it will be necessary to test this method on patients with other conditions, such as acute hemiplegia, higher brain dysfunction, or orthopedic disease, and ladles made of different materials.

In this study, a part of the sock washing process was studied. However, as an activity during daily life, it is crucial to focus on the entire sock washing process in the future.

5. Summary and Conclusions

Hemiplegic patients were instructed to fold socks both with and without a ladle. Subsequently, whether the participants successfully folded the socks was determined, and the ease of folding was subjectively evaluated. Furthermore, the time required to complete the task when the ladle was and was not used was com-

pared. When a ladle was used to fold the socks, all the participants were successful, the task was easier, and the time required was greatly reduced. In this way, these experimental results show the practicality of folding socks using a ladle.

Conflict of Interest

There are no conflicts of interest to declare.

Acknowledgments

I would like to sincerely thank all the participants in this study.

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■ORIGINAL ARTICLE

Influences of the Coronavirus Disease (COVID-19) Pandemic on Occupational Therapy: A Content Analysis of Long-Term Care Insurance Service Facilities in Hokkaido

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Abstract: Objective: This study aimed to clarify the influence of the coronavirus disease (COVID-19) pandemic on occupational therapy (OT), including changes in assessment and treatment, along with other restrictions and measures in long-term care insurance service facilities.
Methods: We conducted a questionnaire survey from representatives of OT departments in long-term care insurance service facilities in Hokkaido and obtained responses from 89 participants.
Results: More than half of the facilities remained unchanged in their assessments and treatments following the first emergency declaration, after which their responses gradually decreased. As for the content of assessment, there were increased needs, such as body temperature, health condition, and physical/cognitive changes due to disuse syndrome, while reduced opportunities were available to assess in areas, such as home environment, mobility outdoors, and instrumental activities of daily living outdoors. As for the content of treatment, while outings and group training had been discontinued, prevention of disuse syndrome had been added. The treatment also incorporated changes in methods, such as fixing the location and time. Restrictions related to OT were reported, including client participation, OT operations, and discontinuation of services. On the other hand, measures related to OT, such as thorough standard precautions, management of health conditions of the clients and housemates, and infection control measures by occupational therapists, were also mentioned.
Conclusions: Despite various restrictions, OT was provided by thoroughly implementing standard precautions, managing the physical conditions of the clients and housemates, providing new means of participant support and infection control for the influences of the COVID-19 pandemic.

Keywords: COVID-19, occupational therapy, combating infectious diseases, content analysis, long-term care insurance service

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1. Introduction

Coronavirus disease (COVID-19) is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), and it was first reported by the World Health Organization (WHO) in December 2019 following a report of a cluster of "viral pneumonia" cases in Wuhan, China [1]. Thereafter, the number of infected persons and related deaths increased worldwide. The WHO stated that COVID-19 could be characterized as a pandemic because of being deeply concerned both by the alarming levels of spread/severity and inaction [2]. In Japan, the first case of COVID-19 was confirmed on January 16, 2020. By December 27, 2020, Polymerase Chain Reaction testing had confirmed positive viral serology for 217,312 people and 3,213 deaths had been reported [3]. In particular, Hokkaido, the largest and northernmost prefecture, has seen a widespread increase in COVID-19 incidence since the early stages of the disease due to transmissions among immigrating tourists, mass infections at events, and problems with the urban structure, such as people from various regions gathering in large cities and dispersing to different regions [4] [5]. Hokkaido's first local emergency declaration ended

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on March 19, 2020, and this was followed by a temporary decrease in the number of infected people [6][7]. However, on April 16, 2020, the Tokyo metropolitan, Osaka, and surrounding areas were found to be infection hotspots. There was a subsequent rapid increase in the number of infected people nationwide; therefore, the government declared a state of emergency, which continued until May 25, 2020 in Hokkaido [6][7]. The pandemic is still ongoing, and the situation remains unpredictable.

The COVID-19 pandemic has had a profound influence on rehabilitation, including occupational therapy (OT). The Japanese Association of Occupational Therapists has published an article titled "COVID-19 Infection Control/Occupational Therapy Work" [8]. According to this, practicing hand hygiene, use of protective equipment, and others are categorized as "Basics of infection control in OT," and places at risk of being closed, densely populated, and compact, such as staff rooms, OT visiting areas, and spaces for group activities (recreation, exercise, and calisthenics) are enlisted. It has provided with tailored preventive strategies provided under "Specific measures in COVID-19 infection control."

Previous studies have shown that older adults are at a higher risk of poor prognosis and fatality from COVID-19 [9][10]. Older adults living in long-term care facilities comprise 79% of the COVID-19 death toll in Canada [11]. Predictive factors of mortality among older adults with COVID-19 were premorbid activities of daily living (ADL) impairment, comorbidity, and increased C-reactive protein levels [12]. Therefore, clients being rehabilitated in long-term care insurance facilities are at risk of severe outcomes of COVID-19. Furthermore, therapists must pay close attention to the client's condition and ensure infection control.

There are no specific protocols for infection control in OT practice in long-term care insurance service facilities. In addition, few studies have comprehensively examined what restrictions and measures were taken in actual settings where OT was provided. It is necessary to accumulate information provided by various sites regarding OT and to consider the measures according to the changing situation of COVID-19. In Hokkaido, a state of emergency was declared twice, (February 28 to March 19, 2020; April 12 to May 25, 2020), and measures against infectious diseases were undertaken to combat the evolving situation from an early stage. The purpose of this study was to clarify the influences of COVID-19 on OT in long-term care insurance facilities in Hokkaido, focusing on changes in the contents of assessment and treatment, as well as other restrictions and measures.

2. Materials and Subjects

2.1. Research design

This was a cross-sectional study conducted using a postal questionnaire survey method.

2.2. Participants

The participants were representatives of OT departments from 725 facilities in Hokkaido belonging to members of the Japanese Association of Occupational Therapists in the fields of medical care, long-term care, and welfare for the disabled.

A list of facilities with occupational therapists was created using the list of facilities of the Japanese Association of Occupational Therapists, with permission for use.

2.3. Data collection

The questionnaire was mailed to the representatives of the OT department of the target facilities, and responses to the questionnaire were requested. All authors reviewed the items and responses in the questionnaire to ensure that the content was valid and aligned with the research questions and objectives. The questionnaires and consent forms were collected by mail using enclosed return envelopes. The survey period was from June 30 to August 14, 2020. The questionnaire survey items are shown below.

2.3.1. Characteristics of facility and OT

We asked about the target category (medical care, long-term care, welfare, and others), presence or absence of COVID-19-infected patients, the number of clients per occupational therapist, and the locations of OT before the first declaration of emergency in Hokkaido due to COVID-19 (before February 27, 2020; hereafter, "pre-declaration").

All applicable OT locations were selected from the following: 1) "facility room/residence": the client's room or home, 2) "in OT department": OT rooms under the jurisdiction of the OT department, 3) "in the facility": day room or hall in the target facilities, and 4) "outside the facility": outdoor or external facilities. In addition, we extracted information on the type of service (facility service, commuting service, home-visit service, and others) using the Japanese Association of Occupational Therapists' list of facilities and categorized the facilities accordingly.

2.3.2. Influences of COVID-19 on OT in each period

To evaluate the influences of COVID-19 on OT, participants were asked about the number of clients per

occupational therapist and location of OT across three time periods: during Hokkaido's first declaration of a state of emergency (February 28 to March 19, 2020; hereafter, Period I), during the period in which the declaration was temporarily lifted (March 20 to April 11, 2020; hereafter, Period II), and during the national declaration of a state of emergency (April 12 to May 25, 2020; hereafter, Period III). Then, they were requested to complete open-ended responses on changes in the content of assessment and treatment from pre-declaration and COVID-19–related restrictions and measures to OT across the three periods indicated above.

2.4. Data analysis

Of the returned questionnaires, those in the "long-term care insurance facilities" were selected for analysis in this study. First, the facility characteristics to which the subjects belonged were tabulated. Next, trends in the number of clients per occupational therapist and location of OT from pre-declaration to Period III were identified. Regarding the number of clients per occupational therapist, the proportion of clients from Period I to Period III was calculated, with that of the pre-declaration period being 100%. For the location of OT, the number and percentage of facilities at each location were determined, and the transition from pre-declaration to Period III was clarified.

Finally, changes in the content of OT assessments, treatments, restrictions on OT, and measures on OT were coded with the procedures of content analysis [13]. In content analysis, qualitative data can be described objectively, systematically, and quantitatively. The procedures for the analysis were as follows:

1) The responses in the questionnaire were divided into contextual sentences, and the sentences were divided into record units to ensure that the meaning of the content could be understood. In addition, data which were not adequately answered the question, were excluded.

2) Record units with similar semantic content were grouped as the same record unit; then, they were coded. At the same time, record units that did not correspond to the options in the questionnaire were excluded from the analysis.

3) Several codes were examined for commonalities and categorized abstractly as a category. In addition, the codes that had no commonality with other codes were classified into a category by a single code.

4) The number of occurrences of record units in the codes and categories were counted, and the percentage of the total was calculated. Restrictions and measures related to OT were analyzed as "Restrictions and measures other than the content of assessment and treatment" because it was assumed that some recording units overlapped in terms of changes in the content of assessment and treatment of OT. The analysis process was shared with the second and third authors, and the contents were repeatedly reviewed and revised. Categories and codes are represented by [ ] and < >, respectively.

2.5. Ethical considerations

This study was approved by the Sapporo Medical University Ethical Review Board (approval number 2−1−2). The participants provided written informed consent for all procedures.

3. Results

3.1. Facility characteristics

In total, 334 questionnaires were returned. Of those questionnaires, 89 (26.7%) were classified as long-term care insurance facilities, with valid responses. The long-term care services included facility service in 54 facilities (60.7%), commuting service in 60 (67.4%), home-visit service in 26 (29.2%), and other services in three (3.4%). One facility (1.1%) confirmed the presence of COVID-19 cases among the staff.

3.2. Number of clients in OT (Figure 1)

The mean values±standard deviations on the proportion of clients during the pre-declaration period and in Periods I, II, and III were 100%, 90.3±16.6%, 92.3±17.4%, and 90.5±19.8%, respectively. Comparing

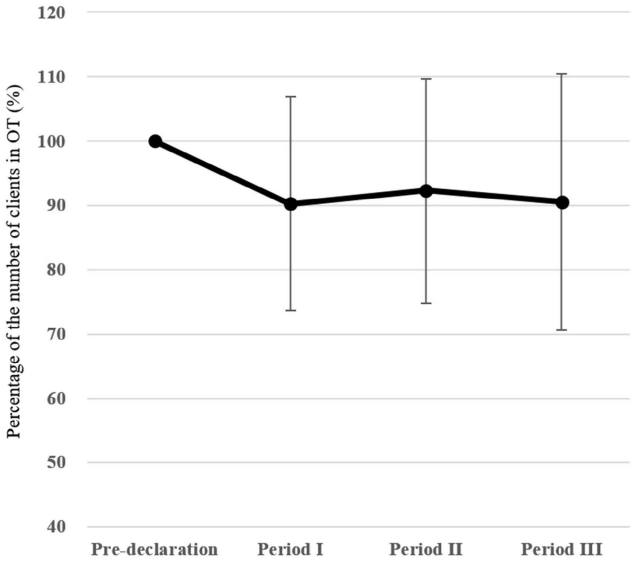

Fig. 1. Number of clients in OT

OT: Occupational Therapy
Note. The trends in the number of clients per occupational therapist from pre-declaration to Period III were shown.

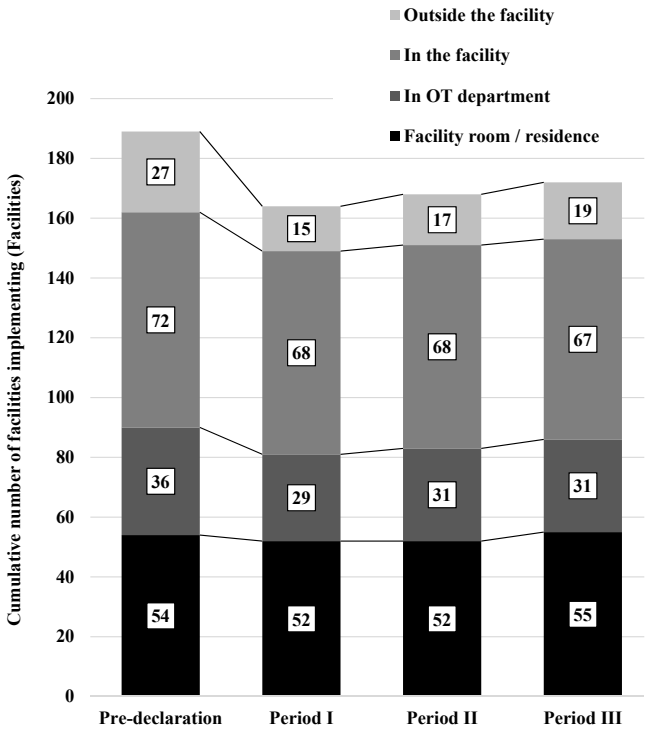

Fig. 2. The location of the implementation of OT in the long-term care insurance

OT: Occupational Therapy
Note. The number of facilities in each location of OT from pre-declaration to Period III were shown.

the number of clients during the pre-declaration period and in Period III, 39 facilities (43.8%) showed a reduction and six (6.7%) showed an increase, while the number remained the same in 44 (49.4%).

3.3. Location of the implementation of OT (Figure 2)

In the pre-declaration period, 54 facilities (60.7%) provided OT in the facility room/residence, 36 (40.4%) in OT department, 72 (80.9%) in the facility, and 27 (30.3%) outside the facility. The OT locations in Period I were 52 facilities (58.4%) in the facility room/home, 29 (32.6%) in the OT department, 68 (76.4%) in the facility, and 15 (16.9%) outside the facility. No change was reported in more than three facilities in any of the locations in Periods II and III compared with that in Period I.

3.4. Changes in the content of assessment in OT due to COVID-19 (Table 1)

Variables that had an [increased need for assessment] were <measurement of body temperature before OT>, <checking health condition before OT>, <changes in physical and cognitive functions due to disuse syndrome>, and <stress responses>. There was an increase in the number of record units as time went on. A small number of record units reported in <status of outdoor activities>, <opportunities for communication>, <awareness of infection control>, <checking the physical con-

Table 1 Changes in the content of assessment in OT from pre-declaration

Category	Code	Number of record units					
		Period I (n=78)		Period II (n=77)		Period III (n=78)	
Increased need for assessment	Measurement of body temperature before OT	8	(8.9%)	7	(7.5%)	7	(7.2%)
	Checking health condition before OT	7	(7.8%)	7	(7.5%)	7	(7.2%)
	Changes in physical and cognitive functions due to disuse syndrome	3	(3.3%)	7	(7.5%)	9	(9.3%)
	Stress responses	2	(2.2%)	8	(8.6%)	9	(9.3%)
	Status of outdoor activities	1	(1.1%)	1	(1.1%)	3	(3.1%)
	Opportunities for communication	1	(1.1%)	1	(1.1%)	1	(1.0%)
	Awareness of infection control	1	(1.1%)	0	(0.0%)	2	(2.1%)
	Checking the physical condition of housemate or roommate	0	(0.0%)	2	(2.2%)	2	(2.1%)
	Contact with visitors from infection hotspots	0	(0.0%)	0	(0.0%)	1	(1.0%)
	Subtotal	23	(25.6%)	33	(35.5%)	41	(42.3%)
Reduced opportunities for assessment	Home environment	4	(4.4%)	4	(4.3%)	5	(5.2%)
	Mobility outdoors	4	(4.4%)	3	(3.2%)	2	(2.1%)
	IADL outdoors	2	(2.2%)	2	(2.2%)	2	(2.1%)
	Living conditions at home	2	(2.2%)	2	(2.2%)	2	(2.1%)
	Subtotal	12	(13.3%)	11	(11.8%)	11	(11.3%)
The changed assessment methods	Changes in the location and time as appropriate	3	(3.3%)	4	(4.3%)	3	(3.1%)
	Using telephone for absent clients	1	(1.1%)	1	(1.1%)	1	(1.0%)
	Subtotal	4	(4.4%)	5	(5.4%)	4	(4.1%)
No change from the pre-declaration period		51	(56.7%)	44	(47.3%)	41	(42.3%)
	Total	90	(100.0%)	93	(100.0%)	97	(100.0%)

OT: Occupational Therapy, IADL: Instrumental Activities of Daily Living
Note. The Changes in the content of assessment in OT from pre-declaration were grouped into four categories. The number of record units for each category and code were shown.

dition of housemate or roommate>, and <contact with visitors from infection hotspots>. In contrast, factors with [reduced opportunities for assessment] included <home environment>, <mobility outdoors>, <instrumental activities of daily living (IADL) outdoors>, and <living conditions at home>. Many of these reports were attributed to restrictions on the provision of OT outside the facility. In addition, the content of [the changed assessment methods] included <changes in the location and time as appropriate> and <using telephone for absent clients>. While the above changes in the content of the assessment were mentioned, there were also responses of [no change from the pre-declaration period], accounting for 51 (56.7%), 44 (47.3%), and 41 (42.3%) of the responses in Periods I, II, and III, respectively.

3.5. Changes in the contents of treatment in OT owing to COVID-19 (Table 2)

The factors involved in the [discontinuation of treatment] due to the COVID-19 pandemic, such as <outdoor training and activities> and <group activities>, were reported. Although infrequently reported, <high-intensity exercise>, <cooking training>, and <swallowing and speech training> were also mentioned. Two respondents (2.3%) reported [total cancellation], that is they completely stopped OT in period III. In contrast, there was an increase in [additional support incorporating infection control] in light of the influences of COVID-19, including <interventions aimed at preventing disuse though self-restraint>, <outdoor training and activities>, <proposals and implementation for voluntary training>, and <interventions aimed at leisure and stress release>. In addition, [changes in treatment methods including infection control] were reported. These included <fixing the location for zoning>, <fixing the time of day for each stay and commute period>, <changing from day care to home visit>, <reducing the number of participants in group activities>, and <strategically placing people and clients to avoid crowding and proximity>. Some respondents indicated [no change from the pre-declaration period], accounting for 47 (61.0%), 42 (53.2%), and 33 (37.5%) of the responses in Periods I, II, and III, respectively. These rates decreased over time.

3.6. Restrictions and measures other than changes in the content of assessment and treatment owing to COVID-19 (Tables 3 and 4)

Regarding restrictions other than the changes in the content of assessment and treatment, [restrictions on client participation] were often mentioned. The most

Table 2 Changes in the content of treatment in OT from pre-declaration

Category	Code	Number of record units					
		Period I (n=80)		Period II (n=76)		Period III (n=78)	
Discontinuation of treatment	Outdoor training and activities	5	(6.5%)	7	(8.9%)	7	(8.0%)
	Group activities	5	(6.5%)	4	(5.1%)	5	(5.7%)
	High-intensity exercise	1	(1.3%)	2	(2.5%)	2	(2.3%)
	Cooking training	1	(1.3%)	1	(1.3%)	1	(1.1%)
	Swallowing and speech training	0	(0.0%)	1	(1.3%)	2	(2.3%)
	Subtotal	12	(15.6%)	15	(19.0%)	17	(19.3%)
Additional support incorporating infection control	Interventions aimed at preventing disuse through self-restraint	3	(3.9%)	5	(6.3%)	7	(8.0%)
	Outdoor training and activities	1	(1.3%)	1	(1.3%)	5	(5.7%)
	Proposals and implementation for voluntary training	1	(1.3%)	1	(1.3%)	3	(3.4%)
	Interventions aimed at leisure and stress release	0	(0.0%)	1	(1.3%)	2	(2.3%)
	Subtotal	5	(6.5%)	8	(10.1%)	17	(19.3%)
Changes in treatment methods including infection control	Fixing the location for zoning	7	(9.1%)	8	(10.1%)	10	(11.4%)
	Fixing the time of day for each stay and commute period	2	(2.6%)	1	(1.3%)	1	(1.1%)
	Changing from day care to home visit	2	(2.6%)	1	(1.3%)	1	(1.1%)
	Reducing the number of participants in group activities	1	(1.3%)	2	(2.5%)	4	(4.5%)
	Strategically placing people and clients to avoid crowding and proximity	1	(1.3%)	2	(2.5%)	3	(3.4%)
	Subtotal	13	(16.9%)	14	(17.7%)	19	(21.6%)
Total cancellation		0	(0.0%)	0	(0.0%)	2	(2.3%)
No change from the pre-declaration period		47	(61.0%)	42	(53.2%)	33	(37.5%)
	Total	77	(100.0%)	79	(100.0%)	88	(100.0%)

OT: Occupational Therapy
Note. The Changes in the content of assessment in OT from pre-declaration were grouped into four categories. The number of record units for each category and code were shown.

Table 3 Restrictions related to OT owing to COVID-19

Category	Code	Number of record units		
		Period I (n=81)	Period II (n=82)	Period III (n=82)
Restrictions on client participation	Available facilities	16 (15.2%)	16 (15.2%)	18 (16.2%)
	Interactions with people outside the facility	11 (10.5%)	11 (10.5%)	14 (12.6%)
	Visits outside of the facility and overnight stay	5 (4.8%)	3 (2.9%)	4 (3.6%)
	Participation by people in poor physical conditions	4 (3.8%)	4 (3.8%)	5 (4.5%)
	Interaction between residents	2 (1.9%)	2 (1.9%)	2 (1.8%)
	Participation of new clients	1 (1.0%)	2 (1.9%)	1 (0.9%)
	Contact with visitors from infection hotspots	0 (0.0%)	1 (1.0%)	3 (2.7%)
	Subtotal	39 (37.1%)	39 (37.1%)	47 (42.3%)
Restrictions on OT operations	Limitation of rehabilitation time and frequency	6 (5.7%)	6 (5.7%)	8 (7.2%)
	The use of equipment and supplies	5 (4.8%)	5 (4.8%)	6 (5.4%)
	Cancellation or shortening of meetings and trainings	4 (3.8%)	5 (4.8%)	4 (3.6%)
	Limiting the scope of staff work	5 (4.8%)	5 (4.8%)	6 (5.4%)
	Time constraints due to infection control	2 (1.9%)	3 (2.9%)	3 (2.7%)
	The use of infection control items	2 (1.9%)	2 (1.9%)	2 (1.8%)
	Lack of manpower due to limitation of staff attendance	2 (1.9%)	3 (2.9%)	3 (2.7%)
	Reduced opportunities for explanation and consent to the client and their family	2 (1.9%)	2 (1.9%)	1 (0.9%)
	Subtotal	28 (26.7%)	31 (29.5%)	33 (29.7%)
Discontinuation of long-term care services	Home-visit services	10 (9.5%)	10 (9.5%)	10 (9.0%)
	Day-care rehabilitation	5 (4.8%)	4 (3.8%)	3 (2.7%)
	Preventive services	2 (1.9%)	2 (1.9%)	2 (1.8%)
	Complete closure of the facility	4 (3.8%)	2 (1.9%)	2 (1.8%)
	Rehabilitation of residents	2 (1.9%)	2 (1.9%)	2 (1.8%)
	Stopping the use of other services	0 (0.0%)	0 (0.0%)	1 (0.9%)
	Subtotal	23 (21.9%)	20 (19.0%)	20 (18.0%)
No restrictions		15 (14.3%)	15 (14.3%)	11 (9.9%)
	Total	105 (100.0%)	105 (100.0%)	111 (100.0%)

OT: Occupational Therapy
Note. The restrictions related to OT owing to COVID-19 were grouped into four categories. The number of record units for each category and code were shown.

frequently reported codes were restrictions on <available facilities> and <interactions with people outside the facility>. Other factors included restrictions on <visits outside of the facility and overnight stay>, <participation by people in poor physical conditions>, <interaction between residents>, <participation of new clients>, and <contact with visitors from infection hotspots>. In addition, [restrictions on OT operations] included <limitation on rehabilitation time and frequency>, <the use of equipment and supplies>, <cancellation or shortening of meetings and trainings>, <limiting the scope of staff work>, and <time constraints due to infection control>. Furthermore, [discontinuation of long-term care services] were also reported, with <home-visit services> and <day-care rehabilitation> as the most commonly discontinued services. Compared with the above-listed restrictions, fewer reports were submitted regarding <preventive services>, <complete closure of the facility>, <rehabilitation of residents>, and <stopping the use of other services>.

Implementation of [thorough standard precautions] accounted for approximately 70% of the recorded units for measures other than assessment and treatment. The most frequently mentioned factors were <wearing masks>, <practice of hand hygiene>, and <disinfection of tools and common areas>, with more than 30 codes in any period. These were followed by <frequent ventilation>, <adjusting the environment to accommodate social distancing>, <gargling>, <minimal sharing of tools and equipment>, <sharing information about infection control measures>, and <use of humidifiers>. [Management of health conditions of the clients and housemates] by <checking body temperature before OT>, <checking the physical conditions>, <setting the criteria for discontinuation of participation>, and <checking the physical conditions of family members living together> was also reported. In addition to interventions for clients, [infection control measures by occupational therapists] were also reported, and these included <thorough management of physical condi-

Table 4 Measures related to OT due to COVID-19

Category	Code	Number of record units		
		Period I (n=86)	Period II (n=85)	Period III (n=85)
Thorough standard precautions	Wearing masks	36 (20.1%)	36 (20.0%)	38 (18.9%)
	Practice of hand hygiene	35 (19.6%)	33 (18.3%)	37 (18.4%)
	Disinfection of tools and common areas	30 (16.8%)	31 (17.2%)	33 (16.4%)
	Frequent ventilation	10 (5.6%)	11 (6.1%)	14 (7.0%)
	Adjusting the environment to accommodate social distancing	9 (5.0%)	9 (5.0%)	10 (5.0%)
	Gargling	2 (1.1%)	2 (1.1%)	2 (1.0%)
	Minimal sharing of tools and equipment	1 (0.6%)	2 (1.1%)	4 (2.0%)
	Sharing information about infection control measures	1 (0.6%)	1 (0.6%)	2 (1.0%)
	Use of humidifiers	1 (0.6%)	1 (0.6%)	1 (0.5%)
	Subtotal	125 (69.8%)	126 (70.0%)	141 (70.1%)
Management of health conditions of the clients and housemates	Checking body temperature before OT	10 (5.6%)	12 (6.7%)	12 (6.0%)
	Checking the physical conditions	4 (2.2%)	3 (1.7%)	3 (1.5%)
	Setting the criteria for discontinuation of participation	1 (0.6%)	1 (0.6%)	3 (1.5%)
	Checking the physical conditions of family members living together	0 (0.0%)	0 (0.0%)	1 (0.5%)
	Subtotal	15 (8.4%)	16 (8.9%)	19 (9.5%)
Infection control measures by occupational therapists	Thorough management of physical conditions	14 (7.8%)	12 (6.7%)	12 (6.0%)
	Use of personal protective equipment during OT	9 (5.0%)	10 (5.6%)	11 (5.5%)
	Fixing work content through reassignment	2 (1.1%)	4 (2.2%)	5 (2.5%)
	Thorough implementation of infection control measures in private life	4 (2.2%)	3 (1.7%)	6 (3.0%)
	Subtotal	29 (16.2%)	29 (16.1%)	34 (16.9%)
Changes in support methods in light of infection control	Changes concerning individual support	3 (1.7%)	2 (1.1%)	2 (1.0%)
	Sharing information and obtaining consent by mail or remotely	2 (1.1%)	2 (1.1%)	3 (1.5%)
	Strengthening inter-professional cooperation	2 (1.1%)	2 (1.1%)	2 (1.0%)
	Subtotal	7 (3.9%)	6 (3.3%)	7 (3.5%)
No measures		3 (1.7%)	3 (1.7%)	0 (0.0%)
	Total	179 (100.0%)	180 (100.0%)	201 (100.0%)

OT: Occupational Therapy
Note. The measures related to OT owing to COVID-19 were grouped into five categories. The number of record units for each category and code were shown.

tions>, <use of personal protective equipment during OT>, <fixing work content through reassignment>, and <thorough implementation of infection control measures in private life>. However, the participants reported [changes in support methods in light of infection control], such as <changes concerning individual support>, <sharing information and obtaining consent by mail or remotely>, and <strengthening inter-professional cooperation>. Finally, [no measures] was rarely reported.

4. Discussion

We investigated the influences of COVID-19 on OT in long-term care insurance facilities. Many facilities performed independent measures, modifying or adding content to assessments and treatments, while maintaining thorough infection control measures, even in the face of restrictions placed on participation and service provision.

