■ORIGINAL ARTICLE

Brake Operation and Palmar Perspiration Reflect Older Adult Drivers' Ability to Predict Hazards: Driving Simulation Research

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Abstract: Objective: Motor accidents caused by older drivers have been increasing and may result from a decline in cognitive functioning and delay in hazard perception. This study examined how brake operation and palmar perspiration indicate hazard predictive ability of older drivers in a driving simulation.
Method: We compared brake operation performance, palmar sweating response, and skin potential reflex responses in healthy older adults (n = 43) and healthy young adults (n = 36) during hazard and hazard prediction scenes in a driving simulator.
Results: In the hazard scene, both groups displayed rapid brake operation and skin potential reflex responses. In the hazard prediction scene, all young adults braked consistent with simulation footage, but 46.5% of older adults failed to brake. Palmar sweating response was greater ($p < 0.01$) in older adults who braked compared to older adults who did not. In those who failed to break, palmar sweating response was lower than the overall average observed in the older adult group, suggesting that non-operating group members lacked a sense of tension.
Conclusion: Cognitive processes of hazard perception and hazard prediction may facilitate the observed increase in palmar sweating response. Brake operation monitoring and palmar sweating response measurement appear to be useful for evaluating hazard perception ability in a driving simulator.

Keywords: simulated driving, older drivers, hazard perception, brake operation, palmar perspiration

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Introduction

In Japan, an increasingly aging population has been accompanied by an increase in automobile accidents. In 2016, drivers aged 75 and older caused 13% of all fatal accidents [1]. Such accidents are associated with age-related cognitive decline [2, 3]; thus, cognitive evaluations are now mandatory to renew the licenses of drivers over 75. According to the National Police Agency, enforcement of this new law resulted in 1,120,000 individuals undergoing cognitive function testing between March and September 2017. Examination resulted in 300,000 aging drivers to be diagnosed with possible dementia; 697 (0.23%) had their licenses suspended or revoked. This implies that it is difficult to determine driving ability via a written cognitive function test administered during license renewal.

Pre-driving (i.e., driving simulation) and practical driving (i.e., road driving) tests can be incorporated into comprehensive evaluations aiming to help disabled individuals resume driving. The Trail Making Test (TMT)— assessing attention, visual search, information processing speed, and executive function—is used for neurophysiological aspects of pre-driving evaluations [4−6] and has been proven effective [7]. The Mini-Men-

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tal State Examination (MMSE) also measures cognitive function; it may be administered when evaluating an older driver. A study using standardized road driving evaluations, neurophysiological examinations, and medical tests to assess Alzheimer's patients found that the MMSE usefully predicted older adults' driving ability [8]. However, others have suggested that cognitive function tests, such as the MMSE, cannot adequately determine the driving ability of older adults with early-stage dementia [9]. Pre-driving evaluations of this nature —even those that include neurophysiological examinations—illustrate that defining one's driving ability is difficult, and costs and accident risks limit the applicability of driving evaluations [10]. Additionally, among older adults, cessation of driving has been associated with a worsening of depressive symptoms [11, 12] and the shrinking of one's social network [13]. Therefore, new research is needed that examines diagnostic methods under which older adults and individuals with cranial trauma may resume or continue driving.

Hazard perception (HP), the process of responding to dangerous conditions with traffic accident potential [14], is a critical ability for safe automobile operation; it is "the ability to read the road and anticipate forthcoming events" [15, 16]. Further, research indicates that HP is related to processes such as "anticipation" and "surprise" [14, 17]. HP paradigms have been used in evaluations wherein several minutes of driving footage are played for participants who must identify hazardous events as they occur [18]. However, these methods do not assess participants' real-time behavior in response to hazards. Consequently, it is imperative that evaluations of automobile driving ability include tests that examine the entire chain of processes from HP to vehicle operation.

The palmar sweating response (PSR) and electrodermal activity (EDA) occur when humans are surprised or perceive hazards. PSR is an indicator of "mental sweating" or "emotional sweating" [19]. It can closely follow emotional changes like tension and surprise [20−22]. The PSR can also be elicited by situations in which one "steels oneself" in response to unfamiliar situations or by higher-order neurological activity, like mental math [21, 22]. It reflects activity of the dermal sympathetic nerves, and while it is subject to modification by the cerebral cortex, the central mechanism is closely related to the limbic system [23, 24]. The amygdala, anterior cingulate gyrus [25], and insula [26] are involved in this response. In contrast, EDA reflects activity of the eccrine sweat glands and can be broadly differentiated into skin potential activity (SPA) and skin conductance activity (SCA) based on the methods used to measure it [27−29]. SPA is often measured via the skin potential reflex (SPR), whereas SCA is measured via galvanic skin response (GSR) or skin conductance response (SCR).

One study measured participants' GSR during driving and found that it reflected their level of emotional tension during driving tasks [30]. Further, research measuring drivers' SCR found a strong correlation ($r = 0.95$) between driving SCR and brake pressure, with SCR occurring 0.2 seconds prior to accelerator release and 1.9 seconds prior to braking [31]. In a study showing video clips of driving, police drivers rapidly identified hazards, and their SCRs were significantly greater than those of novice drivers [20]. Research that involved playing HP video clips to three experimental groups of drivers—training drivers, novice drivers, and experienced drivers —showed that the SCR of experienced drivers was twice that of novice drivers and three times that of training drivers, suggesting that HP is a skill learned through driving experience [32]. The above results indicate that PSR and EDA are experimental measures that can appropriately evaluate drivers' HP ability.

We developed a computer-based driving simulator apparatus [33] to assess drivers' HP abilities. Actual automobile parts were used for the steering wheel, accelerator, and brake pedal, which were connected to a spring-based system to provide appropriate resistance and feedback. Steering wheel, accelerator, and brake pedal responses were measured using a potentiometer connected to a computer via an analog-to-digital (A/D) converter. These responses were recorded alongside the output signals of a perspiration meter (SKINOS SKN-2000) and a skin potentiometer (SKINOS SPN-01; Fig. 1).

Pre-recorded digital driving footage was played on an LCD monitor. Participants were instructed to perform appropriate mock driving operations using the testing apparatus. The footage shown to participants had an approximate field of view of 90° and was a five-minute-long, 1 km course through narrow residential streets. An automatic car was used in the recording. The maximum recorded speed was 40 kph with an average speed of 12 kph. The footage contained scenes requiring participants to predict hazards, such as "jogger approaches from the opposite direction" and sudden hazard scenes, such as "pedestrian runs out from a side street." A green-arrow blinker synced with the footage, indicating the direction participants would need to turn at intersections (Fig. 1-a).

This driving simulator employed only real-world footage to maintain the reality of visually perceived information. However, the steering wheel, accelerator, and brake pedal were not linked to the footage itself. Therefore, even if the brake pedal were to be depressed,