Our results show that the number of OT clients in long-term care insurance facilities had decreased to approximately 90% due to COVID-19. Of these, nearly half of the studied facilities had no change in the number of clients, suggesting that they were still able to provide OT while taking infection control measures.

Regarding the location of OT in the long-term care insurance service facilities, there was a decrease in the number of sessions conducted outside the facilities during Period I. This is assumed to be due to the restrictions imposed by Hokkaido's local emergency declaration that refrained citizens from going outdoors [4]. However, there was a slight decrease in the implementation of the program in visiting rooms/homes, within the OT department, and in each facility after the emergency declaration. Factors involved in treatment, such as fixing the location using zoning and the time of day for each stay and commute period and changing from day care to home visit, were also reported. This suggested that the

location of each treatment was carefully considered and changed to minimize the risk of infection.

Regarding changes in the content of assessments due to COVID-19, the number of recording units with no change decreased from Period I to Period III, indicating that the influences of COVID-19 were gradually considered during assessments. From Period I, body temperature and physical condition were assessed. In addition, especially from Period II, the influences of COVID-19 on physical and cognitive functions due to disuse syndrome and stress response were assessed. When considering how to efficiently capture frailty status in pandemic management settings where time and resources are limited, feasibility and ease of use are paramount [14]. It is necessary to recognize frailty as early as possible in the assessment of OT in daily life. Concomitantly, assessment factors that prevent the spread of infection, such as awareness of infection control and assessment of housemates and visitors of clients, were also reported. Although it was inferred that the contents of the evaluation were important, it was also revealed that the restriction imposed on outside visits due to COVID-19 made it difficult to proceed with the assessment of outdoor activities and home environment. It can be inferred that the content of the assessment was greatly restricted by COVID-19 in most facilities. Therefore, OT should consider alternative means of assessment in the context of infection spread and control.

With regard to the changes in the content of treatment due to COVID-19, it was found that programs with high risk of infection, such as outdoor training and group activities, were discontinued from Period I in response to the local declaration of emergency in Hokkaido [4]. However, these were conducted after changing the treatment structure, such as changing the location to within the unit or own room, or zoning between staying and commuting, such that the risk of infection could be minimized; such changes were apparent from Period I onward. In addition, interventions to prevent disuse were conducted from an early stage. During Period III, outdoor training and activities with consideration for the influences of infectious diseases increased, and there were more reports of suggestions for voluntary training. We consider the possibility that these measures may be effective in ameliorating the decline in physical function and activity related to disuse syndrome and the accumulation of stress associated with changes in lifestyle due to self-restraint and other factors. Furthermore, there were also reports of "no change" in the content of treatment, and these influences tended to decrease gradually with time. This suggests that additional support incorporating infection control and changes in treatment methods are gradually being implemented in more facilities.

Restrictions other than those in OT assessment and treatment were categorized as restrictions on participation of the subject, on OT operations, and discontinuation of long-term care services. Although such restrictions occurred, the clients were guaranteed the opportunity to participate in OT with sufficient COVID-19 control measures through thorough implementation of standard precautions, such as the practice of hand hygiene, use of masks, management of the clients' physical conditions, and changes in support methods. Physical condition management for participation in OT was implemented for housemates as well as the clients, and careful infection control measures were undertaken. In addition, it was revealed that occupational therapists managed their physical conditions thoroughly and wore personal protective equipment such as face shields and gloves. They were taking measures against COVID-19 by introducing individual support, using remote methods, and strengthening multidisciplinary cooperation. These are similar to the results of a questionnaire survey conducted by the Japanese Society for Dementia Care on infection prevention measures in hospitals, residential facilities, and day care facilities [15]. However, changes concerning individual support, criteria for discontinuation of participation, and fixing of work content through reassignment were unique measures that were identified in this study and can be applied in other facilities according to the situation of the region, facility, or condition of the client.

The limitation of this study is that because the questions were asked in an open-ended form for each time period, some of the questions overlapped with other items or were omitted from later answers. In addition, the target population of this study was clients in long-term insurance facilities in Hokkaido. Each facility's characteristics, such as facility service, commuting service, and home-visit service, were not analyzed. The balance between urban and rural areas in Hokkaido is similar to the population structure of Japan as a whole [16], although the population density of Hokkaido is approximately one-fifth of the national average and distances between cities are two to three times longer than the national average [17]. COVID-19 in Hokkaido occurred mostly in the urban area centered on Sapporo [4][5], and it is assumed that there are regional differences as far as the influences of COVID-19. Therefore, further studies are needed to generalize the results of this study to other parts of Japan and worldwide and to examine methods for demonstrating the effectiveness of OT being influenced by COVID-19.

5. Summary and Conclusions

COVID-19 restricts the participation of clients in OT and in services provided to them in long-term insurance facilities. However, the influences of COVID-19 on the lives of the clients must be assessed in addition to general infection control measures and must be incorporated into the treatment contents accordingly. We recommend that the measures reported in this study be applied in each clinical setting, and they should be adopted after considering what methods are effective for taking such measures.

Conflicts of Interest

There are no conflicts of interest to declare.

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■ORIGINAL ARTICLE

Factors Affecting the Performance of Employment Support for People with Higher Brain Dysfunction: Analyzing Conditions at Medical Institutions and Employment Support Organizations in Japan

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Abstract: Objective: In Japan, the introduction of a project aimed at providing support for individuals with higher brain dysfunction has resulted in a substantial increase in their employment rate. While this shows positive effects, many such individuals still have difficulty finding employment and may face various difficulties in cases where employment is secured. This study aimed to clarify the factors that affect the performance of employment support for people with higher brain dysfunction, with a focus on the conditions at medical institutions and employment support organizations in Japan.

Methodology: This study measures scores on the competency scale (WSC-HB) required for employment support for people with higher brain dysfunction. An anonymous self-administered paper-based questionnaire was circulated among a total of 1,384 occupational therapists, speech therapists, social workers, and employment support workers. Factors affecting job performance were processed by hierarchical multiple regression analysis.

Results: The factors of "transdisciplinary learning (ΔR^2=0.105, F(311)=7.699, p<0.01)" and "amount of knowledge (ΔR^2=0.056, F(305)=6.854, p<0.01)" about employment support influenced the performance of employment support for people with higher brain dysfunction.

Conclusions: There are few opportunities to acquire knowledge about employment support for people with higher brain dysfunction. Going forward, systematic professional training should, therefore, be implemented to cover issues such as welfare, employment, and the medical features of higher brain dysfunction. This will help establish a system for providing quality employment support.

Keywords: higher brain dysfunction, employment support, human resource development, medical institution, employment support organization

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1. Introduction

Users of community employment centers for people with disabilities have reportedly increased by a factor of 1.85 in Japan after the introduction of a project for higher brain dysfunction support, which was implemented in fiscal 2002. This was followed by an extension project in fiscal 2013. As a result, the employment rate among this population has grown by a factor of 1.59, moving from 34% to 54% [1]. This indicates that the project has provided a successful support system targeted at employment and other aspects of life for people with higher brain dysfunction, many of whom were inadequately covered through previous systems. However, reports also show that 65% of people in Japan who are affected by higher brain dysfunction in the prime of their lives do not find employment, and may face a variety of work-related difficulties, even in cases where employment is secured [2]. Some of these problems that

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have been reported include "work cannot be performed well," and that there are "interpersonal relationship troubles" [2]. A systematic review was previously conducted in the Netherlands among individuals who had suffered strokes caused by higher brain dysfunction. The review showed that 39.3% had returned to work, but that approximately 60% of those with higher brain dysfunction were still unemployed [3].

Concerning medical institutions in Japan, the main providers of employment support for people with disabilities include occupational therapists (OTs), speech therapists (STs), and social workers (SWs). They can also employ and avail vocational counselors at employment support organizations and/or employment support workers at employment/life-support centers. However, it is difficult to provide employment support for people with higher brain dysfunction in the context of a single profession or organization. While the consensus is that this requires a multidisciplinary approach involving medical institutions and employment support organizations, such multidisciplinary collaboration is often lacking [4−6].

Individual factors related to employment for people with higher brain dysfunction include "activities of daily living capacity" and "family" [7]. However, this may also be problematic due to several external issues, including a lack of knowledge about employment support among medical institutions [8], a lack of skills related to employment support among rehabilitation workers [9], insufficient vocational rehabilitation support [10], and the methods support staff use to provide assistance. In this context, the Japanese Ministry of Health, Labour and Welfare is currently discussing the creation of a systematic framework designed to train workers on providing employment support to people with disabilities, which has been deemed necessary due to a general lack of knowledge and skills related to employment support [11].

In a previous study among OTs who provided employment support for people with higher brain dysfunction, the factors that promoted work performance included (1) understanding the information provided to companies, (2) number of staff, (3) awareness of the roles/functions of regional disability vocational centers, and (4) job satisfaction [12]. Meanwhile, research into other areas of improvement in job performance have emphasized the importance of collaborating with various experts, which is also known as transdisciplinary learning [13]. Similar factors with positive effects include workplace culture, interpersonal relations, organizational commitment, job commitment, and support systems [14,15].

However, there is currently a lack of knowledge about employment support for people with higher brain dysfunction [16]. Furthermore, there is insufficient clarity about which factors influence employment support performance among professionals that provide these services at medical institutions and employment support organizations.

Objectives

This study aims to reveal the factors that affect employment support performance among specialists working at medical institutions and employment support organizations that serve people with higher brain dysfunction. The goal was to produce findings that could be used to establish systems that provide quality employment support for people with higher brain dysfunction who desire entrance into the workforce.

Research Hypothesis

It is hypothesized that knowledge about employment support for people with disabilities, such as creating a conducive work environment (self-improvement, support system, interpersonal relationships, economic situation, job/organizational commitment), and higher frequency of transdisciplinary learning, positively affect job performance.

Operational Definitions

Higher brain dysfunction

This term refers to aphasia, apraxia, agnosia, memory impairments, attention disorders, executive function deficits, and social behavioral disorders caused by brain injuries, such as stroke or head trauma.

Employment support worker

These are workers who perform duties related to employment support at employment/life support centers for people with disabilities

Transdisciplinary learning

This term refers to the crossing of organizational boundaries in order to gain multidisciplinary knowledge related to one's current job.

2. Materials and Subjects

Subjects

Subjects included OTs, STs, SWs, and employment support workers who offered services at employment/life support centers for people with disabilities. All subjects had experience providing employment support to people with higher brain dysfunction at medical institutions across Japan. More specifically, "experience providing employment support" entails exchanging or

sharing information between professions or organizations, participating in simulated work activities/training conducted by the training or consultation departments of medical institutions, and providing consultation support aimed at finding employment or supporting visits to companies or other entities. The target organizations were medical institutions, base institutions for supporting the extension project on employment support for people with higher brain dysfunction, and work-related accident hospitals across Japan that care for workers, whose employees have published papers or presented at conferences sponsored by the Japanese Society of Vocational Rehabilitation or other organizations focused on employment support for people with higher brain dysfunction during the six-year period lasting from 2007 to 2012; this included 126 institutions for OTs and SWs, and 124 institutions for STs. We also included all 316 employment/life support centers for people with disabilities across Japan. We requested two responses from each organization, and thus mailed questionnaires to a total of 1,384 individuals.

Questionnaires

Survey respondents, including OTs, STs, SWs, and employment support workers, were asked to complete questionnaires containing the Work Supporter's Competency Scale for Higher Brain Dysfunction (WSC-HB) [16] wherein they rated elements concerning their job performance according to a 4-point scale (1 = none, 2 = infrequently, 3 = often, 4 = always). The WSC-HB consists of 44 items (four items on "basic knowledge of higher brain dysfunction," eight items on "assessment," two items on "consultation support," four items on "family support," 17 items on "management," six items on "workplace assistance," and three items on "accumulation of specialized knowledge") related to the knowledge and skills required to provide employment support to people with higher brain dysfunction. There were also nine terms that respondents indicated their level of knowledge about using a 4-point scale (1 = cannot explain, 2 = can explain simply, 3 = can explain generally, 4 = can explain fully; terms included disability pension, trial employment system, quality of working life, special affiliate company, school for people with disabilities to develop vocational skills, law on promoting the employment of people with disabilities, workplace adaptation trainers (job coaches), employment/life support centers for people with disabilities, and natural support). The scale was previously tested for both reliability and validity [16]. Respondents were also asked to provide basic demographic information, including gender, age, months of experience, and working hours (mean hours per week, including overtime). Transdisciplinary learning items included both the frequency of participation in workshops (i.e., mean number of academic society meetings, training sessions, and number of seminars attended each year on employment support for people with higher brain dysfunction since graduating from a training institution) and frequency of presentations at academic conferences (i.e., number of conference presentations, including poster presentations, given on employment support for people with higher brain dysfunction between April 2011 and March 2012). Finally, work environment items included self-improvement (one question), support systems (four questions), interpersonal relationships (three questions), economic status (one question), and job/organizational commitment (three questions), all of which were answered on a 4-point scale (1 = dissatisfied, 2 = slightly dissatisfied, 3 = slightly satisfied, 4 = satisfied).

3. Method

Data Collection

All anonymous, self-administered questionnaires were distributed and collected by mail.

Survey Period

The survey was conducted from July 7–31, 2012.

Data Analysis

Descriptive statistics were calculated for the basic demographic items (i.e., gender, age, months of experience, and working hours). To analyze the factors that influenced the performance of employment support for people with higher brain dysfunction, the level of performance was set as the dependent variable in a four-model hierarchical multiple regression, which was designed to examine the influence of each factor on performance, after taking the effects between variables into account. Model 1 contained four variables — the basic attributes of gender, age, months of experience, and working hours. Model 2 added two variables related to transdisciplinary learning —the frequency of participation in workshops and frequency of conference presentations. Next, Model 3 added five work environment factors — self-improvement, support system, interpersonal relations, economic situation, and work/organizational commitment. Finally, Model 4 added one variable — the amount of knowledge about employment support.

Variables that did not have normal distributions (Shapiro-Wilk test), ordinal scales, and nominal scales were converted to dummy variables prior to the hierarchical multiple regression analysis. To convert the ordinal scales and nominal scales to dummy variables, values less than the mean were set to "0," while those equal to or greater than the mean were set to "1" (Table

Table 1. Dummy variable transformation for hierarchical multiple regression analysis

	Mean	Dummy variable transformation (n)
Basic attributes		
Gender		Male = 0 (36), Female = 1 (58)
Age		20-30s = 0 (71), 40-60s = 1 (23)
Months of experience	94.92	<95 = 0 (41), ≥95 = 1 (53)
Working hours per week	46.45	<47 = 0 (59), ≥47 = 1 (35)
Transdisciplinary learning		
Frequency of participation in workshops	1.31	<2 = 0 (64), ≥2 = 1 (30)
Frequency of conference presentations	0.12	<1 = 0 (82), ≥1 = 1 (12)
Working environment		
Self-improvement	2.82	<3 = 0 (72), ≥3 = 1 (22)
Support system	10.41	<11 = 0 (62), ≥11 = 1 (32)
Interpersonal relationships	7.73	<8 = 0 (66), ≥8 = 1 (28)
Economic status	2.36	<3 = 0 (79), ≥3 = 1 (15)
Commitment	8.88	<9 = 0 (69), ≥9 = 1 (25)
Amount of knowledge*	21.84	<22 = 0 (80), ≥22 = 1 (14)

* For the nine terms related to knowledge, total scores were calculated (9–36 points) based on the ability to explain each (1 = cannot explain, 2 = can explain simply, 3 = can explain generally, 4 = can explain fully).

1). In addition, correlation coefficients were used to check for multicollinearity between variables. If variables exhibited correlation coefficients (r) ≥ ± 0.9, then one was excluded. If the variance inflation factor was ≥ 10 after inputting a variable, then it was excluded due to the high possibility of multicollinearity.

The dependent variable (job performance) was calculated based on the total scores (44–176 points) obtained after adding scores from the 44 WSC-HB items (1 = never, 2 = infrequently, 3 = often, 4 = always). The higher the total score of the 44 items of the WSC-HB, the higher the degree of job performance for people with higher brain dysfunction. For the five independent variables on work environment, each item was scored (1 = dissatisfied, 2 = slightly dissatisfied, 3 = slightly satisfied, 4 = satisfied) in order to calculate a total score: self-improvement (one question: 0–3 points), support system (four questions: 0–12 points), interpersonal relationships (three questions: 0–9 points), economic situation (one question: 0–3 points), and job/organizational commitment (three questions: 0–9 points). For the nine terms related to knowledge, total scores were calculated (9–36 points) based on the ability to explain each (1 = cannot explain, 2 = can explain simply, 3 = can explain generally, 4 = can explain fully).

In summary, the hierarchical multiple regression analyses were conducted as follows: First, we examined the effects of gender, age, months of experience, and working hours on job performance (Model 1). Second, we set the basic attributes used in Model 1 as control variables in order to examine the effects of transdisciplinary learning, with the frequency of participation in workshops and frequency of conference presentations set as independent variables (Model 2). Third, we examined the effects of five work environment variables (self-improvement, support system, interpersonal relationships, economic situation, and job/organizational commitment) by adding them to Models 1 and 2 (Model 3). Finally, we examined the effects of the knowledge variable (model 4). All analyses were conducted using the IBM SPSS Statistics software, version 17.0.

Ethical Considerations

All subjects were given written statements that the questionnaires were anonymous and that no individual responses would be published. They were also informed that participation was completely voluntary, and that no negative consequences would be incurred for declining to participate. In this regard, they were told that returning a questionnaire by mail would be taken as consent to participate. This study was conducted with the approval of the ethics committee on human research at the University of Tsukuba (East 24−4).

4. Results

Response Rate

The total number of responses collected equalled 325. Of the 325 respondents, 7 were not OTs, STs, SWs, or employment support workers (physical therapist, nursery teacher, home helper, job coach), and thus were excluded. Overall, data from 318 participants (overall recovery rate of 23%) were included in the analysis. We obtained questionnaire responses from 94 OTs (response

Table 2. Basic attributes and factors of OT, ST, SW, and employment support workers

Item (n)	Content	OT (%)	ST (%)	SW (%)	Employment support workers (%)
Basic attributes					
Gender (318)	Male	36 (38.3)	12 (19.4)	17 (36.2)	62 (53.9)
	Female	58 (61.7)	50 (80.6)	30 (63.8)	53 (46.1)
Age (316)	20s	33 (35.1)	23 (37.1)	17 (36.2)	12 (10.4)
	30s	38 (40.4)	21 (33.9)	18 (38.3)	40 (34.8)
	40s	15 (16.0)	12 (19.4)	6 (12.8)	39 (33.9)
	50s	8 (8.5)	6 (9.7)	5 (10.6)	21 (18.3)
	60s	0 (0.0)	0 (0.0)	1 (2.1)	3 (2.6)
Months of experience (310)		131.90±89.85	131.47±99.98	84.89±71.34	49.10±44.00
Working hours per week (310)[a]		46.71±0.76	48.29±9.49	47.79±10.08	44.68±6.71
Transdisciplinary learning					
Frequency of workshop participation (286)[b]		1.44±1.71	1.34±2.63	2.07±1.80	0.89±0.92
Frequency of conference presentations (302)[c]		0.15±0.41	0.08±0.33	0.17±0.48	0.10±0.38
Work environment[d]					
Self-improvement (318)		2.81±0.81	2.69±0.86	2.83±0.87	2.82±0.78
Support system (318)		10.77±2.42	10.53±2.12	9.74±1.91	10.31±2.01
Interpersonal relationships (318)		7.49±1.94	7.98±1.65	7.34±1.67	7.96±1.66
Economic status (318)		2.36±0.76	2.37±0.87	2.49±0.86	2.31±0.85
Commitment (318)		8.64±1.54	8.85±1.27	9.06±1.29	9.03±1.67
Amount of knowledge (315)[e]		17.35±5.18	15.96±4.84	22.26±5.42	28.51±4.36
Job performance (318)[f]		112.11±29.32	113.08±23.76	118.23±29.06	117.56±28.85

[a] Mean working hours per week (including overtime)
[b] Mean number of academic conferences, workshops, and seminars on employment support for people with higher brain dysfunction attended annually.
[c] Number of conference presentations (including poster presentations) given on employment support for people with higher brain dysfunction from April 2011 to March 2012.
[d] Total scores for each item (1 = dissatisfied, 2 = slightly dissatisfied, 3 = slightly satisfied, 4 = satisfied): self-improvement (0-3 points), support system (0-12 points), interpersonal relationships (0-9 points), economic status (0-3 points), commitment (0-9 points)
[e] Total scores on the ability to explain nine important terms related to employment support (1= cannot explain, 2 = can explain simply, 3 = can explain generally, 4 = can explain fully) (9-36 points)
[f] Total scores for the 44 WSC-HB items (1 = never, 2 = infrequently, 3 = often, 4 = always) (44-176 points)

rate of 37.3%), 62 STs (response rate of 25.0%), 47 SWs (response rate of 18.6%), and 115 employment support workers (response rate of 18.2%).

Basic Attributes

Respondents included 127 men (39.9%) and 191 women (60.1%). The most common age group was people in their 30s, accounting for 117 respondents (36.8%), followed by 20s, with 85 (26.7%). The mean months of experience was 131 months (approximately 10 years) for the OTs and STs, 85 months (approximately 7 years) for the SWs, and 49 months (approximately 4 years) for the employment support workers. The mean weekly working hours were longest for STs (48.29±9.49) and shortest for employment support workers (44.68±6.71).

Factors Affecting Employment Support Performance

The frequency of participation in workshops and seminars was highest among SWs (2.07±1.80) and lowest among employment support workers (0.89±0.92), while the frequency of conference presentations (including poster presentations) was highest among SWs (0.17±0.48) and lowest among STs (0.08±0.33) (Table 2).

Regarding the work environment, score rankings for the individual components were as follows; self-improvement scores were highest among SWs (2.83±0.87) and lowest among STs (2.69±0.86); support system scores were highest among OTs (10.77±2.42) and lowest among SWs (9.74±1.91); interpersonal relationship scores were highest among STs (7.98±1.65) and lowest among SWs (7.34±1.67); economic status scores were highest among SWs (2.49± 0.86) and lowest among employment support workers (2.31±0.85); and finally, commitment scores were highest among SWs (9.06±1.29) and lowest among OTs. The amount of knowledge about employment support was highest for employment support workers (28.51±4.36) and lowest

Table 3. Correlation coefficients between variables

	Gender	Age	Months of experience	Working hours	Workshops Frequency of participation	Conferences Frequency of presentations	Self-improvement	Support system	Interpersonal relationships	Economic status	Commitment	Knowledge
Basic attributes												
Gender	1											
Age	.05	1										
Months of experience	.18**	.24**	1									
Working hours per week	.02	-.13*	.02	1								
Transdisciplinary learning												
Frequency of workshop participation	.07	-.09	.05	.03	1							
Frequent of conference presentations	.09	.12*	.06	-.02	.15**	1						
Working environment												
Self-improvement	-.01	-.05	.04	-.01	.16**	.14*	1					
Support system	.05	-.03	-.03	-.07	.02	.07	.53**	1				
Interpersonal relationships	-.04	.06	-.01	-.08	-.02	.09	.39**	.63**	1			
Economic status	.05	.11	.1	.02	.07	.07	.22**	.35**	.36**	1		
Commitment	.02	.1	-.06	.01	.01	.12*	.31**	.42**	.46**	.24**	1	
Amount of knowledge	-.17**	.35**	-.29**	-.08	.13*	.16**	.06	-.08	.08	.01	.11	1

*p<.0.05 **p<.0.01

Table 4. Effects of variables on job performance in the hierarchical multiple regression analysis

	Model 1 β	Model 2 β	Model 3 β	Model 4 β
Basic attributes				
Gender	-.027	-.009	-.01	-.058
Age	.069	.043	.043	-.044
Months of experience	-.089	-.102	-.095	-.021
Working hours per week	.124*	.128*	.134*	.146*
Transdisciplinary learning				
Workshop participation		.217**	.208**	.182**
Conference presentations		.214**	.196**	.163**
Working environment				
Self-improvement			.059	.047
Support system			.071	.09
Interpersonal relationships			.041	.05
Economic status			-.085	-.085
Commitment			.071	.065
Amount of knowledge				.269**
R^2	.025	.129**	.156**	.212**
ΔR^2		.105**	.027	.056

***p<.0.05 **p<.0.01

β: standardized partial regression coefficient R^2: coefficient of determination ΔR^2: increase in coefficient of determination.

for STs (15.96±4.84) (Table 2).

As no variables showed correlation coefficients ≥ 0.9, all were included (Table 3). Further, all variance inflation factors were ≤ 10, thus indicating the lack of multicollinearity. As mentioned, hierarchical multiple regression analyses were conducted with job performance set as the dependent variable (four models). In Model 1, working hours showed a significant main effect, with a positive standardized partial regression coefficient. In Model 2, the frequency of workshop participation and frequency of conference presentations showed significant main effects, with positive standardized partial regression coefficients for both; these two variables contributed to a significant increase in the coefficient of determination, with Model 2 over Model 1 (ΔR^2=0.105, F(311)=7.699, p<0.01). In Model 3, none of the five work environment variables showed significant differences, nor did the coefficient of determination show significant increases

with respect to Model 2 (ΔR^2=0.027, F(306)=5.152, ns). In Model 4, knowledge showed a significant main effect and increase in the coefficient of determination, with Model 4 over Model 3 (ΔR^2=0.056, F(305)=6.854, $p<0.01$) (Table 12). The coefficient of determination (R^2) was not high (0.212), but showed some level of fit (Table 4).

5. Discussion

In this study, we found that transdisciplinary learning and the amount of knowledge about employment support were important factors for promoting employment support for people with higher brain dysfunction. While these findings support those of previous research, they did not support past findings on the work environment itself. In addition, the longer the working hours, the higher the job performance. This is likely due to the fact that there is a higher probability of performing a variety of duties with increased working hours. Therefore, the results have shown that the degree of job performance related to employment support for people with higher brain dysfunction is positively influenced by the supporter's individual knowledge and skills, working hours, and experience outside the facility. The results also suggest that environmental factors (self-improvement, support system, interpersonal relationships, economic situation, job/organizational commitment) may have little impact on job performance.

Although we found that both transdisciplinary learning and knowledge promoted employment support performance, other studies have shown that there are few opportunities to acquire knowledge about employment support for people with higher brain dysfunction [17,18]. The Ministry of Health, Labour, and Welfare is currently discussing how best to train human resources to provide employment support for people with disabilities; however, it is insufficient to solely acquire knowledge and skills in one's direct area of expertise. Rather, knowledge and skills related to both welfare and employment are also required [8]. The results of this study indicate that when the participants put the knowledge learnt through transdisciplinary learning into practice, it leads to an increase in job performance. We believe that continuing to offer transdisciplinary learning and improving job performance will gradually improve the employment support skills of supporters. In transdisciplinary learning, personal characteristics such as a positive attitude about staying up to date on information, as well as about listening to opinions from other people, may affect the degree of job performance. In the future, it will be necessary to examine the impact of individual characteristics on the quality of job performance, with regard to transdisciplinary learning and employment support.

To address the issues highlighted in this study, there should be a systematic approach to human resource development that includes knowledge and skills training on issues of welfare, employment, medical knowledge concerning the symptoms of higher brain dysfunction. This would help ensure the provision of quality employment support for people with higher brain dysfunction who want to enter the workforce. However, our hierarchical multiple regression analysis showed that the variables had low explanatory power for job performance. In addition to the three variables we examined in this context (transdisciplinary learning, work environment, knowledge), we surmised that other factors also affect job performance, including the level of disability and vocational ability of those seeking assistance, their job category, the circumstances of the company where they will return to work, and legal restrictions on medical care and welfare.

In the future, it will therefore be necessary to verify how job performance affects outcomes for people with higher brain dysfunction, both directly and indirectly. We believe that clarifying this will help to provide high-quality employment support to people with higher brain dysfunction.

6. Limitations

Since the questionnaire survey recovery rate of this study was low at 23%, there is a limit to the generalizability of the results. Our results are also difficult to generalize because we did not survey all types of professionals who provide employment support for people with higher brain dysfunction. While OTs, STs, SWs, and employment support workers are important actors who provide crucial services, such as employment support for people with higher brain dysfunction, this is not an issue that can be solved by individuals working solely in the four occupations examined in this study. However, it is difficult to survey other relevant occupations, including doctors, physical therapists, vocational counselors for people with disabilities, job center staff, and public sector employees. This study was conducted in 2012. Employment support for people with disabilities is susceptible to employment measures for such individuals, as well as revisions to the Japanese medical welfare system. In the future, it will also be important to compare the current situation with that of 2012, as well as examine what kind of social background affects the job performance of employment support. Further, job performance is ultimately a subjective evaluation given by the respondent, and does not include the quality of employment support, satisfaction levels of the recipients, or outcomes of employment support.

7. Conclusions

As people with higher brain dysfunction often fell through the gaps allowed by previous systems in Japan, the government implemented an extension project designed to provide relevant support, including provisions targeted at their employment needs. However, around 60% of people with higher brain dysfunction still do not find jobs. One reason for this is insufficient knowledge and skills among the professionals who provide this support. As such, this study clarified the factors that affect employment support performance for people with higher brain dysfunction. Our results clearly showed that both transdisciplinary learning and knowledge about employment support were crucial factors for promoting this type of support. While there are now areas of relevant specialization, collaborative efforts should be targeted at the development of systematic human resource programs aimed at employment support, specifically covering issues related to welfare, employment itself, and the medical features of higher brain dysfunction. This should aid in the establishment of systems that can provide quality employment support for people with higher brain dysfunction who want to enter the workforce.

8. Ethics

This study was conducted with the approval of the ethics committee on human research at the University of Tsukuba (East 24−4).

9. Conflict of Interest

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

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■ORIGINAL ARTICLE

Initial Practice for the Introduction of a Gaze-Based Augmentative and Alternative Communication Device

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Abstract: Background: Eye movement disorders of amyotrophic lateral sclerosis are unlikely to occur. For this reason, an increasing number of occupational therapists are have started introduction gaze-based AACDs. Although it is desirable to introduce AACDs as early as possible, the optimal method for introducing such devices remains unclear.
Objectives: This study aimed to clarify the initial practice for the introduction of a gaze-based AACD from an operational perspective.
Methods: The study participants were 16 healthy adults (12 males and 4 females; 30.9 ± 6.28 years). The following three aspects were measured according to the two operation methods (gaze groups and switch groups): "physical function", "mental function", "computer operation".
Results: No significant differences in physical or mental functioning were found between the gaze and switch groups. The switch group input significantly more characters in the computer operation than did the gaze group ($P = 0.02$, mean number of characters ± SD: 425.7 ± 156.5 vs. 234.9 ± 84.7, respectively). Furthermore, the switch group became accustomed to the operation significantly faster than the gaze group ($P = 0.01$, 9.1 ± 4.0 vs. 15.1 ± 2.7 minutes, respectively).
Conclusion: The initial training points for the introduction of gaze-based AACDs are as follows: The operating posture may affect the ease of operation. Therefore, always check the operating environment. If you want to input many characters quickly or communicate your intentions in a timely manner, switch input is recommended. Give the patient at least 10–15 minutes per session of continuous practice to become comfortable with the operation.

Keywords: neurodegenerative disease, gaze-based augmentative and alternative communication devices, occupational therapy, initial practice

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1. Introduction

Communication disorders is one of the most difficult challenges for people with neurodegenerative disease [1]. Although the initial symptoms do not interfere with speech intelligibility or language functioning, as neurodegenerative disease progresses, many people are unable to utilize spontaneous speech and written communication to meet their daily communication needs, which has led to the increased use of gaze-based augmentative and alternative communication devices (AACDs) in recent years [2]. In particular, the progression of amyotrophic lateral sclerosis (ALS) can lead to complete tetraplegia and the inability to breathe, swallow, or speak [3, 4]; however, in typical ALS, eye movement disorders are unlikely to occur [5]. For this reason, an increasing number of occupational therapists are have started introduction gaze-based AACDs [6–9].

Occupational therapy for patients with ALS and other severe disabilities involves the following: 1) the maintenance of physical function and consideration of psychological aspects due to the loss of physical and social functions, 2) complementary responses to lost functions using self-help tools and welfare equipment and devices, and 3) the maintenance and adjustment of quality of life to aid the carrying out of social roles [10]. In other words, occupation therapy aims to maintain activities of daily living using self-help devices and equipment while taking the psychological aspects of the patient into account. Communication is therefore essential for expressing intention. As people with severe disabilities and advanced disease such as ALS often have difficulty expressing themselves verbally because

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of tetraplegia and the inability to speak, support for verbal expression is extremely important. Occupational therapists are equipped with assistive technologies that allow such patients to express their intentions visually, thereby supporting their pursuit of living a normal life.

Several studies have reported the effectiveness of AACD implementation. Idemura et al. [11] found that the introduction of AACDs enabled patients with ALS to perform desired tasks and improved their performance and satisfaction scores on the Canadian Occupational Performance Measure. Marco et al. [12] reported that the use of eye-tracking communication devices not only improved quality of life, but also was associated with a high level of user satisfaction. However, those studies reported the results of device implementation, which is often challenging in practice. There are also two methods of eye input devices: gaze and combined use of switches. In most cases, gazing is utilized, and the method of using switches together is often effective. However, in both cases, the differences in operability and the time it takes to get used to the operation are unclear and have not been clarified.

Although it is desirable to introduce AACDs and communication aids as early as possible to predict the patient's disease state [13], the optimal method for introducing such devices remains unclear. Therefore, this study aimed to clarify the initial practice for the introduction of a gaze-based AACD from an operational perspective.

2. Methods

2.1 Research participants

The study participants were 16 healthy adults (12 males and 4 females; mean age ± standard deviation [SD], 30.9 ± 6.28 years) who had experience operating a PC.

2.2 Gaze manipulation

The AACD used in this study was the Tobii Eye Tracker 4C (Stockholm, Sweden). This relatively inexpensive device estimates the direction of the gaze by irradiating the pupil with near-infrared light and detecting the reflected light with a camera, and has recently been used in a number of studies [14, 15]. Regarding software, we used miyasuku EyeConSW (Unicorn Inc., Hirosima, Japan) [16], which specializes in gaze input using two main operation methods. The first is using gaze to select and decide on characters (gaze group), and the second is using gaze to select characters and an external switch to decide on characters (switch group). This study compared these two operation methods.

2.3 Operating environment (Figure 1)

The operating posture was set with a head-up tilt of 60°; the position of the AACD was set according to the manufacturer's instructions. Specifically, the distance from the AACD was set at 50 cm, and it was positioned so that the computer monitor was in front of the participant [17]. The PC with the AACD was mounted in a PC holder (Kawabata Iron Works Co., Ltd., Ishikawa, Japan) [18].

2.4 Operation

Using the AACD and associated software, we input the *History of Hiroshima Motorcycle Race* for 30 minutes. The characters typed were hiragana in Japanese and kanji. This is a book published by Koichiro Miho, an ALS sufferer, using only a line-of-sight input device [19]. In this study, the principal investigator designated a part of the book as the input. The books were displayed by the principal investigator, who printed them out and pasted them at the bottom of the computer screen.

2.5 Measurement and evaluation

For the assignment of the subject's operation method, we adjusted the experimental schedule of the subjects and divided them into two groups: the first 8 subjects in the gaze group and the second 8 subjects in the switch group. All subjects were before the experiment began, the participants' age, sex, years of experience using computers, and presence of glasses or contact lenses were checked. After the experiment, the following three aspects were measured according to the method of operation: "physical function", "mental function", and "computer operation".

The "physical function" items were blood pressure, peripheral oxygen saturation, pulse rate, and muscle hardness of the head and neck area (digital muscle hardness; TDM-Z1., Chiba, Japan) [20]. The "mental functioning items were salivary amylase levels [21] and subjective fatigue (e.g., eyestrain, postural fatigue, and overall fatigue based on a numerical rating scale). The "computer operation" items were the number of characters typed, the number of characters typed incorrectly, and the amount of time the participants felt comfortable with the operation. The number of characters typed and the number of characters typed incorrectly were counted by the principal investigator after the operation. We asked the subjects to report the amount of time the participants felt comfortable with the operation during the operation and asked them directly why they felt accustomed after the experiment. A timer was set up next to the computer screen, and the principal investigator checked the time when the subject reported the time.

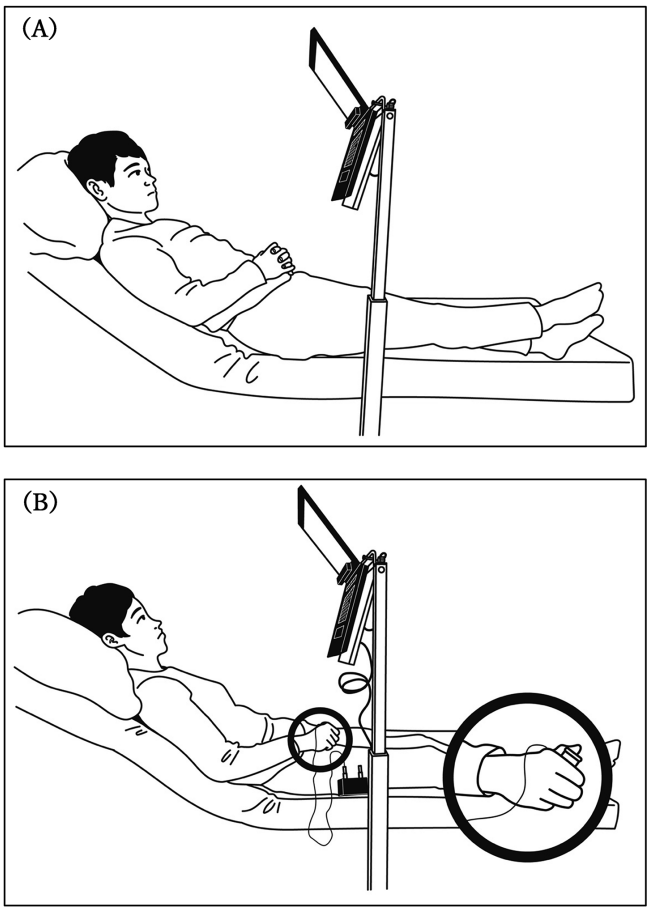

Fig. 1. Operating environment.
The operating posture was set with a head-up tilt of 60°. The distance from the AACD was set at 50 cm, and it was positioned so that the computer monitor was in front of the participant.
(A) Gaze to select and decide on characters (gaze groups).
(B) Gaze to select characters and an external switch to decide on characters (switch groups).

2.6 Statistical analysis

The statistical analysis was conducted according to the two operation methods (gaze and switch groups). The chi-squared test was performed for sex and the presence of glasses or contact lenses, and after the means for the other measurement items were calculated, the Mann–Whitney test was used to compare the two groups. All statistical analyses were performed with IBM SPSS statistics analyses for Windows release 23 (IBM Japan Ltd., Tokyo, Japan). All tests had a significance level of $p < 0.05$.

2.7 Ethical considerations

This study applied for preliminary review by the Medical Research Ethics Committee, Shimane University Faculty of Medicine and received a response that no review was required. This study was conducted in accordance with the Declaration of Helsinki. In addition, informed consent was obtained from all participants after they received both written and oral explanations of the purpose and content of the study.

3. Results

The participants in the gaze group were six males and two females (mean age ± SD, 32.4 ± 7.1 years; mean experience with computer use ± SD, 12.63 ± 6.8 years). The participants in the switch group were also six males and two females (mean age ± SD, 29.5.4 ± 5.5 years, mean experience with computer use ± SD, 10.13 ± 5.9 years).

The results of the comparison by method of operation are shown in Table 1. No significant differences in physical or mental functioning were found between the gaze and switch groups. The switch group input significantly more characters in the computer operation than did the gaze group ($P = 0.02$, mean number of characters ± SD: 425.7 ± 156.5 vs. 234.9 ± 84.7, respectively). Furthermore, the switch group became accustomed to the operation significantly faster than the gaze group ($P = 0.01$, 9.1 ± 4.0 vs. 15.1 ± 2.7 minutes, respectively).

The participants were also asked about the factors that made them feel accustomed to the software (Table 2). Those in the gaze group responded that they were able to understand the features, such as “I understood how to use the predictive conversion” and “I figured out where the characters were”. In addition, they also acknowledged factors related to gaze movement, such as “I can now move the cursor to where I want it to go” and “I can feel the sensation to keep looking at it”.

Similar to the gaze group, the participants in the switch group noted a accustom factor as they became able to understand the features of the software. For example, “I can understand the character layout”, “I can understand the positional relationship of the control panel”, and “I know where to find the characters”. The factor that differed from the gaze group was related to the operation of the switch (e.g., “I could understand the timing of pressing the switch”).

4. Discussion

This study examined whether the operability of the software differed depending on the operating method. We divided the participants into two groups (gaze and switch groups) and then compared physical and mental functioning and PC operation. The results showed that the participants in the switch group input significantly

Table 1 Comparison of measurements by operating method

	Gaze groups	Switch Groups	*P*-Value	
N (%)	8(50)	8(50)		
Age (years)	32.4 ± 7.1	29.5 ± 5.5	0.38	
Sex (Male : Female)	6 : 2	6 : 2	0.72	
Computer use (Years)	12.63 ± 6.8	10.13 ± 5.9	0.45	
Glasses/Contacts (Yes : No)	4 : 4	5 : 3	0.62	
Physical Function				
Blood pressure (mmmHg)				
Systole	120.4 ± 11.4	119 ± 8.1	0.64	
Diastole	78.4 ± 9.9	78.1 ± 8.8	0.83	
Pulse (times)	67.4 ± 10.4	71.6 ± 5.2	0.19	
SpO_2 (%)	98 ± 1.3	98.4 ± 1.1	0.39	
Muscle hardness (points)				
Right	51.6 ± 9.8	48.75 ± 8.8	0.79	
Left	52.8 ± 9.4	46.25 ± 8.2	0.25	
Mental Function				
Salivary Amylase (kU/1)	17.9 ± 13	18 ± 13.4	0.79	
Fatigue level (points)				
Eyesight	5.6 ± 1.6	3.9 ± 1.9	0.10	
Posture	4.4 ± 1.9	4.4 ± 2.7	0.96	
Whole	6.3 ± 1.3	5.8 ± 2	0.65	
PC operation				
Number of inputs (characters)	234.9 ± 84.7	425.7 ± 156.5	0.02	*
Number of incorrect entries (characters)	2.8 ± 4.2	1.38 ± 2.3	0.37	
Time to become familiar with the operation (minutes)	15.1 ± 2.7	9.1 ± 4.0	0.01	*

Values are number or mean ± standard deviation.
Chi-square tests were performed to assess the differences between the two groups with respect to the sex and glasses and contact lenses. To comparatively evaluate age, years of computer experience, Physical Functions, Mental Functions and personal computer operation, Mann-Whitney U tests were performed.
*P values < 0.05 were cosidered statistically sifnificant.

more text than did the gaze group. In addition, the switch group became accustomed to the operation of the computer significantly faster than the gaze group.

4.1 Influence of physical and mental functioning (Table 1)

In this study, the a uniform operating posture was used. As a result, no significant differences were found in the assessment of physical and mental functioning. In a previous study of the operation posture in relation to gaze input, a head-up tilt of 60° was reported to be the least physically and mentally burdensome [22].

The present study was conducted using the less burdensome posture involving a head-up tilt of 60°, which we believe led to the finding of no significant differences in physical and mental functioning. In other words, the appropriate operating posture was considered to be less stressful on the body and mind, even though the operating methods were different. The control environment for gaze input is extremely important [15]. Therefore, proper positioning has the potential to reduce the impact on physical and mental functioning.

4.2 Factors contributing to the high number of characters input in the switch group (Table 1)

The number of characters input in this study was significantly higher in the switch than in the gaze group. The gaze group was instructed to gaze for 1 second to determine the characters. By contrast, the switch group could make a decision in less than 1 second because they were instructed to press the switch at any time voluntarily. Therefore, we believe that allowing the participants to use a switch enabled them to input significantly more characters, which resulted in the time difference seen between groups.

4.3 Factors associated with familiarity with operation (Table 2)

The time to become accustomed to the operation was about 15 minutes for the gaze group and about 9 minutes for the switch group, which represented a significant difference. Furthermore, being able to understand the features of the software was the common factor that allowed both groups to become accustomed to the software. Specifically, they were able to understand the arrangement of the keys and the layout of the control

Table 2 Factors that made subjects feel comfortable with the operation by method (from subjects)

Switch Groups (N = 8)
When I could understood the timing of pressing the switch. When I found out that I could push in the middle.
When I could push the switch without putting pressure on your hands.
When I could understood the characters layout.
When I could get the hang of eye movement and cursor movement.
When I could operated while ignoring the red dot
When I stopped following the red dot with my eyes.
When I could understood the positional relationship of the control panel (screen layout).
When I knew where to find what characters.
Gaze groups (N = 8)
When I could now move the cursor to where I want it to go.
When I could feel the sensation to keep looking at it. When I was able to catch the sense of being able to push.
The part I was looking at often shifted, so I didn't know the feeling I was used to.
When I understood how to use predictive conversion.
When I figured out where the characters are.
When I understood how to convert.
When I figured out the layout of the operation panel characters.
When the predictive conversion becomes available.

panel.

Operating a computer using gaze involves a series of intentional eye movements, and eyes are easily fatigued [23]. Eye fatigue was scored as 3.9 in the switch group compared with 5.6 in the gaze group, indicating that eye fatigue tended to be lower in the switch than in the gaze group. Therefore, the eye movements of the switch group had some leeway. We think that this margin was a factor in the participants' sense of habituation because those in the switch group were able to grasp the overall picture of the key layout and control panel more quickly.

4.4 Application to initial training

Soofi et al. [24] attributed the problem of AACD implementation in patients with ALS to the lack among therapists of proper training in necessary skills and technology provision. For this reason, the authors spent substantial time explaining the character input methods to the participants. However, the participants could not fully understand the input method until they experienced the actual operation. We therefore believe that it is important for participants to gain a good sense of the operation. Based on the results of this study, the initial training points for the introduction of gaze-based AACDs are as follows:

i. Always check the operating environment.

The operating posture may affect the ease of operation. Therefore, it is also necessary to check whether the posture allows ease of operation. In addition, checking for eye fatigue is necessary to get a sense of familiarity with the operation; therefore, this is particularly important as a check during operation.

ii. If you want to input many characters quickly or communicate your intentions in a timely manner, switch input is recommended.

In recent years, many patients have requested to use gaze-input AACDs. Depending on the nature of the patient's request, it may be necessary to recommend a combination of switches. However, if a switch is used, it is important to ensure that it is properly adapted to the patient. Therefore, it is necessary to evaluate not only computer, but also switch operation.

iii. Practice for at least 10–15 minutes per session.

Explain the equipment and control panel thoroughly before the practice. Give the patient at least 10–15 minutes of continuous practice to become comfortable with the operation. Some patients may start the first practice session after receiving an explanation of the operation of the AACD, but then give up within 5 minutes, saying that it is too difficult. This makes it more difficult to get a sense of the operation. Therefore, it appears best to aim for 10–15 minutes or more to become accustomed to the operation.

4.5 Limitations

The limitations of this study are twofold. First, the participants in this study were healthy individuals. Therefore, the results regarding physical and mental functioning may differ in patients with ALS. In this case, experiments should be carried out with caution, as previous studies have shown that such investigations are carried out in patients who are aware of their communication needs [25]. Second, when operating a computer using a switch, the body part and type of switch operation varies from patient to patient. Since this study was

conducted using a uniform operating method, the results may have differed depending on the operability of the switch. Therefore, the operability of the switch also needs to be evaluated and analyzed.

5. Conclusions

This study focused on the operation of a gaze-based AACD and examined differences in physical and mental functioning and computer operability. The results indicated no differences in physical or mental functioning. However, it was possible to input significantly more characters when operating the computer using a switch. The results also indicated that it was necessary to practice continuously for 10–15 minutes or more to get used to the equipment.

In the future, we would like to improve the accuracy of these results by analyzing the operability of the switch and conducting research involving actual patients. In addition, we plan to clarify the social factors necessary for the smooth introduction of AACDs from the perspective of occupational therapists.

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■ORIGINAL ARTICLE

The Importance of Motor Imagery Ability in Determining the Optimal Focus of Attention During Motor Practice

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Abstract: Background: Outcome of motor practice is influenced by focus of attention. Paying attention to the environment (external focus) has been reported to be more effective than paying attention to body movements (internal focus). On the other hand, internal focus was reported to be more effective for novice sports players, indicating that the optimal focus differs among individuals. Outcome of motor practice is also reported to be influenced by motor imagery ability, where subjects with higher motor imagery ability show better outcomes. However, the possible relation between optimal focus of attention and motor imagery ability is not yet known.
Methods: In this study, we evaluated the motor imagery ability of healthy young students using a mental rotation task, and divided the subjects into low-motor-imagery and high-motor-imagery groups. The subjects performed the Functional Reach Test, which reflects balance ability, and performance was examined during and after repeated practice with different focuses of attention.
Results: Internal focus was more effective than external focus for the low-motor-imagery groups, while internal focus and external focus were similarly effective for high-motor-imagery groups.
Conclusion: These results indicate the relation between optimal focus of attention and motor imagery ability, and suggest the importance of evaluating motor imagery ability in choosing optimal focus of attention for motor practice.

Keywords: motor imagery, focus of attention, motor practice

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Introduction

During motor practice, occupational therapists instruct learners to pay attention to specific targets. Focus of attention can be divided into two types. With an external focus of attention (EF), learners pay attention to the environment such as goals of the movement. With an internal focus of attention (IF), learners pay attention to the body parts involved in the movement. The focus of attention is important for optimizing the outcome of motor practice, and the majority of studies have shown that an EF is much more effective than an IF [1]. An EF has been reported to be effective in various motor tasks, including balancing tasks [2]. EF is considered advantageous over IF because the latter may impede the automatic control of movement [3].

However, some studies have indicated that an IF can be effective, especially for novices. While highly skilled golfers performed better with an EF than an IF, low-skilled golfers performed better with an IF [4]. An IF was also shown to be more appropriate for novices during the early stage of motor learning [5, 6]. Peh et al. [6] explained this observation as follows. Novices at the early stage of learning must acquire a functional movement pattern so that the movements of relevant

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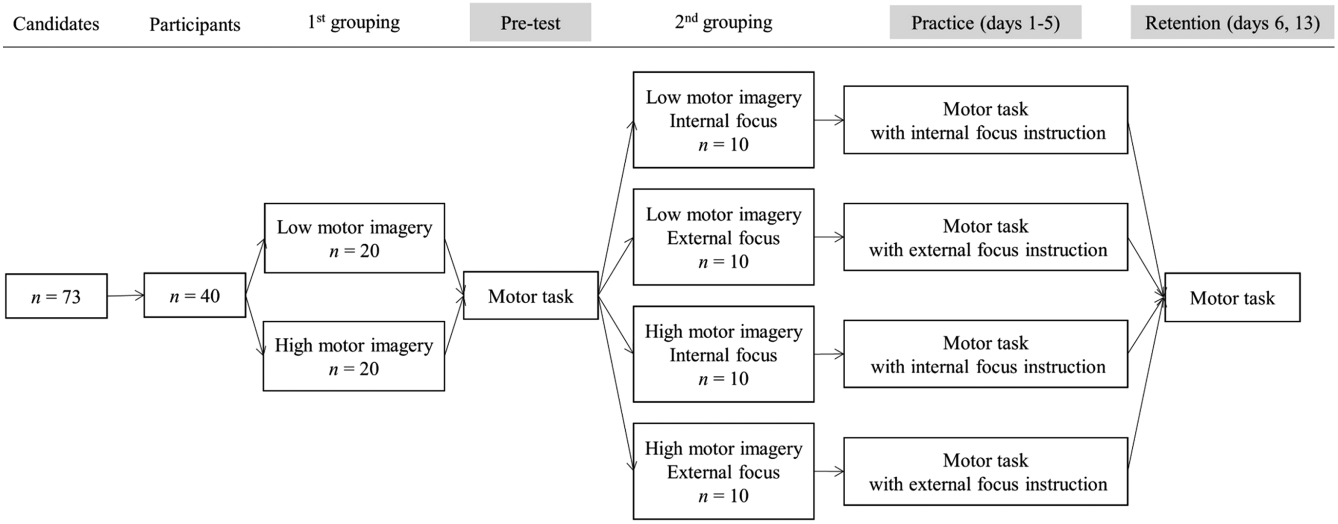

Fig. 1. Procedure of this study.

Among 73 candidates, 40 subjects were selected by the correct rate in the mental rotation task. They were divided into a low motor imagery (LMI) group (n = 20) and a high motor imagery (LMI) group (n = 20) according to the reaction time of the task (1st grouping). Then all the subjects conducted a pre-test of motor task (Functional Reach Test), and each group was further divided into an internal focus group and an external focus group (2nd grouping). The resultant four groups (n = 10 each) did not significantly differ in the age, sex, correct rate of mental rotation task, and outcome of the pre-test. The four groups received 5 days of practice in the motor task with corresponding focus instruction (Practice) and conducted the motor task without instruction on days 6 and 13 (Retention).

body parts co-occur appropriately, and thus need to pay close attention to the movement of their body parts. While such an argument provides an attractive neural basis for the optimal focus of attention, it is not evident how occupational therapists and subjects can choose the optimal focus of attention in various kinds of motor practices in daily life and restoration from injuries and diseases.

To find the optimal focus of attention for individual subjects, information on their motor imagery ability might be helpful. Motor imagery represents initial generation of action plans and movement programs, and is regarded as particularly important for performing motor tasks [7]. Furthermore, the outcome of motor practice is influenced by motor imagery ability. Individuals who easily generate motor imagery can better acquire new movements [8], and motor imagery training improves performance of a motor learning task [9, 10]. Thus, the outcome of motor practice is thought to be influenced both by the motor imagery ability and the focus of attention, which raises the possibility that the optimal focus of attention and motor imagery ability are correlated.

The purpose of this study is to clarify the importance of assessing motor imagery ability in determining optimal attentional focus in motor practice. We here examined whether the effectiveness of motor practice with EF or IF differs according to the motor imagery ability of subjects. We evaluated motor imagery ability by mental rotation task [11], in which subjects are presented with pictures of limbs and indicate whether they are left or right limbs as quickly as possible. Using this task we divided subjects into low-motor-imagery and high-motor-imagery groups. As a motor task for practice, we used the Functional Reach Test (FRT), which represents balance ability that is considered fundamental to various aspects of motor activity [12].

Methods

1. Subjects

Figure 1 shows the procedure of this study. Initially, 73 healthy right-handed college students (41 males, 32 females) with an average age of 19.3 ± 1.1 years (range: 19–24 years) were recruited as candidates of the subjects. The candidates performed the mental rotation task (see the following section), and those who scored above 80% of the correct rate on the task, which is the threshold indicating reliable test performance, were selected as subjects [11, 13]. As a result, 40 healthy right-handed college students (22 males, 18 females) with an average age of 19.3 ± 1.0 years (range: 19–24 years) were selected. They were divided into a low motor imagery (LMI) group (n = 20) and a high motor imagery (HMI) group (n = 20) according to the reaction time of the task, by setting the threshold time to assign an equal number of subjects into the two groups (1st grouping). Then all the

Fig. 2. Example of photographs used in the mental rotation task.
Thirty-two photographs were randomly displayed on a computer display. The photos consisted of the backs and palms of the left and right hands, and dorsal and plantar surfaces of the left and right feet, and were rotated by 0, 90, −90, or 180 degrees. Subjects were requested to answer whether the hands/feet were left or right as quickly as possible.

subjects conducted a pre-test of motor task (Functional Reach Test: FRT), and each group was further divided into an internal focus group and an external focus group (2nd grouping).

None of the subjects had prior experience with the task used in this study (mental rotation task and FRT), and all of them were naive to the purpose of the experiment. Before participating in the study, all subjects gave informed consent. The study was approved by the Institutional Review Board of Tosa Rehabilitation College (TRC; registration No. TRC 201802). The procedures used to collect the data followed all ethical standards of the Declaration of Helsinki.

2. Evaluation of motor imagery ability

To evaluate motor imagery ability, candidates of this study performed a mental rotation task [11]. In this task, subjects are presented with pictures of limbs at various angles and asked to indicate whether they are left or right limbs as quickly as possible; those with higher motor imagery ability have shorter reaction times [7]. The task was conducted using the Multi-PAS System (Q'sfix Corporation, Tokyo, Japan). Thirty-two photographs were randomly displayed on a computer display; the photographs consisted of the backs and palms of the left and right hands, and dorsal and plantar surfaces of the left and right feet, and were rotated by 0, 90, −90, or 180 degrees (Fig. 2). The subjects were asked to indicate whether each photograph was of the right or left hand (or foot) as accurately and quickly as possible, by pressing a button corresponding to the right or left side. During the task, subjects sat in a chair and held the pushbutton switch corresponding to the right and left side in the right and left hand, respectively, so that they could press the button immediately after their decision. Since the button-pressing was detected by a photo sensor, the latency from the button-pressing to the detection was less than 1 msec.

First, the rate of correct responses was determined for each subject, and those with an accuracy below 80% were excluded from the study. Then, the average reaction time (ms) was determined for each subject retained in the study. A threshold reaction time of 1,485 ms was set to divide the 40 subjects into equal (n = 20) shorter reaction time (HMI) and longer reaction time (LMI) groups.

After performing an initial FRT (pre-test), each HMI and LMI group was further divided into IF and EF groups by using a random grouping function of Microsoft Excel software.

3. Motor task

As a motor task, we used the Functional Reach Test (FRT), in which a subject pushes a bar forward with one arm as far as possible in a standing position and the maximum distance reached is measured. The FRT correlates with the center of pressure excursion (COPE) and represents balance ability that is considered fundamental to various aspects of motor activity [12]. Subjects performed FRT using a commercially available device (GB-210; OG Wellness, Okayama, Japan) according to the instructions of Duncan et al. [12] and Fujisawa et al. [14]. The subjects stood in an upright position and then pushed a bar with their right hand as far as possible. In the starting posture, the medial edges of both plantar surfaces of the feet were kept 15 cm apart, and the right upper arm was held horizontally from the acromion to the fingertips, with the forearm in middle position, and elbow joint and finger joints fully extended. The maximum reaching point was measured in mm. Subjects were instructed to push the bar slowly, and to keep their fingers in contact with the bar throughout the task, and their heels in contact with the floor. The forward shift in the COPE, which indicates a shift in the center of gravity (COG) of the body, was measured (in mm) during the FRT using a force plate (Anima Corporation, Tokyo, Japan). Because it correlates with the COPE, the FRT is considered to be a precise and stable balance assessment [12]. There were no outliers according to the Grubbs–Smirnov test, which was performed after all of the data had been collected.

In the initial FRT (pre-test), the FRT was conducted 2 times. The maximum reaching point was measured during both attempts, and the larger value was used in the analysis. When practicing the FRT, the subjects in the IF groups were instructed to stretch their arms as far as possible, while those in the EF groups were instructed to push the bar as far as possible. The instruction was given verbally in every task. This task was conducted 10 times a day for 5 consecutive days (days 1–5). The maximum reaching point of the FRT was measured during all attempts, and the largest value on each day was used in the analysis.

For the retention task performed on days 6 and 13, the FRT was completed twice without practice and the larger value was used in the analysis. The COPE was measured twice on days 6 and 13, and the larger value was used in the analysis. COPE measurement was not conducted during the practice period, to avoid prolongation of the entire time length of the practice (10 times of task per day), which may affect the outcome of the practice.

4. Questionnaire

A questionnaire was administered at the end of the session to investigate whether the subjects attention was appropriately focused during the session. Subjects were asked to indicate whether they paid more attention to their own bodies or to the external environment during the session. The focus of attention was considered appropriate when subjects of IF groups paid more attention to their own bodies and those of EF groups paid more attention to the external environment.

5. Statistics

Profiles of 4 groups (LMI-IF, LMI-EF, HMI-IF and HMI-EF) were compared by one-way ANOVA or chi-square test with the *post-hoc* Bonferroni multiple comparison test. For the comparison of FRT reaching distance and COPE between IF and EF, measurements were conducted repeatedly in the same subjects during practice and retention periods (within-subject factor), while IF and EF were conducted in different subjects (between-subject factor). Thus, two-way repeated measures ANOVA (one repeated measures factor and one non-repeated measures factor) was adopted for this analysis. Furthermore, to confirm the effect of motor practice, FRT of each day during practice and retention periods was compared with that of pre-test by using Dunnett's multiple comparison test. To compare FRT on each day between IF and EF groups, two-tailed *t*-test for between-subject data was first performed and the obtained *p*-values were adjusted for multiple testing by the Benjamini-Hochberg adjustment [15, 16]. The adjusted *p*-values were used for the analysis in Fig. 3.

Statistical analyses were conducted using SPSS software (version 27; IBM Corp.). Statistical significance was set at $p < 0.05$.

Results

1. Profiles of four groups with different motor imagery and focus of attention in motor practice

Table 1 shows the profiles of the four groups (LMI-IF, LMI-EF, HMI-IF and HMI-EF). They did not significantly differ in the age, sex, correct rate of mental rotation task, initial FRT or initial COPE. The four groups differed in the reaction time of the mental rotation task. The HMI groups had shorter reaction times during the mental rotation task than the LMI groups, and the reaction time did not differ between the LMI-IF and LMI-EF groups, or between the HMI-IF and HMI-EF groups. Detailed F and p values for the comparison of each group profile and post-hoc Bonferroni test values for the reaction time of mental rotation task were shown in Table 2.

Table 1 Profiles of the four groups differing by motor image ability and focus of attention type while practicing. MR, mental rotation task.

	Low motor imagery (LMI)		High motor imagery (HMI)		One - way ANOVA/χ^2
	Internal focus (IF) (n = 10)	External focus (EF) (n = 10)	Internal focus (IF) (n = 10)	External focus (EF) (n = 10)	*p* value
Age	19 ± 0.0	18.9 ± 0.3	19.5 ± 1.2	19.6 ± 1.5	$p = 0.33$
Sex (male, female)	4, 6	6, 4	5, 5	7, 3	$p = 0.57$
MR: correct rate (%)	90.9 ± 6.7	88.4 ± 5.5	92.8 ± 5.4	90.0 ± 5.0	$p = 0.57$
MR: reaction time (msec)	1981.4 ± 366.9	1964.4 ± 243.1	1026.7 ± 362.8	1064.1 ± 223.9	$p < 0.01$
FRT (mm)	328.7 ± 31.4	325.6 ± 31.9	338.4 ± 34.3	334.7 ± 35.7	$p = 0.85$
COPE (mm)	50.4 ± 14.6	51.8 ± 11.9	51.1 ± 13.9	51.4 ± 16.1	$p = 0.99$

Table 2 Detailed statistical results for the comparison of the four groups in Table 1.

	one-way ANOVA: Degrees of freedom, F value, *p* value χ^2: Degrees of freedom, Chi-square, *p* value	Bonferroni test: Groups and *p* value
Age	F (3,36) = 1.17, $p = 0.33$	–
Sex	$\chi^2(3) = 2.02$, $p = 0.57$	–
MR: correct rate	F (3,36) = 0.68, $p = 0.56$	–
MR: reaction time	F (3,36) = 27.52, $p < 0.01$	LMI-IF vs. LMI-EF, $p = 1.00$ LMI-IF vs. HMI-IF, $p < 0.01$ LMI-IF vs. HMI-EF, $p < 0.01$ LMI-EF vs. HMI-IF, $p < 0.01$ LMI-EF vs. HMI-EF, $p < 0.01$ HMI-IF vs. HMI-EF, $p = 1.00$
FRT	F (3,36) = 0.27, $p = 0.85$	–
COPE	F (3,36) = 0.03, $p = 0.99$	–

2. Motor practice for the low motor imagery groups

As Fig. 3 shows, the LMI-IF and LMI-EF groups showed consistent improvement in the FRT during both the practice and retention periods ($F_{7,126} = 35.04$, $p < 0.001$ for time course; two-way ANOVA). For both LMI-IF and LMI-EF groups, FRT performance of all days of practice and retention periods (days 1, 2, 3, 4, 5, 6 and 13) was significantly better than that of pre-test ($p < 0.001$ for all days; Dunnett's multiple comparison test).

Notably, the improvement was significantly more evident in the LMI-IF group than the LMI-EF group ($F_{1,18} = 5.029$, $p = 0.038$ for focus of attention; two-way ANOVA). Comparison of FRT on each day between the two groups revealed that the performance of LMI-IF group was better than that of LMI-EF group on days 4 and 5 of the practice period and days 6 and 13 of the retention period (asterisks in Fig. 3; *t*-test with Benjamini-Hochberg adjustment; adjusted $p = 0.037$ for day 4, 0.032 for day 5, 0.046 for day 6, and 0.044 for day 13). There was a significant interaction between time course and focus of attention ($F_{7,126} = 3.241$, $p = 0.003$ for interaction; two-way ANOVA).

The LMI-IF and LMI-EF groups showed consistent improvement in the COPE during the retention periods (in mm; LMI-IF: 69.7 ± 22.3 for day 6, 60.0 ± 16.1 for day 13; LMI-EF: 58.4 ± 16.2 for day 6, 56.9 ± 12.6 for day 13) ($F_{2,36} = 12.42$, $p < 0.001$ for time course; two-way ANOVA). However, the degree of improvement in the two groups did not differ significantly ($F_{1,18} = 0.493$, $p = 0.491$ for focus of attention; two-way ANOVA). There was no interaction between time course and focus of attention ($F_{2,36} = 2.373$, $p = 0.108$ for interaction; two-way ANOVA).

To confirm whether the subjects paid proper attention during practice, they were asked to confirm their focus of attention after all sessions were completed. All subjects in the LMI-IF group declared that they paid attention to their bodies throughout the sessions. In the LMI-EF group, 9 out of 10 subjects declared that they focused on the external objects throughout the session. The remaining subject said that he paid attention to both his body and the external object. However, because his internal attention was oriented toward his heels to keep them on the floor, and not toward the extending arm, he was considered to have adhered to the instructions and was thus included in the analysis.

3. Motor practice for the high motor imagery groups

Subjects in the HMI groups were allowed to practice the FRT as per the LMI groups. The HMI-IF and HMI-EF groups showed consistent improvement in the

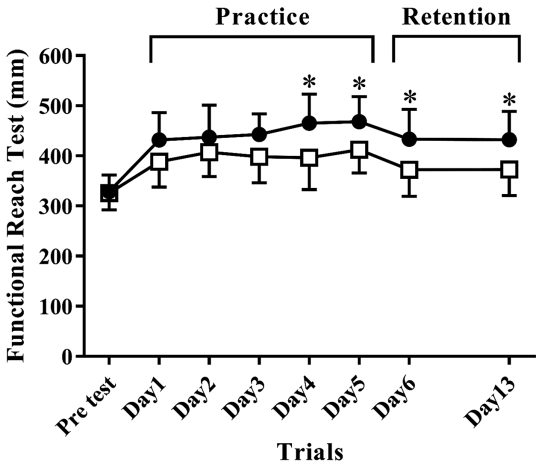

Fig. 3. Functional Reach Test (FRT) in the low-motor-imagery groups.

The FRT reaching measurements during the practice and retention periods are shown for the internal focus of attention (IF, ●) and external focus of attention (EF, □) groups. Data are the mean ± standard deviation (SD) (n = 10 for each group). FRT was significantly better in the IF group than the EF group (two-way ANOVA), and the difference was evident on days 4, 5, 6 and 13 (*adjusted $p < 0.05$; *t*-test with Benjamin-Hochberg adjustment).

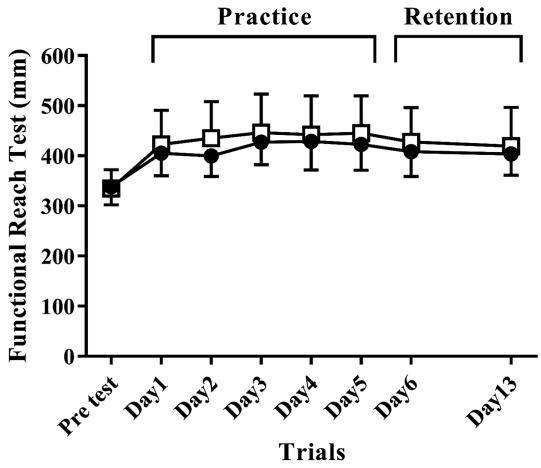

Fig. 4. FRT in the high-motor-imagery groups.

The FRT reaching measurements during the practice and retention periods are shown for the IF (●) and EF (□) groups. Data are the mean ± SD (n = 10 for each group). FRT did not significantly differ between IF and EF groups (two-way ANOVA).

FRT during both the practice and retention periods (Fig. 4) ($F_{7,126} = 20.00$, $p < 0.001$ for time course; two-way ANOVA). For both HMI-IF and HMI-EF groups, FRT performance of all days of practice and retention periods (days 1–13) was significantly better than that of pre-test ($p < 0.001$ for all days, Dunnett's multiple comparison test). However, the extent of the improvement did not differ between the groups ($F_{1,18} = 0.575$, $p = 0.458$ for focus of attention; two-way ANOVA). Comparison of FRT on each day between the two groups showed no significant difference (t-test with Benjamini-Hochberg adjustment). There was no interaction between time course and focus of attention ($F_{7,126} = 0.558$, $p = 0.789$ for interaction; two-way ANOVA).

The HMI-IF and HMI-EF groups showed consistent improvement in the COPE during the retention periods (in mm; HMI-IF: 59.0 ± 8.7 for day 6, 59.8 ± 9.9 for day 13; HMI-EF: 64.5 ± 18.7 for day 6, 62.7 ± 9.0 for day 13) ($F_{2,36} = 5.037$, $p = 0.012$ for time course; two-way ANOVA); the extent of the improvement did not differ significantly between the groups ($F_{1,18} = 0.596$, $p = 0.450$ for focus of attention; two-way ANOVA). There was no interaction between time course and focus of attention ($F_{2,36} = 0.151$, $p = 0.860$ for interaction; two-way ANOVA).

In the questionnaire completed after the final session, all subjects in the HMI-IF group declared that they paid attention to their bodies throughout the sessions. In the HMI-EF group, 8 out of 10 subjects declared that they attended to external objects throughout the sessions. While the remaining two subjects stated that they paid attention both to their bodies and external objects, their internal attention was oriented toward their heels and not toward the extending arm. Therefore, they were considered to have adhered to the instructions and were included in the analysis.

Overall, the analyses showed that an IF was more effective than an EF with respect to FRT practice performance for the LMI subjects. The results indicated the importance of using an optimal focus of attention during motor practice according to motor imagery ability.

Discussion

This study evaluated the motor imagery ability of healthy young students using a mental rotation task. In the LMI groups, IF was markedly more effective than EF with respect to FRT performance. By contrast, in the HMI groups, the effectiveness of IF and EF did not differ significantly. These results indicate that IF is more effective for subjects with poor motor imagery ability, and suggest the usefulness of evaluating motor imagery ability in choosing an appropriate focus of attention during motor practice.

During the initial stage of motor learning, the attention of learners is not focused on the content of the task, but on their own body movements. Learners improve the accuracy of their movements by coordinating the

various parts of the body and adjusting the timing and strength of the movements [17]. Analysis of brain activity also showed that the activity of the superior parietal lobule, which is considered to relate to the body schema [13], is enhanced at the onset of motor learning [18]. These reports support the view that bodily information is particularly important during the early stage of motor learning. LMI subjects in this study resemble those at an early stage of motor learning and rely heavily on body imagery for motor movements. An IF is thought to direct the attention of LMI subjects to their body parts and help to improve their motor practice. In contrast, HMI subjects may be already proficient at integrating the bodily information necessary for executing motor tasks. Because EF promotes a more automatic mode of motor control via use of the unconscious, fast and reflexive processes, EF as well as IF might be useful for HMI subjects who do not need to pay close attention to their body parts [1].

Several methods are commonly used to evaluate motor imagery ability [19]. The mental rotation task was used in this study for the following reasons. First, an fMRI study reported that the superior parietal lobule, which is known to be involved in motor imageries, is activated during the task [13]. Second, the mental rotation task does not rely heavily on language; in contrast, questionnaires, and interviews such as the Motor Imagery Questionnaire [19] depend heavily on language comprehension, which might differ significantly among subjects. Third, the mental rotation task encompasses many kinds of movements, whereas the mental chronometry task [20] represents a highly specific movement pattern and thus might not be suitable as a general evaluation of motor imagery ability. Fourth, the mental rotation task is often novel for subjects. On the other hand, the situations described in questionnaires and interviews, and the movements engaged in during the mental chronometry task, might be familiar to some subjects and this could bias the results. A previous report evaluated individuals' motor imagery ability by using the movement imagery questionnaire and showed the relation between modality-dominance of motor imagery and effects of focus of attention but did not show differences in the improvement of motor performance between different focuses of attention [21]. The discrepancy between this report and our study might be due to the difference in the method of motor imagery evaluation or motor task for practice.

A drawback for the mental rotation task is that a standard reaction time threshold discriminating low and high motor imagery ability is not yet established [7, 14]. Thus we here set a threshold to assign an equal number of subjects to LMI and HMI groups. It would be ideal to find a fixed threshold to judge whether each person has low or high motor imagery ability. Accumulation of studies with similar test design and subjects may enable the identification of the standard threshold.

Other limitations of this study are as follows. First, the mental rotation task might not be effective for the practice of other types of motor tasks. While the FRT used in the present study is a simple task under a stable situation, some motor tasks require that attention be paid to the external environment or other people, and the ability to comprehend spatial information. Improvement on such tasks might require an evaluation of other than motor imagery ability. Second, the improvement in COPE did not differ significantly between the LMI-IF and LMI-EF groups, although FRT and COPE are believed to be correlated [12]. This discrepancy might be due to the postural control strategy used during the FRT practice. Fujisawa et al. [14] reported that, during the FRT, some subjects showed improvement in the reaching distance without moving the COG, by using a "hip strategy" instead of an "ankle strategy" [22]. The FRT and COPE are well correlated under the latter but not the former strategy [23]. It is possible that many subjects in our study used the hip strategy. Because the hip strategy results in a more fixed posture with less movement, it is preferable that subjects be encouraged not to use the hip strategy in view of the purpose of motor practice. In future experiments we plan to prevent the subjects from pulling back their buttocks using their hip joints, by having them stand against a wall.

Conclusion

The present study indicated that choosing the focus of attention is important in motor practice, and that evaluation of motor imagery ability is useful for determining the optimal focus of attention during motor practice. Further understanding of the appropriate combination of motor evaluation and attention focus during practice would improve motor performance in daily life and restoration from injuries and diseases.

Conflicts of interest

The authors declare that there is no conflict of interest.

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■ORIGINAL ARTICLE

Improvement of Upper Limb Coordination by Upper Limb Target-Tracking for Patients with Cerebellar Ataxia: A Case Series Study

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Abstract: Objective: Few intervention studies have focused on upper limb function in patients with cerebellar ataxia. This study aimed to evaluate the influence of upper limb target-tracking task training on upper limb coordination in patients with cerebellar ataxia.
Methods: Six patients with cerebellar-type multiple system atrophy underwent training (20 min/day for 10 days), which involved using the left and right index fingers to track a target that moved at a constant speed on several kinds of simple figures. The evaluation was conducted using the iPad® Application for Evaluating Ataxia (iPatax), Scale for the Assessment and Rating of Ataxia (SARA), and Simple Test for Evaluating Hand Function (STEF).
Results: The coefficient of variation of the velocity of iPatax showed a tendency to decrease after training with the straight line and circle test, indicating the stability of upper limb movement speed. However, the SARA score did not change after training. The total time of STEF was shortened for the left and right hand after training in all cases, indicating improvements in the accuracy of motion and motor performance of the upper limbs.
Conclusion: Upper limb target-tracking task training may be useful for improving upper limb coordination in patients with cerebellar ataxia. In addition, iPatax can be used to detect smaller changes in symptoms that are not reflected in SARA.

Keywords: cerebellar ataxia, upper limb coordination, upper limb target-tracking task training, case series study

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1. Introduction

Spinocerebellar degeneration (SCD) is a general term for progressive degenerative diseases with ataxia as the main symptom. Ataxia involves lesion formation in the nerve cells of the spinal cord, brainstem, cerebrum, and cerebellum. SCD comprises clinical symptoms, pathological findings, or several genetically distinct disease types, with cerebellar ataxia occurring in several disease types [1]. Cerebellar ataxia is caused by ataxia of the limbs and trunk, postural reflex disorder, and gait disturbance and decreases overall activities of daily living (ADL). Moreover, as dysmetria and coordination disturbance impair fine motor movement, hand movements deteriorate, making the use of tools difficult [2]. There is no effective pathophysiologic treatment for cerebellar ataxia, with rehabilitation mainly aimed at improving and maintaining symptomatic treatment of each symptom and physical function.

Walking speed, stride, and lateral swaying during walking were reportedly reduced by limb muscular strength training, cooperative motion training, and balance training in patients with cerebellar ataxia, with improvements in motor performance and ADL [3]. However, few studies have focused on upper limb function. Upper limb training for cerebellar ataxia involves loading with a weight or compression with an elastic bandage. However, its effect has not been sufficiently verified. One reason for this is that no method has been established that is capable of specifically and quantitatively evaluating cerebellar ataxia in the upper limbs. Conventional neurological examinations have been developed to evaluate upper limb ataxia; however,

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Table 1 Patient characteristics.
Sex, age, disease type, duration of disease, and past medical history are indicated for all cases.

Case ID	Sex	Age	Type of disease	Duration of disease (months)	Past medical history
case A	female	67	MSA-C	14	hypothyroidism, diabetes mellitus
case B	male	67	MSA-C	14	
case C	male	60	MSA-C	29	diabetes mellitus, dyslipidemia
case D	male	70	MSA-C	36	sleep apnea syndrome
case E	female	50	MSA-C	29	
case F	female	76	MSA-C	50	hypertension

MSA-C: Multiple system atrophy with predominant cerebellar ataxia

results are difficult to quantify. Therefore, we developed the iPad® Application for Evaluating Ataxia (iPatax) as a new system to quantitatively evaluate upper limb ataxia in patients with cerebellar ataxia [4]. In this system, the iPad (Apple Inc., Cupertino, CA) utilizes a target-tracking task program that keeps track of the target moving at a constant speed using the fingers and is based on the measurement of the distance (space gap) between the finger and indicator, denoting the speed of the finger. This allows the convenient evaluation of upper limb movement function. Interestingly, we confirmed that the coefficient of variation (CV) of the tracking speed with fingers decreases during the inspection process [4]. A decrease in CV suggests that the target-tracking task improves upper limb coordination. This target-tracking task training requires visual information to track the finger at a constant speed. Further, the tracking movement requires information from deep sensation. Repeating this training that requires visual and deep sensation feedback may form an internal model in the cerebellum and allow smooth movement to be learned. [5]. However, it is important to confirm the influence of target-tracking task training for fingers on cerebellar ataxia.

Therefore, this study aimed to examine intensive upper limb target-tracking task training for patients with cerebellar ataxia to verify the change in upper limb coordination. It was hypothesized that upper limb target-tracking task training could improve upper limb coordination in cerebellar ataxia. We conducted a case series study as a pilot study to verify this hypothesis.

2. Methods

2.1. Subjects

This study included six patients (three male and three female; age, 50–76 years; duration of disease, 14–50 months) who had multiple system atrophy with predominant cerebellar ataxia (MSA-C) and were admitted to Niigata University Medical and Dental Hospital between April 2018 and January 2019 (Table 1). Table 1 shows the past medical history of all patients. However, no medical history affecting cognitive function was noted. All patients were right-handed. All participants provided written informed consent prior to the study. The study was conducted in accordance with the Declaration of Helsinki, and the study protocol was approved by the ethics committee of Niigata University (approval no. 2017-0326).

2.2. Procedures

The patients performed a 20-minute upper limb target-tracking task training for 10 days. They underwent cerebellar ataxia evaluation and upper limb function evaluation before and after training. In the intervention period, upper limb function training was conducted for upper limb target-tracking task training alone. Physical and occupational therapies were also performed at the same time.

2.3. Intervention

Upper limb target-tracking task training

TraceCoder™ (System-network, Japan) is a device for evaluating upper limb coordination. In this study, we used this device as a training tool to improve upper limb coordination. In this training, a target point, which was 1.5 cm in diameter, was displayed on a 10.6-inch tablet screen. The target point started from a point on the left side of the screen and constantly moved at a speed of 12 mm/s to the right. The patients were asked to track this point with their right or left index fingers. The training tasks were performed by tracing the four patterns of sine, rectangular, triangular, and spiral waveforms on the tablet. The patients' posture during training was the chair-sitting position. The tasks of four patterns of unilateral upper limb were conducted twice, and training tasks were performed with the left and right upper limbs. The training time was 10 minutes each for the right and left upper limbs, for a total of 20 min/day for 10 days (Fig. 1).

Fig. 1. Upper limb target-tracking task training.
This figure shows a patient tracking a sine wave with the right hand. A 1.5-cm-diameter index point was displayed on the 10.6-inch tablet PC screen, starting from the left side of the screen. The target, which moved at a constant speed of 12 mm/s to the right, was tracked with the index finger.

2.4. Outcome measures
2.4.1. Evaluation of cerebellar ataxia
2.4.1.1. iPatax

iPatax is a program that instruments the Visually Guided Tracking straight Movement Test (VGTMT-straight) and Visually Guided Tracking circle Movement Test (VGTMT-circle) based on the eye-tracking method operating on a 9.7-inch iPad screen developed by the authors (Fig. 2). In VGTMT-straight, a target point with a diameter of 1.5 cm is displayed on the iPad screen, moving at a constant speed of 5 cm/s along a 15-cm-long straight line. In VGTMT-circle, a target point with a diameter of 1.5 cm is displayed on the iPad screen, moving around a 10-cm-diameter circle in 6 seconds. The subjects were instructed that their index fingers follow immediately above the target point before the examination. Both tests were conducted with the right and left index fingers for 1 minute each. In both tests, the distance between the visual target and the finger (spatial displacement), velocity, and acceleration were measured every 0.03 seconds. Thereafter, the examination time of 60 seconds was divided into three sections: P1 (3 to

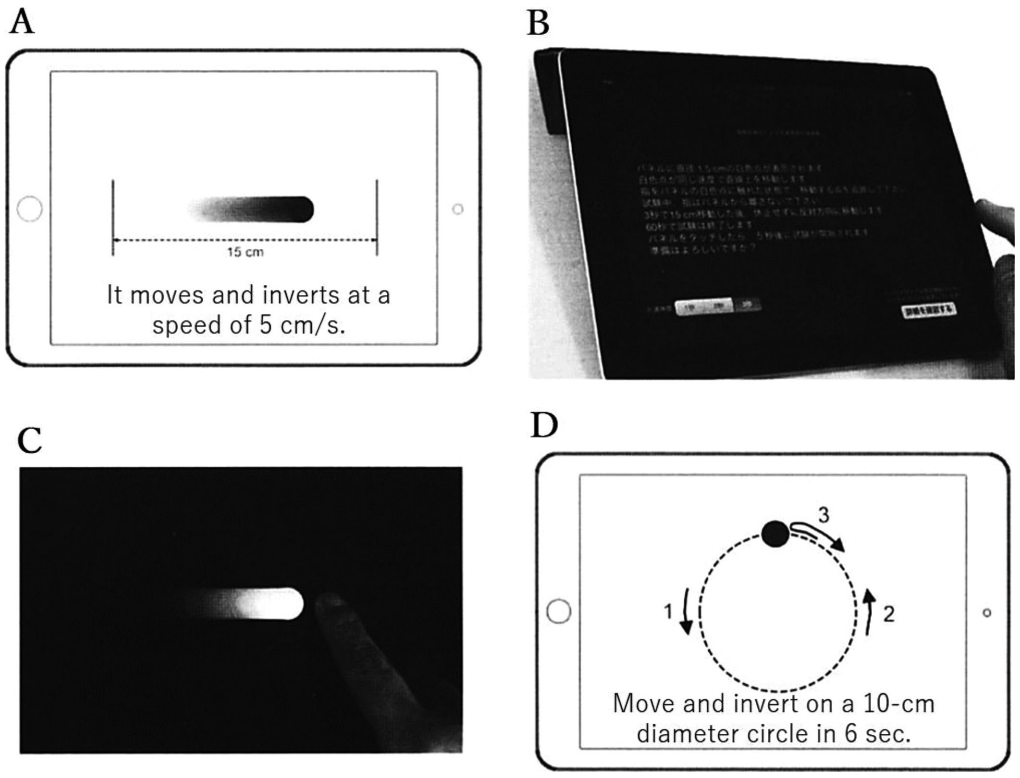

Fig. 2. Examination using iPatax (Jun T. 2015).
(A) The visually guided tracking-straight movement test. A 1.5-cm-diameter point was displayed on the iPad screen, which moved at a constant speed of 5 cm/s on a 15-cm-long straight line. (B) Screen involving the explanations and conditions of examination for the visually guided tracking-straight movement test. (C) Image under examination. The patients were instructed to track the target directly as much as possible with either the left or right index finger. (D) This figure shows the visually guided tracking-circle movement test. A 1.5-cm-diameter point was displayed on the iPad screen, which moved around a circle that was 10 cm in diameter for 6 s.

< 20 s), P2 (≥ 20 to < 40 s), and P3 (≥ 40 to ≤ 60 s). CV (standard deviation of population/average value) of the distance, velocity and acceleration of the finger in each section was calculated. In the previous study of iPatax, a strong correlation was noted between CV of the smallest speed among the three sections mentioned above and the score of Scale for the Assessment and Rating of Ataxia (SARA) [3]. In this study, CV of the smallest speed among the three sections was used as an outcome measure in conformity with a previous study [4]. The value of CV was presented as a percentage (%CV). A decreasing %CV with both tests indicated a stable change in upper limb coordination.

2.4.1.2. SARA

One of the clinical outcome measures was SARA [6], which has been proven to be a valid measure of disease severity in spinocerebellar ataxias [7]. The SARA score includes 8 items: 3 items rating gait and posture, 1 item for speech disturbances, and 4 items for limb-kinetic functions.

2.4.2. Evaluation of upper limb function

The Simple Test for Evaluating Hand Function (STEF) (SAKAI Medical, Japan) is an examination used for evaluating the patient's ability to pinch, grasp, and transfer objects [8]. STEF comprises 10 object-moving tasks, using objects with different shapes and sizes (large, medium-sized, and small balls; large, medium-sized, circular, and small blocks; and clothes, coins, and pegs). These tasks require different levels of hand dexterity. In each object-moving task, the subjects were required to pick up one set of these objects one by one from a storage space and move them into a target area as quickly as possible. If the patient completed the task within the set time limit, a score was provided according to the time required to complete the task based on a predetermined table for scores and time. The maximum score of each object-moving task was 10 points, and the total maximum score for STEF was 100 points. However, the score calculated at 100 points cannot sufficiently compare changes in movement accuracy and agility. Therefore, we compared the total time (seconds) required for the 10-item test in this study. STEF was evaluated for the left and right upper limbs.

3. Results

3.1. Changes in the tracking trajectory at the first (Day 1) and final (Day 10) training

Figures 3 and 4 show the trajectory of the target tracking with the right hand for the sine and triangular wave tasks as an example of the training. In the first training, the tracked trajectory tended to deviate from the baseline. In addition, the tracked trajectory tended to be a dotted line, indicating that the speed was unstable. However, at the final training, deviations from the baseline tended to decrease in all cases in the trajectories tracked; the trajectories were often indicated by a solid line, suggesting a stable speed.

3.2. Changes in velocity CV by iPatax

Figure 5 shows the change in the %CV of both the VGTMT-straight and VGTMT-circle. In the VGTMT-straight, the left and right %CV of all cases decreased after training compared to baseline measures. In the VGTMT-circle, the left and right %CV, excluding the right hand of case C and the left hand of case E, decreased after the training compared to baseline measures. The average value (standard deviation) of %CV in the subjects was 68.43 (12.31) for baseline and 57.95 (9.65) after training on the right hand of VGTMT-straight. The baseline was 79.03 (14.26) and 66.32 (4.63) on the left hand after training. On the right hand of the VGTMT-circle, the baseline was 56.38 (9.52) and training was 48.77 (6.41). The baseline was 61.46 (12.12) in the left hand, and training was 57.87 (9.73).

3.3. Changes in SARA

Figure 6 shows the changes in SARA. SARA demonstrated no change in total score after training compared to baseline measures in all cases. The average value (standard deviation) of SARA score was 17.08 (10.21) points for both baselines and after training.

3.4. Changes in the total time of STEF

Figure 7 shows the change in the total required time for STEF. In all cases except for the left hand of case E, the total time was shorter after training than that of baseline measures for both hands. The average value (standard deviation) of the total required time in the subjects was 204.8 s (87.1) for baseline and 177.1 s (85.3) after training on the right hand. On the left hand, the baseline was 250.1 s (90.8) and 214.4 s (78.3) after training.

4. Discussion

The target-tracking training task to improve the CV of iPatax velocity seems to be an effective training tool for improving upper limb coordination, and a larger-scale study with more extensive outcome measures is warranted to verify its full effects.

4.1. Changes in trajectory with upper limb target-tracking task training

The trajectory at the first training showed several

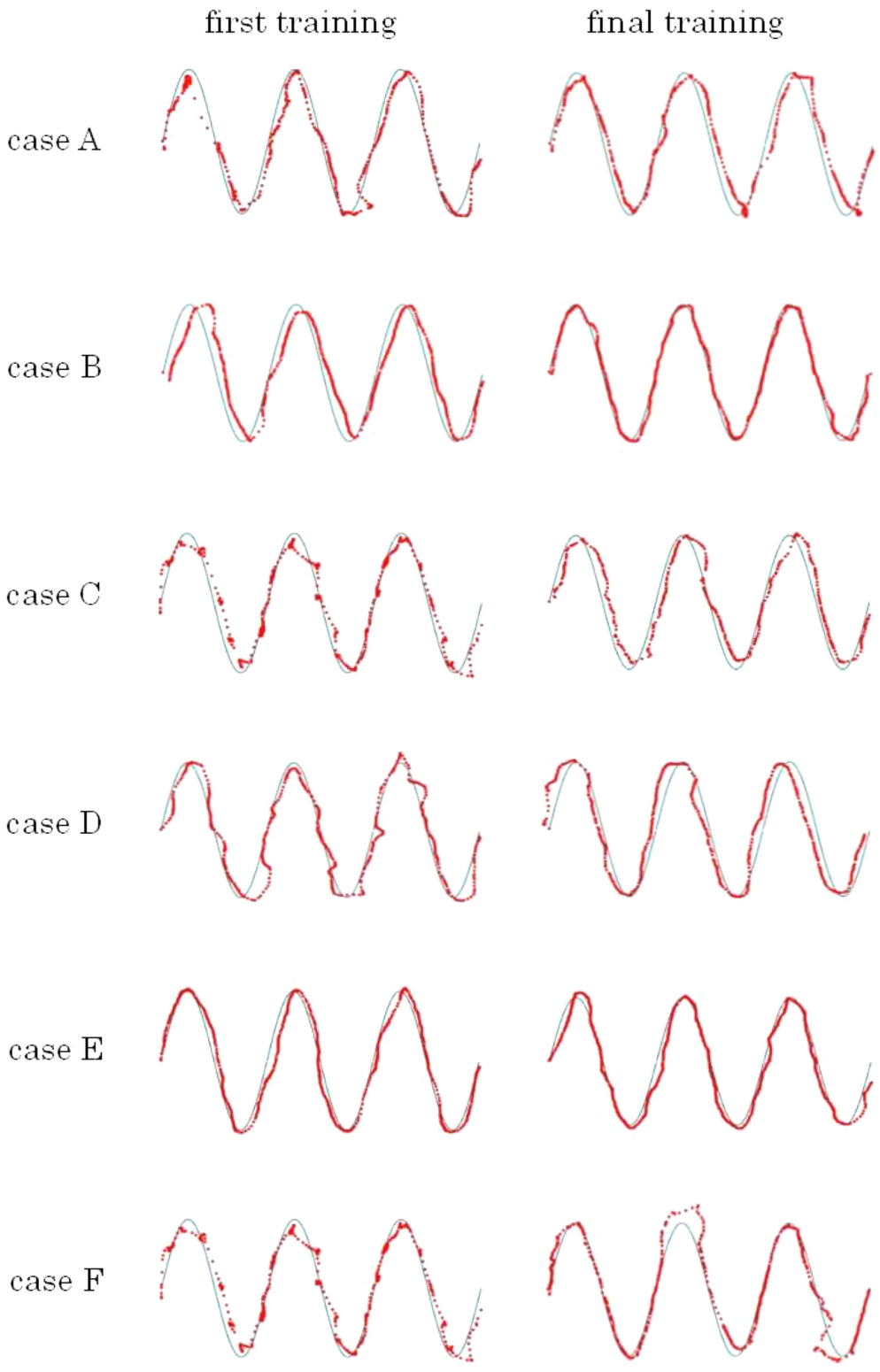

Fig. 3. Changes in trajectory at the first (Day 1) and final (Day 10) upper limb target-tracking task training (sine wave).

The figure shows the trajectory of all the cases who trained with the sine wave task for the right hand. The left and right lines show the first trainings (Day 1) and final trainings (Day 10), respectively. In the left line, we observed a deviation from baseline measures and a dotted line. However, the right line shows a decrease in the dotted line and less deviation from the baseline.

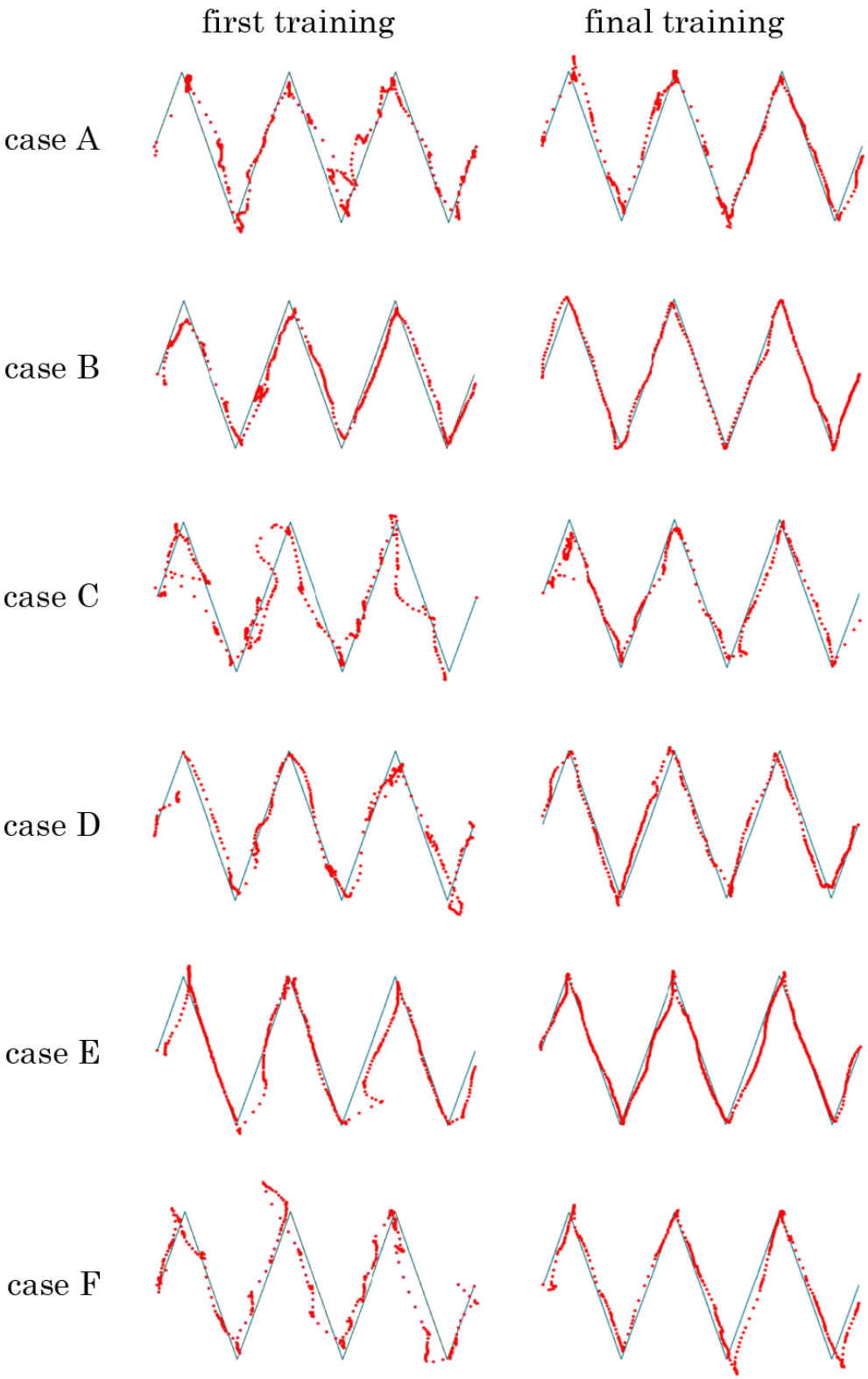

Fig. 4. Changes in trajectory at the first (Day 1) and final (Day 10) upper limb target-tracking task training (triangular wave).

The figure shows the trajectory of all the cases who trained with the triangular wave task for the right hand. The left and right lines show the first trainings (Day 1) and final trainings (Day 10), respectively. As in Fig. 3, in the left line, we observed a deviation from baseline measures and a dotted line. However, the right line shows a decrease in the dotted line and less deviation from the baseline.

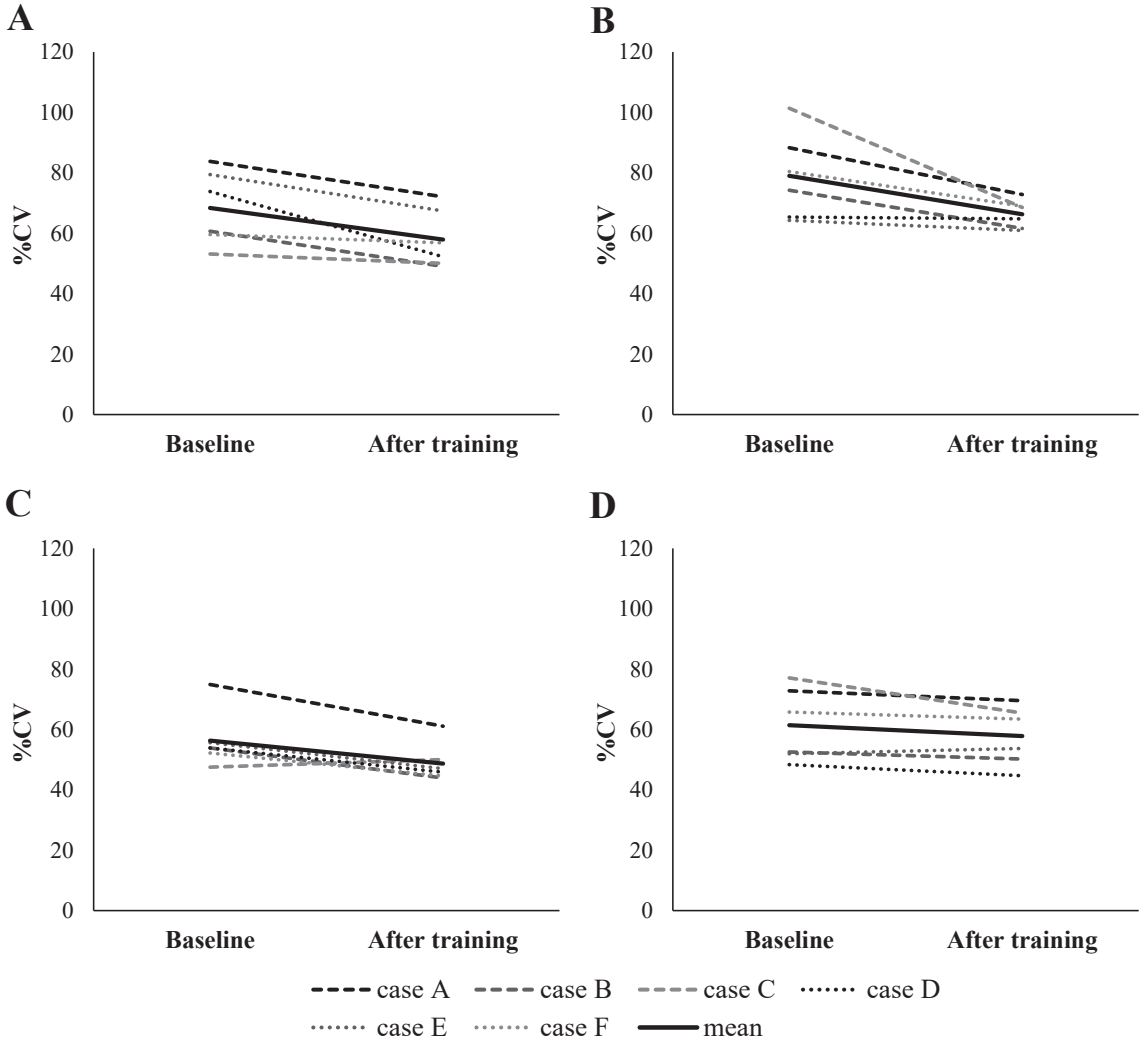

Fig. 5. The change in the %CV using iPatax at baseline and after training.

This figure shows the change in the %CV in the right and left hands of the velocity of VGTMT-straight and VGTMT-circle using iPatax at baseline and after training. A) VGTMT-Straight (right-hand), B) VGTMT-Straight (left-hand), C) VGTMT-Circle (right-hand), D) VGTMT-Circle (left-hand) . The solid line in the figure shows the average value of %CV in the six subjects. The average value (standard deviation) is shown baseline and after training. Figure A was 68.43 (12.31) for baseline and 57.95 (9.65) for after training. Figure B was 79.03 (14.26) for baseline and 66.32 (4.63) for after training. Figure C was 56.38 (9.52) for baseline and 48.77 (6.41) for after training. Figure D was 61.46 (12.12) for baseline and 57.87 (69.73) for after training.

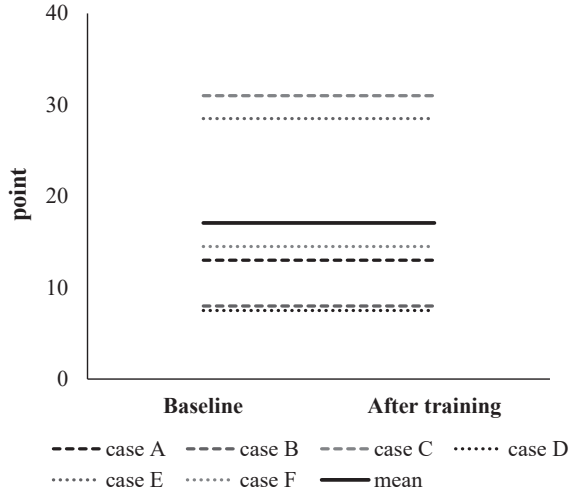

Fig. 6. The change in SARA score at baseline and after training.

This figure shows the change in SARA score at baseline and after training. The solid line in the figure shows the average value of the six subjects. This figure shows the change in SARA score at baseline and after training. The solid line in the figure shows the average value of the score in the six subjects. The average value (standard deviation) of SARA score was 17.08 (10.21) points for baseline and 17.08 (10.21) points for after training.

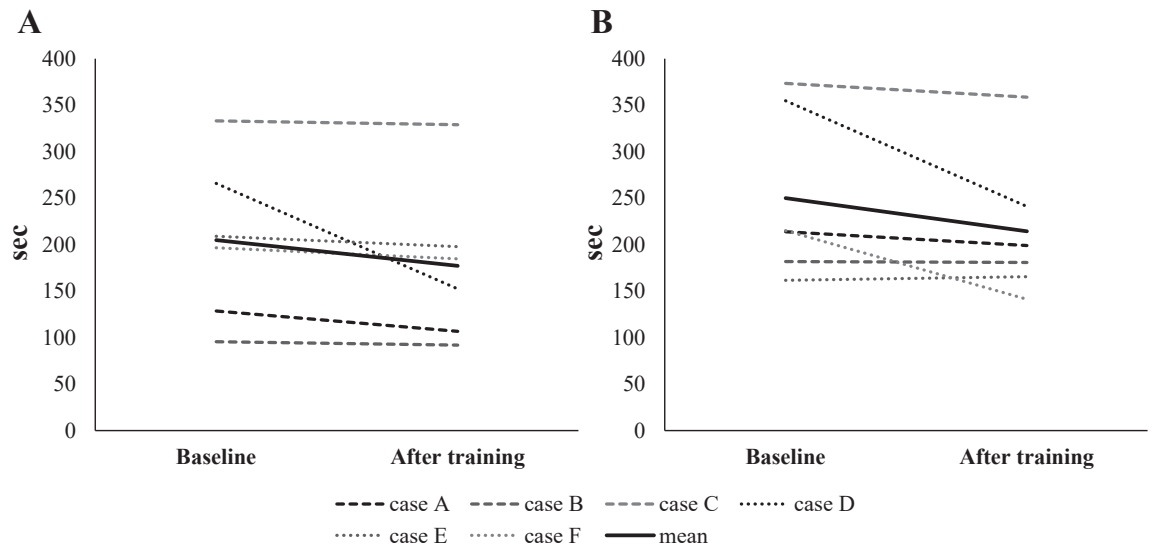

Fig. 7. The change in the total time of STEF at baseline and after training.
This figure shows the change in the total time of STEF in the right and left hands after training and baseline. A) Right hand, B) Left hand. The solid line in the figure shows the average value of the six subjects. The average value (standard deviation) of the total required time is shown baseline and after training. Figure A was 204.8 s (87.1) for baseline and 177.1 s (85.3) for after training. Figure B was 250.1 s (90.8)for baseline and 214.4 s (78.3) for after training.

areas deviating from the reference line, which was displayed as a broken line. However, in the training on the 10th day, the deviation from the baseline decreased, and the trajectory was demonstrated as a solid line. This solid line indicated improved speed stability. In this training, observing the graphic tasks displayed and the tracked trajectory is crucial. This is because errors between the reference line of the graphic tasks and the traced trajectory are recorded as visual feedback, allowing participants to learn the correct tracking motion. Ito et al. [9] reported that erroneous motion was inhibited by repeated training, and stable motion with less error was learned. It is believed that errors in learning are facilitated by cerebellar feedback control. Dendrites of Purkinje cells and basket cells of the cerebellum, which are most crucial to motor learning, respond only to some inputs, and most are inactive [10]. Therefore, it is possible to activate inactive cells and synapses. However, Payoux et al. [11] reported that cerebellar activity declined, and the activities of the supplementary motor cortex and parietal lobe increased during finger motion among patients with MSA-C. The supplementary motor area is activated by unfamiliar motion tasks, inducing motor learning [12]. Because this training was short-term, motor learning may have been insufficient. Therefore, the change in trajectory caused by training may involve not only feedback control by the cerebellum but also motor learning in motor-related cortical areas.

4.2. Changes in velocity CV by iPatax

In this study, it was confirmed that the CV of velocity decreased after training. In the past iPatax research, the CV of velocity decreased in the second half of the test time, and the task was gradually performed smoothly by motor learning [4]. Similarly, in this study, it is considered that, after the training, motor learning was induced because the CV of velocity decreased, and the task could be performed more smoothly. Cerebellar ataxia is believed to be an abnormality in the temporal pattern generation of agonist, antagonistic, and synergistic muscle activities. It is important to evaluate this temporal measurement abnormality [4]. Generally, for examining upper limb ataxia, point check and trace examinations using writing instruments are often used. However, these examinations are insufficient for quantification and cannot assess temporal measurement abnormalities. The CV of velocity by iPatax used in this study markedly reflects the temporal measurement abnormality of cerebellar ataxia and was highly correlated with SARA, which is used to evaluate ataxia severity [4]. This decrease in CV means that the movement velocity was stable, indicating an improvement of upper limb coordination in cerebellar ataxia. In VGTMT-circle, in all except two cases, there was a tendency for CV to decrease after training, implying that the training could stabilize the velocity of movement and improve cerebellar ataxia. In addition, it has been reported that training involving curves is more complicated than that involving a straight line and the difficulty level is higher

in drawing tasks in cerebellar ataxia [13]. In the results following this training, not only VGTMT-straight, which is a relatively simple task, but also the more complicated VGTMT-circle exhibited a decrease in the CV of velocity.

4.3. Change in SARA score

SARA is widely used internationally as an evaluation method for cerebellar ataxia because it correlates well with the stage of SCD and is an excellent measure of severity [6]. However, the SARA annual rate of change of SCD is only 1.1–2.1 out of 40, and this lack of sensitivity is a drawback [14]. In this study, the SARA score did not change, and this could be because the evaluation by SARA could not sufficiently detect the symptom change due to the short duration of the training. Moreover, we reported that using iPatax, in addition to SARA, could evaluate minute symptomatic changes [4]. In this study, as well as in previous studies, SARA seemed able to detect a small change in symptoms that could not be detected.

4.4. Change in the total time of STEF

Exercise-training intervention for patients with cerebellar ataxia has been shown to improve gait speed and stride [15, 16]. Rodríguez-Díaz et al. [15] showed an improvement in gait, standing, and sitting balance via 19 exercise-training programs aimed at improving limb muscle strength and coordination for 24 weeks for patients with SCD. Ilg et al. [16] showed improvements in walking speed, stride, lateral swaying, and balancing ability after intensive walking for 4 weeks for 10 patients with cerebellar degenerative disease. It is suggested that these exercise-training effects improve the motor performance of walking and dynamic balance ability by improving intra-limb coordination for the knee and ankle joints. Based on these facts, we proposed that repeating the upper limb target-tracking task training improved intra-limb coordination for the shoulder and elbow joints and had a positive effect on STEF performance. However, in this study, the training's effect on ADL was not evaluated. We aim to improve ADL in patients with cerebellar ataxia with this training.

5. Limitations and Future Studies

Because SCD, including MSA-C, is a degenerative disease of the cerebellum, reversible changes cannot be expected. It is still unclear whether deterioration of the cerebellum will compensate for impaired or prolonged motor learning depending on the intensity of rehabilitation or the intervention method. Since this study is a case series, there is no control group. As a result, statistical analysis is not possible, and the effect of the intervention is insufficiently verified.

In the future, we will examine the effective task content of upper limb target tracking and its sustained effect longitudinally. Next, you need to set up a control group and statistically prove the effectiveness of this training. The mechanism of effect of this training is elucidated by diagnostic imaging and neurophysiological methods. In addition, since all patients had no history of neurological diseases other than MSA-C, they were able to fully understand the content of the upper limb target-tracking task training. However, since MSA-C shows a decline in cognitive function as the symptoms progress, it is necessary to grasp the degree of cognitive function and verify the degree of understanding of training and its effect.

6. Summary and Conclusions

The present study demonstrated that upper limb target-tracking task training decreased the CV of velocity in tracking movements and improved upper limb performance in patients with cerebellar ataxia. Our results suggest that this training may help improve upper limb coordination in patients with cerebellar ataxia. Moreover, iPatax detected smaller changes in symptoms that were not reflected in SARA.

Conflict of interest

The authors have no conflicts of interest to declare.

Acknowledgments

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■CASE REPORT

Effect of the Perceptive Exploration Approach on Upper Extremity Movement Disorder in Patients with Acute Stroke Hemiparesis: Case Series Study

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Abstract: Introduction: The perceptive exploration approach is a therapy for upper extremity movement disorders in patients with acute stroke hemiparesis. It facilitates the organization of actions in terms of perceptual information exploration and motor control, and may help develop the functional use of the upper extremities. The purpose of this study was to determine whether the perceptive exploration approach is effective in improving upper extremity movement disorders in patients with acute stroke hemiparesis.

Methods: I used pretest-posttest data to examine the therapeutic effects of the perceptive exploration approach in eight hemiparesis patients. In addition to a standard occupational therapy program, the therapy included a tailored perceptive exploration activity based on the assessment of patient-specific upper extremity function. I examined three main outcome measurements: Fugl-Meyer Assessment (FMA), and amount of use (AOU) and quality of movement (QOM) in the motor activity log (MAL).

Results: Outcome data measured before and after therapy showed improvement in all patients. FMA scores for motor function ($p = 0.01$, $\Delta = 0.55$) and sensory function ($p = 0.02$, $\Delta = 0.59$) assessment were significantly improved, and the effect size was moderate. AOU ($p = 0.01$, $\Delta = 0.81$) and QOM ($p = 0.01$, $\Delta = 0.80$) in the MAL were also significantly improved, and the effect size showed a large change.

Conclusion: The present results suggest that the perceptive exploration approach may be useful for the recovery of upper extremity movement in patients with acute stroke hemiparesis.

Keywords: hemiparesis, acute stroke, paralyzed upper extremity, perceptive exploration activity

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Introduction

Restoration of the functional use of the affected upper extremity is one of the goals of occupational therapy (OT) for many stroke hemiparesis patients. Currently, rehabilitation in acute stroke patients concentrates on impairment-oriented approaches [1]. In acute stroke therapy, it is important to focus on functional recovery while utilizing both natural recovery and tissue reproduction of the central nervous system [2]. I have found that the perceptive exploration approach, an impairment-oriented approach, facilitates the readaptation of stroke patients and patients with developmental disabilities to activities of daily living (ADLs). This approach is a therapy that uses daily items and tools as therapeutic means to extract the perceptual information necessary to perform daily tasks; it facilitates the organization of actions based on sets of motor skills [3, 4]. Exploration to obtain perceptual information and motor control, which is a feature of this therapy, are important for the development of functional use of the upper extremities [5]. The purpose of the present study was to clarify whether the perceptive exploration approach is effective in improving upper extremity movement disorders in patients with acute stroke.

Subjects

The subjects were stroke hemiparesis patients who underwent occupational therapy at Hashimoto Municipal Hospital in 2021 (Table 1). The participation criteria

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were the following: (1) diagnosis of stroke, (2) paralytic symptoms of one upper extremity, (3) no severe disturbance of consciousness or cognitive impairment that interferes with clinical assessment. All subjects provided their informed consent before participation.

Method

Procedure

Each patient underwent a pretest and a posttest to examine the effect of the perceptive exploration approach on the paralyzed upper extremity. Therapy consisted of a standard OT program (40 minutes daily) and a tailored perceptive exploration activity (5 days per week). The standard OT program consisted of facilitation of muscle activity and coordinated multi-joint movement, tactile and proprioceptive input, and soft tissue mobilization. The perceptive exploration activity was based on patient-specific upper extremity function. The perception information essential for task performance was extracted from the tactile-motor sense by the patient with the assistance of an occupational therapist, and it was carried out in such a way that motor skills could be demonstrated [3, 4]. For hand motor skills, the manipulation functions for accomplishing the task were categorized into 10 items, and the activity task and the target to be used were updated according to the recovery stage of the patient's upper extremity function. Motor skills based on the fundamental movement of the hand include reaching, holding, moving, releasing, throwing, picking, stroking, scratching, wiping, and varied prehension.

Outcome measurements

1) Fugl-Meyer Assessment: FMA

The FMA was used to measure upper extremity motor function, sensory function, range, and pain.

2) Motor activity log: MAL

For the MAL, the amount of use (AOU) and quality of movement (QOM) were used to measure the use behavior of paralyzed hands in ADLs.

Data analysis

The Wilcoxon t-test was used to compare outcome data measured at the start and end of each patient's OT: a p value of < 0.05 was considered to indicate statistical significance. To verify the effect of therapy, the effect size was calculated using Glass's Δ [6]. In addition, since there is a bias due to spontaneous recovery in the acute phase, I analyzed the amount of change using the minimal clinically important difference (MCID) [7].

Results

Outcome data measured before and after therapy showed improvement in all patients (Table 2). Upper extremity motor function measured by FMA significantly improved from 28.3 ± 25.8 to 42.5 ± 26.3 (p = 0.01, Δ = 0.55) and sensory function likewise improved significantly from 6.6 ± 5.4 to 9.8 ± 3.3 (p = 0.02, Δ = 0.59). However, the effect size was moderate. Regarding range and pain, all those with a score of 24 or less on the pretest showed improvement. AOU measured by the MAL was significantly improved from 1.4 ± 1.6 to 2.7 ± 2.1 (p = 0.01, Δ = 0.81), and QOM was significantly improved from 1.4 ± 1.5 to 2.6 ± 2.1 (p = 0.01, Δ = 0.80). The effect size also showed a large change in both cases. The functional change of paralyzed upper extremity in ADLs has been recognized to patient-specific changes to the manipulation of tools from holding the objects.

Discussion

In this study, I used the perceptive exploration approach to treat hemiparesis patients with upper extremity movement disorder after acute stroke, and analyzed the therapeutic effect of this approach from the viewpoint of the MCID.

The MCID of FMA after the acute phase has been reported to be 4.25–7.25 [8]. The MCID of the FMA of motor function in this study was 14.2 ± 0.5, and all patients showed changes exceeding the MCID. Regarding sensory function, range, and pain, many subjects scored higher after therapy than before, but there was a ceiling effect, and they did not achieve changes beyond the MCID. In addition, the MCIDs of AOU and QOM in the MAL are reported to be 0.5 and 1.0–1.1, respectively [9, 10]. The MCID of AOU in this study was 1.4 ± 0.4, and that of QOM was 1.2 ± 0.6. These results indicate that the perceptive exploration approach is effective in facilitating the recovery of upper extremity motor function, although spontaneous recovery in the acute phase may also occur, and there may be a ceiling effect of assessment. Nevertheless, the present results suggest that this approach may be effective in facilitating the use behavior of paralyzed hands in patients with a mild to moderate degree of upper extremity paralysis.

However, the patient's age and damaged part / area are predisposing factors that affect the recovery of paralysis, so the sample size should be increased to verify the therapeutic effect, and further research is required in randomized controlled trials.

Table 1 Subject' attributes.

Case		A	B	C	D	E	F	G	H	Mean ± SD
Age (years)		66	76	66	68	66	71	67	78	69.8 ± 4.8
Gender (M/F) (number)		M	F	F	F	F	M	M	F	3 / 5
Dominant hand (R/L) (number)		R	R	R	L	R	R	R	R	7 / 1
Type of stroke (H/I) (number)		I	I	H	H	I	I	I	I	2 / 6
Lesion site		lacunar	lacunar	subcortical	subarachnoid	corona radiata	lacunar	lacunar	medial medullary	
Hemiparetic side (R/L) (number)		R	L	R	R	L	R	R	L	5 / 3
Time post-stroke (days)		1	3	2	7	2	2	2	2	2.6 ± 1.8
Rehabilitation period (days)		14	20	14	49	30	28	28	18	25.1 ± 11.6
FMA (score)	Motor	50	53	60	45	4	0	6	8	28.3 ± 25.8
	Sensory	12	12	12	9	0	0	2	6	6.6 ± 5.4
	Range	18	24	24	22	24	24	24	20	22.5 ± 2.3
	Pain	19	24	24	22	24	24	24	20	22.6 ± 2.1
MAL (score)	AOU	2.60	3.28	3.43	2.00	0.00	0.00	0.00	0.00	1.4 ± 1.6
	QOM	2.50	3.28	3.21	2.25	0.00	0.00	0.00	0.00	1.4 ± 1.5

M: male; F: female; R: right; L: left; H: hemorrhage; I: infarction;
FMA: Fugl-Meyer Assessment; MAL: motor activity log; AOU: amount of use; QOM: quality of movement; SD: standard deviation.

Table 2 Effect of therapies on the main outcome measures.

	FMA (score)												MAL (score)					
	Motor			Sensory			Range			Pain			AOU			QOM		
	Pre	Post	Variation	Pre	Post	Variation	Pre	Post	Variation	Pre	Post	Variation	Pre	Post	Variation	Pre	Post	Variation
A	50	63	13	12	12	0	18	23	5	19	22	3	2.6	4.6	2.0	2.5	4.6	2.1
B	53	66	13	12	12	0	24	24	0	24	24	0	3.3	4.9	1.6	3.3	4.6	1.3
C	60	66	6	12	12	0	12	12	0	12	12	0	3.4	4.9	1.5	3.2	4.9	1.7
D	45	59	14	9	12	3	22	23	1	22	24	2	2.0	3.8	1.8	2.3	3.8	1.5
E	4	14	10	0	4	4	24	24	0	24	24	0	0.0	0.5	0.5	0.0	0.3	0.3
F	0	7	7	0	8	8	24	24	0	24	24	0	0.0	0.3	0.3	0.0	0.3	0.3
G	6	13	7	2	6	4	24	24	0	24	24	0	0.0	0.5	0.5	0.0	0.3	0.3
H	8	52	44	6	12	6	20	22	2	20	24	4	0.0	2.2	2.2	0.0	1.9	1.9
Mean	28.3	42.5	14.2	6.6	9.8	3.2	21.0	22.0	1.0	21.1	22.3	1.2	1.4	2.7	1.4	1.4	2.6	1.2
SD	25.8	26.3	0.5	5.4	3.3	2.1	4.3	4.1	0.2	4.2	4.2	0.0	1.6	2.1	0.4	1.5	2.1	0.6
p-value		0.01			0.02			0.05			1.00			0.01			0.01	
Effect size (Δ)		0.55			0.59			0.23			0.29			0.81			0.80	

FMA: Fugl-Meyer Assessment; MAL: motor activity log; AOU: amount of use; QOM: quality of movement; SD: standard deviation.
Δ: delta is an indicator of effect size. The effect size was considered to be small at values of 0.2–0.5, medium at values of 0.51–0.8, and large at values above 0.8.

Conclusion

The present results suggest that the perceptive exploration approach may be useful to help patients with acute stroke hemiparesis recover from upper extremity movement disorders.

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The author would like to thank the patients for their participation.

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■CASE REPORT

Tau-U Analysis Demonstrated the Effect of the Therapeutic Use of Ultrasound on Shoulder Range of Motion in Flexion: A Case Study

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Abstract:
Introduction: Ultrasound (US) has been used to improve range of motion; however, there is no consensus on its therapeutic effects. This study aimed to explore the therapeutic effects of US in combination with exercise and mobilization on range of motion based on a single-case design.
Methods: The patient was a 40-year-old man who had a fracture of the greater tuberosity of the right humerus and presented with limited shoulder range of motion in flexion postoperatively. In addition to standard treatment (exercise and mobilization), US was performed as an additional intervention. The therapeutic effect of US was examined using Tau-U.
Results: The range of motion of the shoulder flexion significantly increased in the period when standard treatment and US were combined compared to that in the period when only standard treatment was administered ($p < 0.001$). The effect size was high (tau-U = 0.758).
Conclusion: The use of US improved shoulder range of motion during flexion. The Tau-U analysis can be useful to indicate the effect of intervention in a single-case design.

Keywords: ultrasound, Tau-U, single-case experimental design

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1. Introduction

Ultrasound (US) has been used in patients with frozen shoulder and adhesive capsulitis [1]. US provides heat on not only the surface but also the deeper ligaments and joint capsules. Therefore, US is expected to be used in conjunction with exercise therapy to improve joint range of motion (ROM) and reduce pain [1].

However, the efficacy of the therapeutic use of US remains controversial. Desmeules et al. reported that US has no additional effect on ROM when used in combination with physical therapy [2]. Balci et al. also demonstrated that no significant difference in the improvement of ROM was observed compared with placebo US [3]. Therefore, it remains unclear whether US can improve the ROM and reduce pain.

Some rehabilitation studies have used Tau-U analysis to examine whether the improvement in outcome after the intervention can be interpreted as a result of the intervention in a single-case design [4]. The present study aimed to investigate the therapeutic effects of US combined with exercise and mobilization on ROM based on a single-case design.

2. Case

A 40-year-old man presented with a fracture of the

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Fig. 1. X-ray images of the right humerus before (a) and after (b) surgery.

greater tuberosity of the right humerus and had limited ROM in shoulder flexion after surgery. The surgery was performed with osteosynthesis to the greater tuberosity of the right humerus after injured 16 days (Fig. 1). He had worked in the construction industry prior to injury. To return to work, he needs to use electric tools with his affected arm approximately 150° elevated. However, he elevated his arm up to 90° and experienced pain, although he had received standard interventions comprised of stretching for shoulder extensor and adductor muscles and ROM exercises approximately 1 month postoperatively. Therefore, US was performed as additional treatment. The gleno-humeral joint capsule and rotator cuff tendons were targeted.

3. Methods

The standard intervention, namely stretching and ROM exercises of the glenohumeral joint, was administered in five sessions (twice a week for 4 weeks), and US was performed in 10 sessions (twice a week for 8 weeks). US was applied to the anterior–posterior aspects of the affected glenohumeral joint at a dose of 1.5 W/cm^2 with a frequency of 1 MHz for 5 min continuously, based on the previous study [1]. After coating the skin with an aquasonic gel, US was delivered by moving the probe over the anterior and posterior regions of the glenohumeral joint in slow, overlapping strokes.

We defined the last five sessions in which the patient received standard treatment, namely, stretching and ROM exercises of the glenohumeral joint, as the baseline phase (Phase A), and the period from the start of the combination of standard treatment and US to the time when the patient returned to work was defined as Phase B. The primary outcome was ROM in flexion, which is required for returning to work. The end feeling of flexion after treatment was subjectively evaluated as the secondary outcome. Tau-U, which allowed us to identify the effect of the intervention on the outcomes based on a comparison between the baseline and intervention phases, was used to compare Phases A and B [6]. The Tau-U analysis was conducted on a free single-case experimental design-analysis website: https://manolov.shinyapps.io/overlap [7]. Tau-U indicates the effect size, which was defined in the present study based on the study reported by Vannest (2015): < 0.20, small, 0.20–0.60, moderate, 0.60–0.80, large; and > 0.80, very large [8]. As the Tau-U coefficients showed no significant difference in Trend A, the analysis (A vs. B + Trend B) was used [9].

After oral and written explanations of the case were provided, written informed consent for this study was obtained.

4. Results

Figure 2 and Table 1 show the ROM outcomes in the flexion and Tau-U results, respectively. The ROM outcomes in flexion ranged from 90° to 100° during Phase A. However, those during Phase B increased from 100° to maximally 135°. Tau-U analysis indicated that there was no significant trend during Phase A (Tau-U = 0.100, $p > 0.999$), whereas Phase B showed a significant trend with a mild effect size (Tau-U = 0.556, $p = 0.025$). There was a significant difference in the primary outcome of shoulder joint flexion between Phases A and B ($p < 0.001$). In addition, the effect size, Tau-U, was high (Tau-U = 0.758).

As for the secondary outcome, the patient had less pain when he raised his arm after all sessions (Phase B) compared to that in Phase A. After session 15, the patient was able to return to work.

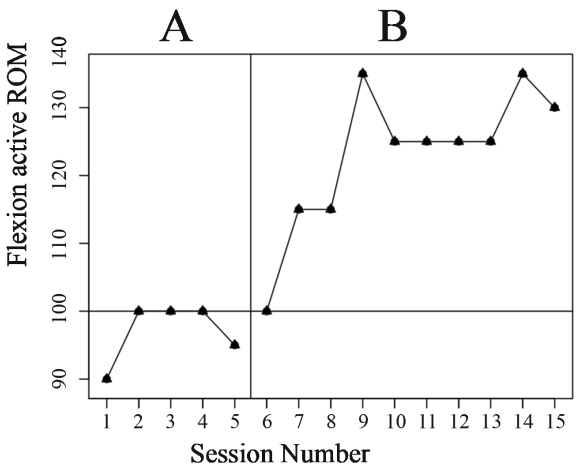

Fig. 2. Treatment results in relation to Phase A and B.
The vertical axis shows the active shoulder flexion angle and the horizontal axis shows the session number. Visual aids computed on a free single-case experimental designs (SCED)-analysis website: https://manolov.shinyapps.io/overlap.

Table 1 Tau-U analysis results.

	Trend A	Trend B	A vs B + Trend B*
Tau-U**	0.1	0.5556	0.7579
p	n.s.	0.0248	$p < 0.01$

n.s. = not significant; $p = p$-value
* Because of Trend A was not significant, we used A vs B + Trend B.
** Tau-U indicates the effect size. "A 0.20 improvement may be considered a small change, 0.20 to 0.60 a moderate change, 0.60 to 0.80 a large change, and above 0.80 a large to very large change, depending on the context" (Vannest, 2015, p.408).

5. Discussion

Tau-U analysis can address problematic trends and can be directly interpreted as an indicator of improvement [6]. Based on the results of our case, no trend was observed in Phase A, in which only standard treatment was administered in the last five sessions. A significant increase in ROM was observed in Phase B, in which standard treatment was performed in combination with US. This suggests that US prompted improvement in shoulder ROM in flexion.

Jellad et al. reported that the range of motion of the shoulder flexion was 140° one month after surgery in the patients with greater tuberosity fracture [5]. Our case was able to elevate 90° of shoulder flexion one month after surgery. This relatively slow improvement in shoulder flexion in our case enhanced us to suspect some limiting factor around gleno-humeral joint such as the potential adhesive capsulitis. Dogru et al. showed that stretching with US is more effective than stretching alone for limited ROM [1]. In this regard, Leung et al. maintained that the combination of deep heating and stretching exercises significantly improves shoulder ROM [10]. These findings also support that the increase in ROM observed in our study was derived from the use of US in combination with exercise therapy.

Some studies have reported that US can reduce pain [1]. Therefore, the increase in ROM in our case could also be explained by the pain relief effect of US.

A limitation of this study was its single-case design. Therefore, the effectiveness of US for ROM cannot be interpreted as a general conclusion. Recent rehabilitation studies have used Tau-U analysis to complement visual analysis [4, 11]. These single-case studies will be helpful in finding validated criteria for interventions that remain controversial. Another limitation is that we were unable to prove which tissue was affected by the US and contribute to the increase in flexion. However, there are facts that the range of motion of the flexion improved during the period when the US intervention around the glenohumeral joint added. Therefore, we assume that the US affect some limiting factor around gleno-humeral joint such as the potential adhesive capsulitis.

In summary, US prompted an improvement in shoulder ROM during flexion. Tau-U analysis can be a useful tool to demonstrate the effect of intervention in a single-case design.

Conflict of Interest

None declared.

Acknowledgements

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■ORIGINAL ARTICLE

Conditions and Situations of Occupation-Based Practice for Patients with Severe Acute Cerebrovascular Accident: A Qualitative Study

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Abstract: Introduction: Occupation-based practice (OBP) is seldom performed for people with severe acute cerebrovascular accidents (CVA). This study aimed to explore the conditions and situations in which occupational therapists (OTs) provide OBP to patients with severe acute CVA.
Methods: Semi-structured interviews with eight OTs were conducted to determine OBP for patients with severe acute CVA. The participants were OTs who had conducted OBP for patients with CVA in an acute care setting. Data were analyzed using inductive analysis. The procedures were: (i) to create verbatim records, (ii) to separate the verbatim records by context and to code while comparing the differences and commonalities of each code, (iii) to create subcategories, and (iv) to create categories by grouping together the subcategories with concepts that have similarities.
Results: The participants (OTs) reported that they have performed OBP for patients with severe acute CVA patients when (1) environments are available to perform occupations, (2) OTs establish good quality teamwork with multidisciplinary professionals, (3) OTs emphasize patient-centered practice, (4) patients express their wishes to do occupations, (5) patients and families are getting to ready to resume occupation, (6) patients' occupations are actionable and meaningful.
Conclusion: The OTs' belief, the supportive environment, the client and family oriented toward occupations, and the identification of actionable and meaningful occupations were critical for the OTs to implement OBP for the severe acute CVA patients. These results could provide OTs with insights for promoting OBP in acute settings, especially working with patients with severe acute CVA.

Keywords: severe, acute cerebrovascular accident, occupation-based practice, qualitative study, interview

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1. Introduction

Fisher [1] recommended that occupation-focused practice (OFP), occupation-based practice (OBP) be undertaken within the occupational therapy process. In Japan, occupational therapy was defined as occupation-focused therapy, guidance, and support [2]. These emphasize the occupational therapists (OTs) do OFP, OBP. Wolf et al. [3] recommended OBP for adults with cerebrovascular accidents (CVA), which is one of the familiar diseases for OTs, to improve their activities of daily living (ADL) in the inpatient or home setting. The American Occupational Therapy Association [4] also recommends OBP for adults with CVA to improve ADL in the home setting (categorized as grade A treatment).

OTs often treat patients with CVA in their acute phase. Patil et al. [5] investigated the use of gardening as a meaningful occupation in the initial rehabilitation of people with CVA. Bungay et al. [6] investigated the perceptions of patients with CVA regarding the impact of participating in a group dance session in an acute care hospital. The main advantages of these practices were as follows: (i) skills training, (ii) source of emotional support, (iii) opportunities for social interaction, and (iv) recalling of past experiences, which gives hope for the future. What these two studies have in common was that they investigated the effects of performing specific occupations such as gardening and dancing. Furthermore,

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regarding the acute CVA setting, there is no research on individualized occupations, which is important in patient-centered occupational therapy, nor is there research that examines other aspects apart from the impact of OBP.

One Australian report [7] found that 58% of OTs assessed more than 75% of their clients with occupation-based assessments, and another Danish report [8] found that only 9% of OTs used a standardized occupation-based assessment. Therefore, although the studies by Patil [5] et al. and Bungay [6] et al. show the need for patients with acute CVA to perform occupations, in fact, the percentage of OBP given to them varies from survey to survey.

Bigelius et al. [9] reported a study in which the Assessment of Motor and Process Skills (AMPS) (an occupation-based assessment) was implemented in Swedish acute patients who were independent in their ADL before their admission and had no cognitive impairment. Thus, this study [9] was an occupation-based assessment for people with mild, acute CVA. Ikeuchi et al. [10] clarified the conditions, situations, and processes of OBPs for patients with acute CVA. They found that an occupation-centered evaluation was smoothly performed when the degree of disability was mild. This finding indicates that that while occupation-centered evaluation was smoothly performed when the degree of disability was mild, little OBP was performed when the degree of disability was severe. However, Ikeuchi et al. [10] also reported that OBP after certain recovery was accepted in severe cases. Thus, to perform OBP for people with severe CVA, it is necessary to understand when OBP should be provided, which remains unclear. This study, therefore, aimed to explore the conditions and situations in which occupational therapists provide OBP to patients with severe acute CVA.

The terms in this study are defined as follows: Occupation [11] refers to daily activities that a person wants to, needs to, or is expected to do. Occupation-based [1] makes use of a person's engagement in occupation as the method of our evaluations and interventions. Conditions and situations refer to patients and families, occupations, environments (include OTs and multi-disciplinary professions) conditions and reactions that affect OBP by OTs. The acute phase was defined as within four weeks of onset, and "severe" was defined as meeting one of the following conditions: (i) Japan Coma Scale with II or III consciousness disturbance; (ii) Brunnstrom recovery stage (Br-stage) with either item below IV and (iii) Japanese version of modified Rankin Scale scoring 4 or 5.

2. Methods

2.1 Study Design

The research design was a qualitative study using interview data using inductive approaches.

2.2 Participants

Convenience sampling was used to recruit participants. We asked to interview OTs who had been interviewed in a previous study [10] and other OTs recommended by them. The requirements for OTs interviewed in the previous study [10] to refer to other OTs were as follows: (i) have done OBP for patients with acute CVA within the past three years, or (ii) have presented in occupational therapy related conferences and articles on OBP for people with acute CVA.

2.3 Data Collection Method

The first author conducted individual and semi-structured interviews using the online tool Zoom and asked questions about the OBPs practiced by the participants of OTs. The interviewer had conducted qualitative research dealing with interview data on several occasions. Before the interview, we confirmed that the participants understood the concept of OBP correctly. In addition, we asked participants from previous studies, so many participants were familiar with the interviewers. However, several participants had never met me before because I asked another participant, who was introduced by participants of the previous study, to be interviewed. An IC recorder was used to document the interviews with the consent of the participants. Referring to the previous study by Ikeuchi et al. [10] mentioned above, the interview items were as follows: (i) basic information about the patient (name of the disease, age, ADL ability, presence of disability, etc.), (ii) details of the OBP, and if necessary, the thoughts of OTs and other multidisciplinary professions, the patient's preferences, and efforts made to provide the OBP (Supplemental material). Interviews were conducted from May to October 2020, once for each participant.

2.4 Analysis Methods

We conducted inductive analysis to perform the analysis. First, we extracted the data on the conditions and situations of OBP from the interview data. The subsequent analysis procedures were (i) to create verbatim records from the records of the interview data, (ii) to separate the verbatim records by context and to code titles indicating contents, (iii) to create them into subcategories while comparing the differences and commonalities of each code, (iv) to create categories by grouping together subcategories with concepts that have

similarities. Interventions for patients were confirmed to meet this study's definition of "occupation-based", and the above process was carried out until the authors agreed with the results of the analysis. Furthermore, three of the four authors had experience in qualitative research.

2.5 Member Checking

We conducted member checking to confirm the reliability of the analysis. Specifically, we emailed final reports include the raw data, codes, subcategories and categories to all participants of OTs and asked them if they agreed with the results when they considered their own experiences with people around them. As a result, all participants e-mailed us back. All of participants were agreeable with final reports. However, a participant stated that he felt uncomfortable although he was agreeable. He stated that the final reports included categories and subcategories that were not specific to patients with severe acute CVA.

2.6 Funding Sources and Research Ethics

In the execution of this research, a grant from the Priority Research Project of the Prefectural University of Hiroshima in the 2020 fiscal year. The study was approved by the Research Ethics Committee of the Prefectural University of Hiroshima (approval number: Issue 20MH007), and written consent was obtained from all participants prior to the interview.

3. Results

3.1 Characteristics of Participants (OTs)

A total of eight participants (OTs), including five males and three females, participated in this study. None of the OTs refused to be interviewed. The median number of years of experiencing an acute CVA domain in OT practice was 5.5 (range, 3–32) years, with four participants having less than five years of experience, two participants having more than five years and less than 10 years of experience, and two participants having more than 10 years of experience (Table 1). The median number of years of experience as an OT was 8.5 years (range, 3–33 years). Each participant was employed at different workplaces.

3.2 Duration of the Interview and Characteristics of Patients

The duration of the interview was an average of 43.5 (range, 30–65) minutes. The 12 patients' information were provided by the participants, and their interview data on the conditions and situations of OBP were included in the analysis. The diagnoses of patients included nine cases of cerebral infarction, two cases of cerebral hemorrhage, and one case of subarachnoid hemorrhage; of all the patients, three were in their 50s, one was in his 60s, five were in their 70s, and three were in their 80s (Table 2). Two patients had Japan Coma Scale-II or higher, six patients had Br-stage III or lower, and 12 patients had a score ≥ 4 on the Japanese version of the modified Rankin Scale at the beginning of OBP. The occupations in OBPs included self-care, housework, music appreciation, and plant cultivation.

Table 1 Characteristics of participants (occupational therapists).

No.	Sex	Years experiencing an acute CVA domain	Years of experience as an occupational therapist
A	Female	8	8
B	Male	11	11
C	Female	3	8
D	Male	3	7
E	Male	32	33
F	Male	3	11
G	Male	3	3
H	Female	9	9
Median		5.5	8.5

3.3 Results of Analysis

Codes, categories, and subcategories were created from the interview data on OBP conditions and situations (Table 3). In the following portions, [ ] indicates categories, and < > indicates subcategories. The six categories created are as follows: [environments where occupations can be done], [multi-disciplinary professionals who establish good quality teamwork with OTs], [OTs who emphasize patient-centered practice are in charge of patients], [patients who express their wishes to do occupations], [patients and families who are getting to ready to resume occupations], and [actionable and meaningful occupations].

(1) [Environments where occupations can be done]

This category was structured by four subcategories with 12 codes. In this category, the environments and rules of the hospital, the tools used by the patients, places where the patients responded well, and the family members who supported the patient's occupation, were included.

<Hospital environments and rules that can provide occupations>

This subcategory included data on physical environments or hospital rules for patients for performing occupations. This meant that the OTs were allowed to bring in their food and use knives at any time. The OTs

Table 2 Characteristics of patients whom participants narrated in the interviews.

No.	Sex	Age	Major diagnosis	JCS	Br-stage	mRS
1	Female	80's	Cerebral infarction	Not applicable	I–II	4
2	Male	60's	Cerebral hemorrhage	Not applicable	Not applicable	5
3	Male	70's	Cerebral infarction, traumatic brain injury	Not applicable	Not applicable	5
4	Female	50's	Cerebral infarction	Not applicable	Not applicable	4
5	Female	70's	Cerebral infarction	Not applicable	II	4
6	Male	70's	Cerebral infarction	Not applicable	II–III	4
7	Female	50's	Subarachnoid hemorrhage	Not applicable	II	4
8	Female	70's	Cerebral infarction	II	I	5
9	Male	50's	Cerebral hemorrhage	III	II	5
10	Female	70's	Cerebral infarction	Not applicable	Not applicable	4
11	Male	80's	Cerebral infarction	Not applicable	IV	4
12	Male	80's	Cerebral infarction	Not applicable	V	4

JCS: Japan Coma scale, Br-stage: Brunnstrom Recovery Stage, mRS: Japanese version of modified Rankin Scale
In the severe definition was defined as meeting one of the following three points: (i) Japan Coma Scale with II or III consciousness disturbance; (ii) Br-stage with either item below IV; (iii) Japanese version of modified Rankin Scale scoring 4 or 5. The "applicable definition of severity" indicates which of the definitions (i) to (iii) was met by each patient.

also had access to a kitchen where patients could cook. Participant A's narrative is described as follows: "*In the hospital where I work, we do not have strict rules about handling knives. We have an environment where if we want to cook, we can do it immediately*."

<Patients can use the tools they used before admission>

This subcategory included the ability to use the tools that the patients had used at home before admission, during acute rehabilitation. The patient's family members brought the patient's tools to the hospital. Participant A's narrative is described as follows: "*I was able to use the same beauty lotion that the patient was using at home during the occupational therapy session, which allowed me to develop specific strategies with the patient.*"

<Places where patients respond well>

This subcategory included some places where the OTs observed good responses from the patients, such as the patient being satisfied or having less assistance with elimination. This was focused on location. Participant C's narrative is described as follows: "*When the patient went to the actual toilet and saw the toilet seat, the patient was able to move more quickly than expected, and with less assistance.*"

<Family members supporting the patients to do occupations>

This subcategory included the patient's families supporting the patients by visiting the hospital, observing the rehabilitation, and praising the patients. Participant A's narrative is described as follows: "*When the patient's grandchild observed the occupational therapy session, the patient with right hemiparesis held a knife with her left hand to cut vegetables. When the patient's grandchild saw her cut vegetables, she praised the patient.*"

(2) [Multi-disciplinary professionals who establish good quality teamwork with OTs]

This category was structured by two subcategories that created six codes. In this category, participants talked about collaborating with trusted multidisciplinary professionals such as nurses, physical therapists, and speech therapists, and also supporting multi-disciplinary professionals who experience difficulties in dealing with patients.

<Cooperative and reliable multi-disciplinary professionals>

This subcategory included multi-disciplinary professionals supportive of OBP and the OTs' trust in those multi-disciplinary professionals. Participant C's narrative is described as follows: "*When I told the nurse that the patient and I had cooked together, the nurse asked the patient what kind of food she had cooked. The nurse talking about the occupations with the patient was beneficial to OBP.*"

<Some medical professionals experience difficulty in responding>

This subcategory referred to the difficulty that some medical professionals experience in responding to patients who could not communicate. Participants showed them the patient's original competence and the improved response elicited by the OBP, which relieved the feeling of difficulty in responding. Participant C's narrative is described as follows: "*There were nurses who were struggling to deal with a patient with delirium who sud-*

Table 3 Conditions and situations of OBP.

Category	Subcategory	Code
Environments where occupations can be done	Hospital environments and rules that can provide occupations	The hospital is permitted to bring food items There is an environment where occupations can be provided quickly There is a kitchen for practice in the hospital Knives can be used whenever OTs want to use it
	Patients can use the tools they used before admission	Patients can use the tools they used at home before admission A patient's daughter brings patients the tools
	Places where patients respond well	There is a place where patients are satisfied The patient responds well to the ward The amount of assistance is less if practice is conducted in the bathroom that the patients normally use
	Family members supporting the patients to do occupations	Grandchildren praise the food made by patients in practice Patients' much-loved grandchild comes to the hospital to visit Grandchildren's visit motivates patients to cook
Multi-disciplinary professionals who establish good quality teamwork with OTs	Cooperative and reliable multi-disciplinary professionals	High awareness of the work that nurses have STs can help in OTs' practices There are PTs that OTs trust Nurses have a conversation with patients about a dish they made
	Some medical professionals experience difficulty in responding	There are multi-disciplinary professionals who cannot communicate well with patients Some multi-disciplinary professionals think that the amount of patient care is too much
OTs who emphasize patient-centered practice are in charge of patients		There are OTs who always take care of occupations There are OTs who emphasize the importance of doing challenges together with patients
Patients who express their wishes to do occupations	Patient has a strong intention to resume occupations	Patients want to enable occupations Patients want to enjoy a hobby again Patients are eager to become better at what they can do Patients prioritize occupations rather than walking The patient frequently mentions cooking
	Patients have good understanding and application	Patients have excellent understanding and application skills Patients voluntarily confirm the content of instruction
	Patients' consent to OTs' explanations and suggestions	Patients tolerate changes in the way they perform occupations Patient agrees with OT's explanation
Patients and families who are getting to ready to resume occupations	Changes in the positive statements and behaviors of patients and families	Improvement in patient's motivation Patient has positive emotions while using the computer Increase the number of times patients use their paralyzed hand Increase in patients' statements about life after hospital discharge Family members become more proactive in talking to OTs
	Improvement in mental and physical function, ability and risk reduction	Early improvements in paralysis are observed Patients can stay safe while drains are inserted Patients can keep doing occupations longer Speech becomes clearer Patients' ability to walk improves
Actionable and meaningful occupations	Actionable occupations that are appropriate for patients	OTs want to increase the number of occupations patients can perform OTs prioritize occupations that the patient has experience in There are a variety of occupations that can be adjusted OTs choose an occupation that patients do not need to be moved for There are some creative options OTs and patients can perform
	Occupations leading to leaving the bed	Intervention with a purpose to get up Thinking about what occupations will help patients to get up

OT: occupational therapist, ST: speech therapist, PT: physical therapist

denly rose. I invited nurses to observe the occupational therapy session and explained the relationship between the patient's desires and behavior to them."

(3) [OTs who emphasize patient-centered practice are in charge of patients]

This category was structured by a subcategory that created two codes. In this category, the participants' own policies as OTs were included. The participants talked about how they always valued collaboration with the patients and their occupations. Participant A's narrative is described as follows: "*I believe it is one of my strengths as an OT that I can try to challenge with a patient the occupations that she has difficulty doing after the onset of CVA.*"

(4) [Patients who express their wishes to do occupations]

This category was structured by three subcategories that created nine codes. In this category, strong intention, comprehension, application, and consent of patients to resume occupations were mentioned.

<Patient has a strong intention to resume occupations>

This subcategory included patients' desires and priorities regarding occupations after experiencing a CVA. Participant D's narrative is described as follows: "*The patient strongly said, 'Because my husband does not do the housework, I have to do the housework, so I want to be able to do the housework that I used to do before I had the stroke.'*"

The participants also perceived that the patients' high frequency regarding specific occupations indicated that they had strong feelings about important occupations. In other words, the participants felt the patients' strong willingness to resume occupations based on their comments. Participant G's narrative is described as follows: "*There were so many conversations about cooking than comments about the right upper limb that is paralyzed.*"

<Patients have good understanding and application>

In some cases, the participants decided to implement OBP based on the patient's ability to understand and apply, and not based on their words. Participants also felt that the confirmation of the patient's spontaneous attitude would encourage them to continue with the OBP. Participant D's narrative is described as follows: "*The patient I was assigned to experienced lightheadedness whenever she was standing or walking. During a shopping activity, she spontaneously took items that were placed in various positions. That is, she explored where they could safely take the goods.*"

<Patients' consent to OTs' explanations and suggestions>

This subcategory included cases in which the participants were able to confirm the patient's intentions after the patient agreed with the OTs' explanations and suggestions. Participant G's narrative is described as follows: "*I was in charge of a patient who was impatient to be discharged from the hospital as soon as possible to take care of her husband. Since the patient still needed assistance in her daily life, I explained to her that she needed to be able to perform her own daily activities first, rather than trying to achieve early discharge, to which she agreed.*"

(5) [Patients and families who are getting to ready to resume occupations]

This category was structured by two subcategories that created ten codes and included: changes in the statements and behaviors of the patients and their families, improvement of the patient's mental and body function, ability, and risk reduction.

<Changes in the positive statements and behaviors of patients and families>

After the start of occupational therapy, the OBP conditions and situations appeared to be due to changes in the patients' and families' positive statements and behaviors. Participant F's narrative about the patients is described as follows: "*I think the reason for starting OBP was that patients gradually started to think about what they would do with their lives after being discharged from the hospital.*"

<Improvement in mental and physical function, ability, and risk reduction>

This subcategory included improvements in the patient's mental and physical functions, ability, and risk reduction, which encouraged the OTs to initiate OBP. Therefore, the improvements in functions and abilities, as well as the reduction in risks, prompted the initiation of OBP. The narrative of Participant B who treated a perioperative patient who was being managed with a drain is described as follows: "*When the risk is still high right after the drain is inserted, I asked the patient for about his favorite computer. After that, he was able to begin to spend time safely even while being managed by drains, so I decided to do computers with him during occupational therapy.*"

(6) [Actionable and meaningful occupations]

This category was structured by the two subcategories that created seven codes. In this category, participants discussed the following types of occupations: Occupations that OTs wanted their patients to do were

feasible and prompted the patients to leave their hospital bed.

<Actionable occupations that are appropriate for patients>

Participants reported that they thought of actionable occupations that their patients should perform. Participant C's narrative is described as follows: "*We decided to begin with the occupations that he had been performing before his admission to the hospital, so we started with practicing toileting.*"

Another participant reported that there were occupations that patients could perform based on their abilities and the environment of the rehabilitation room. Participant D's narrative is described as follows: "*Since the patient's gait was quite unsteady, she initially washed dishes in the kitchen, which did not require her to walk.*"

<Occupations leading to leaving the bed>

Participants reported that some occupations were aimed at getting out of bed and standing up. Participant E's narrative is described as follows: "*This is the story of a patient who could scarcely leave her bed due to headaches after a subarachnoid hemorrhage. I promised her that if she was able to get up and go to the rehabilitation room, we would make her favorite sweet pudding together.*"

4. Discussion

The analysis showed that the conditions and situations for OBP for patients with severe acute CVA appeared to be composed of three elements: (i) environments such as physical environments, multi-disciplinary professionals around the patients, and the OTs, (ii) patients and families, and (iii) occupations.

4.1 Conditions and Situations about Environments Around Patients

Three categories [environments where occupations can be done], [multi-disciplinary professionals who establish good quality teamwork with OTs], [OTs who emphasize patient-centered practice are in charge of patients] included aspects of environments such as the physical environments people around the patients including the patients' families, multi-disciplinary professionals, and the OTs.

Occupational performance [12] is defined by three elements: environments, patients and families, and occupations. In this study, we obtained several narratives about the physical environment and family members, such as the tools available to patients and family members visiting the hospital. This indicates that the ability of a patient to perform occupations is greatly influenced by these environments. Since the participants reported that there were specific environments that the patients found comfortable to do occupations in, it can be assumed that suitable environments for doing occupations would lead to OBP.

Rosbergen et al. [13] explored the perceptions and experiences of the nursing and allied health professionals involved in implementing an enriched environment to enhance the physical, social, and cognitive activities in an acute CVA unit. They reported the need for teamwork, including frequent communication between departments, to provide an enriched environment. In this study, there were narratives about multi-disciplinary professionals who were cooperative in OBP and whom the participants trusted, and the narratives about OTs' support through OBP for multi-disciplinary professionals who were having trouble dealing with the patients who were unable to communicate. Both the studies by Rosbergen et al. [13] and this study indicate that it is essential for OTs to collaborate with multi-disciplinary professionals. As narrated by Participant C: "*There were nurses who were struggling to (...)*." OTs could notice the meaning of patients' needs and behaviors that could not be noticed by other professionals because they performed occupations with patients. Thus, establishing good teamwork with multi-disciplinary professionals can guarantee the patients perform occupations.

The policy of the participants was also important for OBP to be implemented. Schell et al. [14] described as follows: "clients are, of course, an essential component of OT intervention, but OT practitioners are also part of the equation. (…) Occupational therapy is a relational practice; thus, practitioners' characteristics and habits enter into practice." It goes without saying that the OTs' thoughts are reflected in their occupational therapy practice. The participants in this study emphasized the importance of patients' occupations and their collaboration. To implement OBP, OTs need to resolve to support their patients' occupations.

4.2 Conditions and Situations about Patients and Families

There are two categories based on patients' aspects.

First, we describe the category of [patients who express their wishes to do occupations], which indicated that clients should have a strong desire to do occupations and that the client's response should be good or self-initiating. This result is the same as that of a previous study [10]. Occupational therapy aims to enable clients to participate in the occupations they want to do personally, and the things they need to do or are expected to do socially and culturally [15]. In occupa-

tional therapy, OT respects and partners with patients, values their subjective experiences of their participation, and appreciates people's knowledge, hopes, dreams, and autonomy [15]. Therefore, a patient's strong will and good understanding can be powerful factors for patients and OTs to collaborate and promote the patient's participation in occupations. It was shown that OTs should evaluate the patient's intentions and occupations, even if the patient is a person with severe acute CVA and for whom it will be difficult to implement OBP.

Second, we describe the category of [patients and families who are getting to ready to resume occupations]. This does not mean that OBP should be initiated after confirming complete improvement of paralysis or risk reduction, but it suggests that improvement of paralysis or risk reduction may promote the implementation of OBP. This is because we can understand from narrative of Participant B in the same category who was ask his patient about the patient's favorite computer when the risks were still high participant B may have conducted an occupation-focused practice before the initiation of OBP. Occupation-focused [1] is defined as having an occupation as the proximal focus of the evaluation or the proximal intent of the intervention, regardless of whether or not an occupation is performed, which is distinct from OBP. Thus, it may be important to encourage patients and families to recall and talk about important occupations to prevent patients from forgetting their occupations, rather than completely disconnecting occupations from patients when OBP is not performed.

4.3 Conditions and Situations about Occupations

There was one category of [actionable and meaningful occupations] regarding the aspect of occupations.

First, we describe the subcategory <actionable occupations that are appropriate for patients>. This included occupations that were appropriate for the patients' abilities and strategies for the patients to perform occupations. It is suspected that this subcategory was created because patients with severe CVA had become significantly less abled than they were before the onset of the disease. There was also a code in which OTs prioritized occupations in which the patient had experience. Patil et al. [5] emphasized that occupational participation allows patients with acute CVA to consider life in general and remember past occupational identities and occupational preferences. This indicates that performing occupations is related to time. Yoshikawa [16] considered the connection with time to be one of the key elements of meaningful occupations. Therefore, it appears that having meaningful occupations that connect patients to time, such as the past and the future, is an important condition for OBP.

Second, we describe the subcategory <Occupations leading to leaving the bed>. In Japan, CVA is sometimes the second event [17] leading to being bedridden, and in the Japanese guidelines for the management of stroke 2015 [18], positive early sit-to-stand, gait training, self-care training, among others, are recommended as grade A treatment. However, there are quite a few patients who are delayed leaving the bed due to headache or nausea, therefore the OTs need to assist patients to perform activities such as sitting and standing, but also to maintain and improve the patient's motivation by trying to leave the bed for occupation.

4.4 Research Limitations and Future Challenges

The range of years that participants worked with patients experiencing acute CVA was 3–32 years. Therefore, we interviewed OTs with a wide range of experience, although many of the participants were young. The disability and degree of disability of the patients attended to by the participants were diverse. These included patients whose ADL was low at the start of OBP due to dizziness and headaches and who were able to walk at the time of rehabilitation session; patients whose paralysis was severe, but their higher cerebral function was not problematic, and patients whose consciousness was disturbed and motor paralysis were both severe. Therefore, we think that Participant F stated that he felt uncomfortable, although he was agreeable during member checking. This participant dealt with patients who had the most severe loss of consciousness or motor paralysis. We believe that the results of the member-checking were influenced by the fact that the results of the analysis were more applicable to patients with milder conditions than those described by participant F in the interview. Although severe conditions were defined in this study, patients with many types of disabilities and a wide range of disabilities were included in the analysis. For this reason, occupations that are not generally adapted for the severe person, such as housework and plant cultivation, were also listed. In the future, studies restricted to patients with a marked deterioration in both psychosomatic functions and patients with consciousness disorders, are required.

Based on the results of this study, it could be inferred that (1) the occupational therapist's competence in accurately sensing the patient's wishes and changes in recovery and subsequently identifying actionable and meaningful occupations and (2) the physical and human environment in the OTs' workplace have a significant impact on whether OBP is implemented. This indicates that the competence of OTs and the workplace environments might be important factors in enabling the implementation of OBP. All eight participants (OTs) were

employed at different workplaces and met the eligibility criteria for this study. Therefore, we infer that the participants in this study are somewhat competent, although it is not clear how the physical and human environments of the participants' workplaces affect the implementation of the OBP. It might be beneficial to determine the impact of the physical and human environments of their workplaces on the implementation of OBP in the future studies.

5. Conclusion

The conditions and situations of OBP for patients with severe acute CVA included three elements: environments, patients/families, and occupations. The environments included physical environments that are suitable for performing occupations, multi-disciplinary professionals who establish good quality teamwork with OTs, and OTs who emphasized patient-centered practice that was in charge of patients. Patients/families include those who express their wishes to do occupations or are getting to ready to resume occupations. Occupations were those that are actionable and meaningful. If these conditions and situations exist, OBP can be performed even in patients with severe acute CVA. We would like to present these findings to OT occupations in the acute care setting and offer the results of this study to provide a reference for clinical practice.

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■ORIGINAL ARTICLE

Sense of Difficulties Experienced by Japanese Occupational Therapists in Cancer Rehabilitation

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Abstract: Objective: This study aimed to identify the difficulties experienced by occupational therapists during cancer rehabilitation, and explore potential solutions.
Methods: Eighteen occupational therapists with experience in cancer rehabilitation were interviewed, and the interviews were analyzed and synthesized using qualitative research methods.
Results: A total of 206 primary, 60 secondary, and 12 tertiary category themes were identified. These themes were discussed from three perspectives: "Related to the practice of occupational therapy," "Related to occupational therapists themselves," and "The environment surrounding the occupational therapist."
Conclusions: Occupational therapists in Japan have multiple difficulties in cancer rehabilitation because few of them specialize in cancer. Therefore, their sense of difficulties could be reduced by improving their pre and post graduate education as well as for nurses who had similar problems.

Keywords: qualitative study, cancer rehabilitation, sense of difficulties

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Introduction

Cancer has been the leading cause of death in Japan since 1981. However, the mortality rate has been declining annually, and more than half of cancer patients can now be cured. To maintain and improve the quality of life of people living with cancer, Japan is promoting high-quality rehabilitation that improves motor function and prevents a decline in living functions [1].

The third phase of the Japanese National Plan for the Promotion of Cancer Control, which started in 2017, stipulates that cancer rehabilitation should be conducted in outpatient clinics and local medical institutions from the perspectives of recovery, maintenance of functions, and reintegration into society. From the perspective of social reintegration and social cooperation of cancer patients, it has also been indicated that cancer patients should receive high-quality cancer care regardless of where they receive treatment [2]. This means that cancer rehabilitation should be conducted at home and in long-term care facilities. Therefore, occupational therapists who work in cancer hospitals, at home, or in long-term care facilities, are expected to have additional opportunities to be involved in cancer rehabilitation.

Occupational therapists are involved in preventative, convalescent, maintenance, and palliative cancer rehabilitation [3]. The main types of cancers covered are brain tumors, head and neck cancers, lung cancer, breast cancer, and bone and soft tissue tumors. Treatment includes surgery, chemotherapy, radiation therapy, and palliative therapy [4]. Thus, occupational therapists need a great deal of knowledge because of the wide range of cancer stages and treatment methods. In addition, cancer treatment is constantly advancing; therefore, current knowledge is required. However, Miki stated that the system for conducting undergraduate education on cancer is insufficient, and that the effectiveness index of occupational therapy for cancer is not clear [5]. Nishikori also reported that occupational therapists are confused about participating in cancer rehabilitation be-

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Table 1 Interview guide

No.	Questions
1	What sense of difficulties do you have with cancer rehabilitation?
2	What sense of difficulties do you have in setting goals?
3	What sense of difficulties do you have in communicating with cancer patients and their families?
4	What sense of difficulties do you feel in cooperation with doctors, nurses, and other professionals?
5	How do you explain occupational therapy to cancer patients and their families?
6	What sense of difficulties do you have in sharing informed consent, goals and programs of occupational therapy?
7	What sense of difficulties do you feel about your knowledge and skills?
8	What sense of difficulties do you have in working with patients at the end of life?
9	What sense of difficulties do you feel about the environment, system, and regional cooperation?
10	Compared with rehabilitation for other diseases, what difficulties do you feel?
11	Please tell us about the patients with cancer you have had difficulty in dealing with, including the reason why they asked for occupational therapy.
12	Please tell us about any other difficulties you have experienced throughout the whole process.

cause of their lack of knowledge and experience [6]. In addition, during the palliative phase, the psychological burden on occupational therapists is high because they face death more often.

In the field of nursing, there have been many studies on the sense of difficulty in cancer nursing, and it has been reported that many nurses feel a sense of difficulty [7–11]. However, there are no reports on the difficulties experienced by occupational therapists in occupational therapy for cancer. Clarifying the difficulties experienced by occupational therapists when they are involved in cancer rehabilitation is likely to suggest how they can overcome their difficulties, solve problems, and work on rehabilitation tailored to each patient. Additionally, clarification of the core difficulty will contribute to pre- and post-graduate education on cancer rehabilitation, and high-quality cancer rehabilitation practice, which is clearly stated in the national policy.

The objectives of this study were to identify the difficulties experienced by occupational therapists during cancer rehabilitation, and explore potential solutions.

Methods

A qualitative research method was used in this research design. Prior to commencement of the study, human ethics approval was obtained from the ethical review committee of the university to which the first author belonged.

Recruitment of participants

The research plan and request form were sent to all hospitals providing occupational therapy for cancer in Prefecture A. Eighteen occupational therapists who responded to this request were interviewed by the first author. Written consent was obtained from all of them.

Data Collection

Based on the interview guide (Table 1), semi-structured face-to-face individual interviews were conducted with occupational therapists regarding the difficulties they perceived when providing cancer rehabilitation. The interviews were conducted individually. The content of the interview guide was developed with reference to the Difficulties in Cancer Nursing Scale for Nurses developed by Sasahara and Onodera, and with the supervision of an occupational therapist who is an expert in education and qualitative research. Sense of difficulty was defined as a mental burden, such as problems and difficulties in practicing cancer rehabilitation.

In addition to the sense of difficulty, we collected information on the attributes of the participants, such as age, sex, years of clinical experience, type of institution they belonged to, type of work, ward they worked in, number of cancer patients per stage they had been in charge of, and whether they had any training opportunities related to cancer. The interviews were conducted between November 2016 and April 2017.

Data Analysis

Qualitative content analysis was used to analyze the interview content. This method analyzes messages obtained from interviews and questionnaires, and makes valid contextual inferences based on the context by extracting, categorizing, and hierarchizing issues [12].

All interviews were recorded on an integrated circuit (IC) recorder with the consent of the participants, and verbatim transcripts were generated. Subsequently, we coded the concepts of the sense of difficulty that could be read from the verbatim transcripts. Codes were categorized based on their similarities. A higher category was created if there was a relationship between the categories and the categories were organized into a

Table 2 Characteristics of participants

	Age	Gender	Clinical experience	Type of institution	Interview time
A	Early fifties	Female	30 to 35 years	Cancer control center hospital	28 m 14 s
B	Late twenties	Female	5 to 10 years	Cancer control center hospital	23 m 44 s
C	Late thirties	Male	10 to 15 years	Cancer control center hospital	41 m 46 s
D	Late twenties	Female	5 to 10 years	Cancer control center hospital	51 m 19 s
E	Early thirties	Male	10 to 15 years	Cancer control center hospital	41 m 52 s
F	Early thirties	Male	5 to 10 years	Cancer control center hospital	41 m 20 s
G	Early fifties	Male	30 to 35 years	Cancer control center hospital	39 m 34 s
H	Early fifties	Female	30 to 35 years	Cancer control center hospital	51 m 12 s
I	Late forties	Male	20 to 25 years	Cancer control center hospital	48 m 00 s
J	Early forties	Male	15 to 20 years	General hospital	48 m 01 s
K	Late thirties	Female	15 to 20 years	General hospital	58 m 38 s
L	Late thirties	Female	15 to 20 years	General hospital	45 m 06 s
M	Late fifties	Female	25 to 30 years	General hospital	51 m 21 s
N	Late thirties	Female	10 to 15 years	Home rehabilitation station	35 m 51 s
O	Late thirties	Male	10 to 15 years	Home rehabilitation station	38 m 31 s
P	Early forties	Male	10 to 15 years	Home rehabilitation station	44 m 05 s
Q	Early thirties	Female	10 to 15 years	Long-term care facilities	29 m 59 s
R	Late thirties	Female	15 to 20 years	Long-term care facilities	35 m 11 s
	39 ± 9 years (mean ± SD)		16 ± 8 years (mean ± SD)		41 m 52 s

hierarchical structure.

To ensure the validity of the analysis results obtained in this way, they were presented to the research participants and revised until the validity of the content was obtained. In addition, triangulation was conducted under the supervision of two occupational therapists with more than 20 years of experience in research and education in the field of physical disabilities, and one occupational therapist with extensive experience in qualitative research.

Results

The 18 interviewees included 10 women and 8 men, with a mean clinical experience of 16 ± 8 years. The average interview time was 42 minutes and 41 seconds. The detailed attributes of the interviewees and the interview times are listed in Table 2.

In total, 721 codes were obtained. Each code was aggregated into 206 primary categories based on similarities, and the primary categories were further aggregated into 60 secondary categories. Finally, the secondary categories were aggregated into 12 third level categories: “Sense of difficulties related to the occupational therapy program,” “Sense of difficulties related to goal setting,” “Sense of difficulties in dealing with mental health,” “Sense of difficulties in responding to medical conditions,” “Sense of difficulties in communication,” “Sense of difficulties in informed consent,” “Sense of difficulties in the mental health of occupational therapists,” “Sense of difficulties related to knowledge, skills, and experience,” “Sense of difficulties related to family support,” “Sense of difficulties related to home support,” “Sense of difficulties related to the environment,” and “Sense of difficulties with multidisciplinary cooperation” (Table 3).

Sense of difficulties related to the occupational therapy program

This category consisted of three subcategories: Presentation of the unique program and effects of occupational therapy, appropriate decisions on when to administer occupational therapy, and introduction of an appropriate occupational therapy program.

Some of the participants noted, “I felt that it was difficult to separate physical therapy and occupational therapy, or rehabilitation for physical functions was inevitably demanded more and more. Then, I wondered what occupational therapy was all about,” and “I sometimes asked myself if the approach I had taken was really for the benefit of the patients.”

Sense of difficulties related to goal setting

This category consisted of four subcategories: Sharing of goals between patients and families, occupational therapists and health care professionals, matters related to goal planning, sharing of goals between patients and families, and sharing of goals among multiple professions.

One participant said, “I felt that it was difficult to bridge the gap between our motivation and the patients. For example, we wanted the patient to move even

Table 3 Concepts and structures derived from the interview analysis

Tertiary category (number of secondary categories)

Secondary category (number of primary categories)
- Primary category (number of codes)

1. Sense of difficulties related to the occupational therapy program (3)

Presentation of the unique program and effects of occupational therapy (2)
- Presentation of the difference between occupational therapy and physical therapy (4)
- Presentation of the effects of occupational therapy (3)

Appropriate decisions on when to occupational therapy (1)
- Appropriate decisions on when to occupational therapy (4)

Introduction of an appropriate occupational therapy program (6)
- Confusion about whether the program is appropriate (10)
- Reluctance to carry out the program due to the deadly disease (5)
- Thought of whether enough occupational therapy could have provided to patients with little time to left (12)
- Confusion about what I can do as occupational therapist for patients with little time left to live (3)
- Timely execution of the program according to the patient's physical condition (2)
- Devising a program when the patient is aware of functional decline (1)

2. Sense of difficulties related to goal setting (4)

Sharing of goals between patients and families, occupational therapists, and health care professionals (7)
- Inability to talk to patients about realistic, achievable goals (7)
- Inability to determine if goals are appropriate for the patient (1)
- Adjustment when the patient's wishes are too high compared to the medical condition (10)
- Adjustment when the family's wishes are too high compared to the medical condition (5)
- Inability to determine if goals are appropriate for the patient (1)
- Adjustment for there is a disagreement in opinion between patient and occupational therapist (3)
- Adjustment for there is a disagreement in opinion between patient and medical staff other than occupational therapist (2)

Matters related to goal planning (12)
- Difficulties in goal setting for patients with low motivation (2)
- Difficulties in goal setting for patients with unannounced prognosis (1)
- Difficulties in goal setting for patients with no relatives (1)
- Difficulties in setting goals according to life expectancy (6)
- Difficulties in setting goals according to the stage of the disease (1)
- Occupational therapy itself must become a goal (2)
- Difficulties in setting clear goals (11)
- Difficulties in goal setting when patient wishes are unknown (3)
- Lack of clarity about the difference between the goals of physical therapy and occupational therapy (1)
- Difficulties in setting goals when the disease is worsening (5)
- Difficulties in setting high goals (5)
- Difficulties of setting a goal with little time left to live (4)

Sharing of goals between patients and families (2)
- Adjusting for differences between occupational therapy goals and family wishes (1)
- Adjustment when patient and family have different wishes (11)

Sharing of goals among multiple professions (1)
- Adjustment when the goals of other medical professionals are high (1)

3. Sense of difficulties in coping with mental health (2)

Emotional support for patient distress (10)
- Emotional support for depression in patients (3)
- Emotional support for patients with limited life expectancy (6)
- No one to take care of the feelings of patients who have no relatives (2)
- Fear of the word "cancer" itself (2)
- Emotional support for mentally unstable patients (7)
- Emotional support for patient and family anxiety (3)
- Emotional support for patients when they are depressed (4)
- Emotional support for young patients (4)
- Emotional support for patients and their families when they become aware of functional decline (8)
- Emotional support for patients who have been shocked by the announcement of cancer (3)

How to work with patients who are not active in occupational therapy (7)
- How to work with patients who are not motivated (5)
- How to work with patients who have decreased motivation (6)
- How to work with patients who refuse occupational therapy (5)
- How to work with dependent patients (2)
- How to work with patients who are unstable and unmotivated to receive occupational therapy (5)
- How to work with patients who do not find value in occupational therapy (3)
- Emotional support for patients who have lost their purpose in life (4)

4. Sense of difficulties in coping with medical conditions (8)

Accurate judgment of the patient's condition (7)
- Difficulties of occupational therapy according to patients' nutritional status (1)
- Difficulty in determining prognosis (5)
- Drastic changes in medication status at the end of life (1)
- There is a high possibility of sudden deterioration of the disease (6)
- Determining medical conditions when performing occupational therapy on my own (6)
- Gradual worsening of the disease (18)
- Significant change in medical condition (14)

Implementation of programs for worsening of disease conditions (5)
- Program does not proceed as planned due to deteriorating medical condition (5)
- Unable to actively pursue the program due to deteriorating medical condition (5)
- Program contents in case of worsening medical conditions (2)
- Failure to meet patient's expectations due to worsening medical condition (3)
- Pressure ulcer control for terminally ill patients (1)

Coping with inadequate control of pain and numbness (3)
- Coping with inadequate control of pain and numbness when physical pain is high (13)
- Emotional support for patients with severe pain (1)
- Coping with Patients with Severe Numbness (1)

Coping with metastatic bone cancer (6)
- Occupational therapy for patients with bone metastases (2)
- Risk management for patients with bone metastases (3)
- Difficulties in teaching daily life while suffering from wearing a corset in pain (1)

Table 3 Continued.

- Determining possible ADL activities for patients with bone metastases (4)
- Determining the degree of loading for patients with bone metastases (3)
- Rehabilitation for patients with pathological fractures (2)

Difficulties of avoiding the risk of falling while respecting the patient's wishes (1)
- Difficulties of avoiding the risk of falling while respecting the patient's wishes (1)

Difficulties specific to cancer (1)
- Difficulties in coping with the unique characteristics of cancer (1)

Coping with other coexisting diseases, complications, and side effects (5)
- In patients with dementia, it is difficult to determine whether they are feeling unwell or demotivated (1)
- Patient self-management of lymphedema (3)
- Coping with a patient with delirium (1)
- Coping with changes in physical condition due to side effects of medication (3)
- Implementation of occupational therapy for patients with other comorbidities (5)

Coping with patients with little time left to live (1)
- Coping with patients with short life expectancy (8)

5. Sense of difficulties in communication (7)

Wording that considers the feelings of patients and their families (11)
- Coping with family members and patients who express concerns (4)
- Coping with a patient who brings up the topic of death (3)
- Be nervous about hurting the patient with careless words (6)
- Difficulties in talking to patients when they become pessimistic (6)
- Consideration to avoid mentioning the disease (4)
- Difficulties in speaking encouragingly to patients (4)
- Be considerate of the content of conversations so that family members are not discouraged (4)
- Coping with patients who think they will get better even though their condition is worsening (3)
- Consideration for conversation content when the patient's condition worsens (3)
- Coping with patients when they become emotional (1)
- Consideration for the content of the words directed at the patient (11)

Patients have factors that make communication difficult (3)
- Difficulties in guessing the patient's thoughts when the patients do not express their feelings (6)
- Communicating with patients with cognitive decline due to brain tumors or dementia (3)
- Communicating with patients with oral and laryngeal cancer (1)

Communication with uninformed patients (3)
- Difficulties in coping with having to tell family members things that cannot be told to uninformed patients (1)
- Difficulties in coping with uninformed patients when they begin to have doubts about their condition (2)
- Communicate with uninformed patients so that they do not realize their illness (14)

Occupational therapists do not have time to spare (1)
- Lack of time to talk to the patient (2)

Communication with families (3)
- Communicating with family members who have limited visitation (2)
- How to tell the family that the patient is doing well (1)
- Family visiting hours do not coincide with occupational therapist's working hours (2)

Questions from patients and families about their condition and treatment (2)
- Questions from family members about the patient's condition and treatment (3)
- Questions from patients about their condition and treatment (6)

Establishing a relationship with patients (1)
- Not being able to have in-depth conversations with patients until you have a deeper relationship with them (3)

6. Sense of difficulties in informed consent (5)

Informed consent for occupational therapy (2)
- Difficulties in communicating the need for occupational therapy to patients (2)
- Difficulties in communicating the role of occupational therapists (3)

Explanation of the rehabilitation plan to uninformed patients (1)
- Explanation of the rehabilitation plan to uninformed patients (1)

Insufficient explanations regarding the start of rehabilitation by the doctor (1)
- Insufficient explanations regarding the start of rehabilitation by the doctor (1)

Helping patients and their families understand that getting better is not the only rehabilitation (1)
- Helping patients and their families understand that getting better is not the only rehabilitation (2)

Informed consent when the patient does not understand (2)
- Difficulties in obtaining informed consent for patients who refuse occupational therapy for financial reasons (1)
- Difficulties in obtaining informed consent from patients with dementia and few family visits (2)

7. Sense of difficulties in the mental health of occupational therapists (3)

Mental burden on occupational therapists due to increased contact with patients facing death (3)
- Difficulty in changing their minds when working with patients who are dying and those who are not (2)
- Being in contact with patients who are dying (15)
- Mental burden on occupational therapists due to the high number of patients who die (6)

Mental health of occupational therapists (1)
- Mental health of occupational therapists (1)

Helplessness due to the inability of occupational therapy to help or do anything about it (1)
- Helplessness due to the inability of occupational therapy to help or do anything about it (8)

Table 3 Continued.

8. Sense of difficulties related to knowledge, skills, and experience (16)

Overall insufficient knowledge about cancer (6)
- Updating knowledge in response to advances in treatment (2)
- Lack of knowledge about cancer treatment (1)
- Lack of knowledge about cancer as a whole (15)
- Lack of knowledge about cancer risk management (1)
- Anxiety due to lack of knowledge about cancer treatment (3)
- Diverse knowledge for diverse cancers (3)

Lack of knowledge about internal disorders (2)
- Lack of knowledge of internal diseases (2)
- Lack of knowledge about respiratory rehabilitation (1)

Lack of knowledge in postoperative management (2)
- Lack of knowledge about postoperative management (2)
- Lack of knowledge about postoperative risk management (2)

Insufficient experience in cancer rehabilitation (6)
- Even new, inexperienced OTs must be involved (1)
- Differences in experience and knowledge with nurses (1)
- Gap between occupational therapy that I have experienced and occupational therapy for cancer (3)
- Lack of experience in cancer rehabilitation (13)
- Fewer orders for cancer rehabilitation (4)
- Surprising when orders for cancer occupational therapy occurs rarely (1)

Insufficient technical skills of occupational therapists (5)
- Ability to correctly communicate the patient's condition to other professionals (1)
- Lack of technical skills (4)
- Lack of communication skills(2)
- Lack of technical skills to objectively record information in medical records (3)
- All capacities of occupational therapy are needed (1)

Insufficient education in cancer rehabilitation (5)
- Little training in cancer rehabilitation (5)
- Low motivation for learning and lack of knowledge acquisition (1)
- Training is mandatory for reimbursement calculation (2)
- Inadequate pre-graduation education (5)
- Things don't always go according to the manual (5)

Lack of knowledge about edema management (3)
- Lack of knowledge about edema management (1)
- Lack of knowledge about edema (3)
- Lack of knowledge about lymphatic massage (3)

Lack of knowledge about palliative care (1)
- Lack of knowledge about palliative care (1)

Lack of knowledge in physical fitness (1)
- Lack of knowledge in physical fitness (1)

Lack of knowledge in medical equipment (1)
- Lack of knowledge in Medical equipment (1)

Lack of knowledge in biochemistry (1)
- Lack of knowledge in biochemistry (4)

Lack of knowledge in radiotherapy (1)
- Lack of knowledge in radiotherapy (3)

Lack of knowledge in bone metastases (1)
- Lack of knowledge in bone metastases (1)

Lack of knowledge in pain (1)
- Lack of knowledge in pain (1)

Lack of knowledge in drugs (4)
- Lack of knowledge of the side effects of chemotherapy (2)
- Lack of knowledge of the characteristics of pharmacotherapy (1)
- Lack of knowledge in drugs (10)
- Lack of knowledge about anticancer drugs (3)

Lack of psychological support for patients (4)
- Lack of knowledge of psychological support (1)
- Lack of knowledge of spiritual pain (2)
- Understanding of death (3)
- Lack of knowledge about patients' acceptance of disease (1)

9. Sense of difficulties related to family support (4)

Helping family members to understand how to care and understand the disease (3)
- How to communicate the correct method of care to family members (2)
- How to teach elderly parents to learn how to care for their children (1)
- Helping family members understand the disease (1)

Getting cooperation from uncooperative family members (2)
- Coping with a patient with a deteriorating family relationship (2)
- Coping with uncooperative family members (1)

Intervening in strong marital relationships (1)
- Strong marital relationships make it difficult for occupational therapists to get involved

Emotional support for family members (1)
- How to support mentally unstable families (3)

10. Sense of difficulties related to home support (2)

Support for discharge from the hospital (8)
- Early discharge in acute care hospitals (1)
- Disagreement among family members about discharge from home (1)
- Securing an appropriate hospital transfer (4)
- Discharge support for patients living in rented houses (1)
- Determining the appropriate time to leave the hospital (6)
- Support for discharging patients to home with insufficient nursing care capacity (7)
- Support for discharge of patients with limited life expectancy to their homes (1)
- Disagreement between family and medical staff about discharge from home (1)

Support for home and treatment (6)
- Support for those who are not well accepted by the long-term care insurance services (4)
- Patient's home is not suitable for medical treatment (1)
- Home support for patients with lymphedema (1)
- Support for patients who are unable to visit the hospital for family reasons (1)
- Fewer occupational therapists working in the community and insufficient support (3)
- Support for patients who are unable to visit hospitals for financial reasons (1)

Table 3 Continued.

11. Sense of difficulties related to the environment (3)

Physical environmental factors of hospitals and institutions (6)
- In multi-bed rooms, conversations can be overheard by other patients (3)
- Lack of supplies needed for rehabilitation (1)
- Being in the same room with a terminally ill patient and a recovering or maintenance patient (3)
- Secure a place with privacy (2)
- Considerations for when patients do not feel comfortable with each other (1)
- Lack of places to get a change of scenery (2)

Differences in treatment between hospitals and institutions (1)
- Differences in treatment between hospitals and institutions (1)

Human environmental factors (3)
- Lack of rehabilitation staff (2)
- Lack of occupational therapists with extensive experience in cancer rehabilitation (1)
- Determining the best occupational therapist for the patient (2)

12. Sense of difficulties with multidisciplinary cooperation (3)

Collaboration with doctors (8)
- Insufficient understanding of rehabilitation by doctors (7)
- Insufficient understanding of cancer rehabilitation by doctors (1)
- Ambiguity in the purpose of physicians' rehabilitation orders (8)
- Insufficient cooperation among doctors (1)
- Different doctors have different policies (1)
- Discretion to the rehabilitation department after ordering (2)
- Insufficient cooperation with non-primary physicians (2)
- Inadequate exchange of information with the attending physician (9)

Collaboration with multiple professions, including doctors and nurses (7)
- Timely information sharing with other professions (4)
- Difficulties in working with the team (6)
- Difficulty in managing risk due to lack of rapid information management (2)
- Difficulties of working alone as an occupational therapist in collaboration with other professions (2)
- Insufficient understanding of cancer rehabilitation by other professions (4)
- Insufficient recognition of occupational therapy (1)
- Expedited nursing care insurance procedures for patients with short life expectancy (1)

Collaboration with nurses (5)
- Differences in the ease of collaboration among nurses (5)
- Insufficient understanding of cancer rehabilitation by nurses (1)
- Difficulties in working with nurses to achieve goals (2)
- Difficulties in collaboration due to nurses' busy schedules (2)
- Collaborating with visiting nurses in supporting patients with lymphedema (4)

slightly, but the patient did not care." Another participant noted, "I had to start rehabilitation for a patient in a dire situation, and I did not know where to set my goal. I started byfumbling, and I was not able to determine a specific goal."

Sense of difficulties in coping with mental health

This category consists of two subcategories: Emotional support for patient distress, and how to work with patients who are not active in occupational therapy.

It was noted here that, "The patients may have been informed, but they did not accept it even though they knew it. It was like they were in some kind of turmoil wanting to be cured," and "Well, they had been vaguely aware of the fact that their condition was getting worse, and I had some difficulties in terms of how to talk to them."

Sense of difficulties in coping with medical conditions

This category consisted of eight subcategories: Accurate judgment of the patient's condition, implementation of programs for worsening disease conditions, coping with inadequate control of pain and numbness, coping with metastatic bone cancer, difficulties in avoiding the risk of falling while respecting the patient's wishes, difficulties specific to cancer, coping with other coexisting diseases, complications, and side effects, and coping with patients with little time left to live.

According to some participants, "It is difficult to ensure rest and determine what can be done and what should not be done, especially for people who have pathological fractures of the long bones or spine, which can significantly change their ADLs," and "I had a lot of difficulty with this patient's rehabilitation because treatment and pain control were not progressing."

Sense of difficulties in communication

This category consisted of seven subcategories: Wording that considers the feelings of patients and their families, patients who have factors that make communication difficult, communication with uninformed patients, occupational therapists who do not have time to spare, communication with families, questions from patients and families about their condition and treatment, and establishing a relationship with patients.

Some participants said, "I think it is a really subtle nuance, but it is difficult to choose the right words because I think patients sometimes wonder if it is true."

"For example, when patients ask me if they will improve in the future, I can tell some of them that they will improve. However, some patients will gradually get worse in the long run, so I find it difficult in such cases."

Sense of difficulties in informed consent

This category consisted of five subcategories: Informed consent for occupational therapy, explanation of

the rehabilitation plan for uninformed patients, insufficient explanations regarding the start of rehabilitation by the doctor, helping patients and their families understand that getting better is not the only rehabilitation, and informed consent when the patient does not understand.

Participants noted that, "The doctor orders rehabilitation. However, when I actually try to do it, I cannot imagine doing so because the patient is in such a serious situation. There is such a gap," and "I do not think I am doing a good job of communicating the need for rehabilitation."

Sense of difficulties in the mental health of occupational therapists

This category consisted of three subcategories: Mental burden on occupational therapists due to increased contact with patients facing death, the mental health of occupational therapists, and helplessness due to the inability of occupational therapy to help or do anything about it.

According to certain participants, "In rehabilitation, there is a certain amount of time I am in contact with the person. I see them every day for half an hour or one hour. I actually talk to them and am involved with them, so I see they are passing away. Therefore, when that kind of thing happens repeatedly, I feel it is a bit hard." Others noted, "I have been doing rehabilitation for orthopedics and neurosurgery, so I have to slightly change my mind a little bit or slightly prepare myself when I go to rehabilitate terminal cancer patients."

Sense of difficulties related to knowledge, skills, and experience

This category consisted of 16 subcategories: Insufficient knowledge about cancer, lack of knowledge about internal disorders, lack of knowledge about postoperative management, insufficient experience in cancer rehabilitation, insufficient technical skills of occupational therapists, insufficient education in cancer rehabilitation, lack of knowledge about edema management, lack of knowledge about palliative care, lack of knowledge about physical fitness, lack of knowledge about medical equipment, lack of knowledge about biochemistry, lack of knowledge about radiotherapy, lack of knowledge about bone metastases, lack of knowledge about pain, lack of knowledge about drugs, and lack of psychological support for patients.

Some participants said, "First of all, I don't know enough about the different cancers." "I know I need to study, but it's hard to study because this is not my main disease." "When I studied cancer at university, I didn't think that cancer patients would be rehabilitated. I thought it was just a part of internal medicine. Cancer has become a subject of rehabilitation in our society, and I feel that I am late to the scene. I have to keep my antennae as high as possible."

Sense of difficulties related to family support

This category consisted of four subcategories: Helping family members understand how to care for and understand the disease, getting cooperation from uncooperative family members, intervening in strong marital relationships, and emotional support for family members.

It was reported here that, "When a person dies, it is not just the person who dies but the family and the people around them. The range of people involved is quite wide. Therefore, I think it is only cancer that makes the way we relate to and support the bereaved different."

Sense of difficulties related to home support

This category consisted of two subcategories: Support for discharge from the hospital, and support for home and treatment.

According to participants, "Some families reminisce and regret that they did not take their family members to the hospital at that time," and "Some patients were advised to go to a hospice, but it was too far away, so they came to this hospital."

Sense of difficulties related to the environment

This category consists of three subcategories: Physical environmental factors of hospitals and institutions, differences in treatment between hospitals and institutions, and human environmental factors.

Various participants reported that, "As an occupational therapist in the hospital environment, I would like to provide a more personable life for the patient. However, the hospital environment is not really suitable," and "I am always worried about who is going to be in charge of this patient to get the best results."

Sense of difficulties with multidisciplinary cooperation

This category consisted of three subcategories: collaboration with doctors; collaboration with multiple professions, including doctors and nurses; and collaboration with nurses.

Some participants said, "Sometimes rehabilitation is prescribed without any specifics, such as what can we do in this remaining time." "Well, it's difficult to answer because I have not actually seen the patient, but I have received a report and the condition changed. I did not actually see the patient, so it was difficult to answer. I want to respond to the patient's changes, but I cannot say anything because I do not know the patient's current

state. This is a bit of a problem."

Discussion

As described in the previous section, 12 themes emerged regarding the difficulties experienced by Japanese occupational therapists in cancer rehabilitation. These 12 themes can be discussed from three perspectives: those related to the practice of occupational therapy, those related to occupational therapists themselves, and those related to the environment surrounding occupational therapists (Table 3). In addition to these three perspectives, the characteristics of occupational therapists' sense of difficulty compared to the nursing care of cancer patients, for which there are many previous studies, are described below.

Carrying out occupational therapy

The narratives obtained in this study regarding the sense of difficulties related to the occupational therapy program, goal setting, coping with mental health, coping with medical conditions, communication, and informed consent suggest that occupational therapists are trying to provide occupational therapy unique to cancer patients with consideration of the patient's feelings, even while they are concerned about whether they are providing adequate occupational therapy.

Miki et al. reported that the majority of occupational therapists feel anxious and doubtful about their professional involvement [13]. The theme of "sense of difficulties related to the occupational therapy program" obtained in this study is consistent with the professional concerns and doubts that occupational therapists have, as reported by Miki et al.

This difficulty may be related to the fact that occupational therapists in Japan often work with patients during the palliative phase. In Japan, many cancer-based hospitals are acute-phase hospitals, where patients with cerebrovascular and musculoskeletal diseases are often offered occupational therapy to restore function. It has been reported that the aim of rehabilitation at the end of life is to achieve the best possible quality of life [14, 15]. Therefore, occupational therapists involved in cancer rehabilitation should shift their focus to improving the quality of life of patients who are unlikely to regain function.

"Sense of difficulties in setting goals," and "sense of difficulties in coping with the disease state" suggested that the goals desired by patients and their families were higher than their actual abilities, it was difficult to set clear goals, and it was difficult to cope with worsening of the disease and bone metastases. The reason for this is that the pressure to change goals and programs as patients' conditions change, and the number of patient conditions and risks to be managed, may cause a sense of difficulty for occupational therapists. Therefore, occupational therapists must have the ability and knowledge to assess the patient's condition appropriately, and modify the program to suit the situation.

"Sense of difficulties in dealing with mental health issues" suggested that there were difficulties in dealing with the patient's distress, and the patient's psychological problems affected the performance of occupational therapy. This is because occupational therapists try to understand the patient holistically, not only in terms of physical functioning, but also in terms of psychological aspects. Lehmann reported that psychological issues are the most common problems faced by patients during cancer rehabilitation [16]. Therefore, occupational therapists, who spend most of the time one-on-one with the patient, can play an important role in providing psychological support to the patient.

In the "Sense of difficulties in communication" category, although occupational therapists have a will to encourage and provide emotional support to patients and their families, they need to be careful not to mention medical conditions or death, regardless of whether they have been informed. Occupational therapists' difficulties are caused by their environment, such as busy work schedules and family commitments. This may be due to the conflict between occupational therapists' willingness to relieve the patient's anxiety, and the reality of not being able to talk honestly about the patient's condition during the time spent with them. It has also been reported that nurses have a strong sense of difficulty when communicating with patients and their families [7, 8]. Nakazawa et al. reported that the degree of postgraduate education and clinical experience are related to the sense of difficulty [8]. Therefore, experience and professional education in cancer rehabilitation may help reduce the sense of difficulty experienced by occupational therapists. Training in communication skills, such as delivering "bad news," is also important.

In the "Sense of difficulties related to informed consent" category, respondents indicated difficulties when the physician did not provide a sufficient explanation, the patient was not informed of the role and necessity of occupational therapy, and the patient's consent was not obtained. In Yamano's survey of Japanese occupational therapists working in the field of physical and geriatric disabilities, 70% of the respondents noted that the reason for providing occupational therapy without the subject's consent was "because it would benefit the subject" [17]. Grisso stated that a patient's decision-making capacity consists of four elements: the ability to express choices, to understand, to recognize, and to think logically [18].

As some patients are not fully informed about their disease and prognosis and do not understand occupational therapy, it is necessary for physicians and occupational therapists to discuss and explain the disease in advance to patients and their families. Occupational therapists should then promote self-determination, build trust, and facilitate occupational therapy.

Points of view from occupational therapists themselves

"Sense of difficulties in the mental health of occupational therapists" indicated that they had more contact with patients who were dying, and felt unable to help them. Another factor may be that, although empathy for the subject is generated through the time spent in one-to-one contact, the emotional burden of losing the patient is present. Rogers et al. reported that a decreased sense of personal accomplishment and negative self-evaluation influenced burnout in a study among occupational therapists in the United States and Australia [19]. For occupational therapists in Japan, feelings of helplessness and deaths of patients are also considered strong contributors to occupational stress, and it is necessary to take measures to reduce stress, such as setting up a place to share worries.

It was indicated that "Sense of difficulties related to knowledge, skills, and experience" was related to lack of knowledge, experience, skills in cancer rehabilitation, and insufficient education. In Japan's disease-specific rehabilitation system, cancer rehabilitation was institutionalized in 2010. However, cancer rehabilitation was being conducted before it was institutionalized. Despite this, the description of occupational therapy for cancer was not included as a separate chapter in typical Japanese textbooks on physical disabilities until 2016; before that, only a few pages were included. Therefore, even experienced occupational therapists have received little education regarding cancer. In addition, postgraduate education is only a one- to several-day course. Since Rogers et al. reported that the number of years of education is related to motivation [19], it is predicted that enhanced pre- and postgraduate education is likely to reduce the sense of difficulty.

Points of view from occupational therapists' environments

The results indicated that "Sense of difficulties related to family support," "Sense of difficulties related to home support," and "Sense of difficulties related to the environment" were related to difficulties in caring for older adults at home due to aging and nuclear families, problems specific to acute-care hospitals that must shorten the average length of stay, uneven distribution of resources related to home support and palliative care, inadequate financial support, and inadequate recuperation and treatment environments. The third phase of the Japanese National Plan for the promotion of cancer control aims to construct a society in which people can live with dignity and peace of mind [2]. The family is the key person who supports the patient's life at home, and an improved system of support for the family is necessary to achieve this goal.

In the "Sense of difficulties with multidisciplinary cooperation" section, the difficulty of working with doctors, nurses, and other medical professionals was mentioned, which suggests the difficulty of team medicine. In 2010, the Ministry of Health, Labor, and Welfare (MHLW) proposed that to achieve higher quality medical care for patients and their families, it is necessary to change the concept of integration through team medicine, while improving the expertise of individual medical staff [20]. Jünger et al. reported the presence of close communication, team philosophy, good interpersonal relationships, high team commitment, autonomy, and the ability to cope with death as essential elements of multidisciplinary cooperation in palliative care [21]. Compared to other professions, occupational therapists are able to take their time and engage with patients on a one-on-one basis, which enables them to comprehensively understand patients not only physically, but also psychologically and socially, and to share the information obtained with other professionals. In other words, the benefits of occupational therapists' involvement in the treatment of cancer patients should be demonstrated to other professions to increase the possibility of supporting their personal lives. In addition, the involvement of occupational therapists in medical care, nursing care, welfare, and employment support, particularly in basic cancer hospitals, will enable cancer patients to live in communities with dignity.

Characteristics of sense of difficulties experienced by occupational therapists compared to nurses

Sasahara et al. reported that 78 items were identified as difficulties experienced by nurses working in a general ward and caring for terminally ill cancer patients [7]. Although it is difficult to make a simple comparison because the methods and objectives of the studies are not the same, this study also identified a large number of difficulties, suggesting that both occupational therapists and nurses have a great sense of difficulty when dealing with cancer patients.

Nakazawa et al. indicated that the difficulties faced by nurses decreased slightly in 2015 compared with the 2008 survey, and they speculated that this might be due to the increase in the number of workshops on palliative care [8]. In contrast, while post-graduate education on

cancer has also been held for occupational therapists, the duration is only one to several days. In addition, there is often more than one nurse in charge of each patient. Moreover, there is a system of certified nurse specialists in oncology nursing and a system of certified nurses in the fields of palliative care, cancer chemotherapy, cancer pain nursing, breast cancer nursing, and cancer radiotherapy nursing, which are already qualified and have leadership roles in their institutions [22]. In contrast, occupational therapists in Japan often deal with a small number of patients with various cancer types, stages, and treatment methods, and one occupational therapist is usually responsible for one patient. The number of occupational therapists specializing in oncology is still small [23], and there are few people in leadership roles in their institutions, which may contribute to the sense of difficulties faced by occupational therapists. Therefore, we believe that it is crucial to alleviate each of the difficulties identified in this study based on previous nursing and occupational therapy practices in other countries, which will lead to high-quality occupational therapy for cancer.

Limitations

This study is a qualitative analysis of the narratives obtained from 18 occupational therapists in Prefecture A. In the analysis, we tried to draw as many valid inferences as possible, but it was difficult to completely escape the subjectivity of the researcher through this method. In addition, this study design did not allow for the separation of occupational therapy difficulties related to cancer and non-cancer diseases. Therefore, it cannot be denied that the difficulties of occupational therapists obtained in this study may include not only those specific to cancer, but also those that apply to occupational therapy in general, or those applying to other terminal diseases as well.

Conclusions

The results of this study show that Japanese occupational therapists face many difficulties in providing occupational therapy to cancer patients. To alleviate this difficulty, it is crucial to follow the precedent set by nurses and other countries, including the United States, and to train more occupational therapists specializing in cancer, especially through more extensive post-graduate programs. In addition, occupational therapists should contribute as members of the medical team, taking advantage of the fact that they can easily obtain psychosocial and physical information. In this way, collaboration with the community and other professionals will help resolve the sense of difficulties that occupational therapists cannot solve alone.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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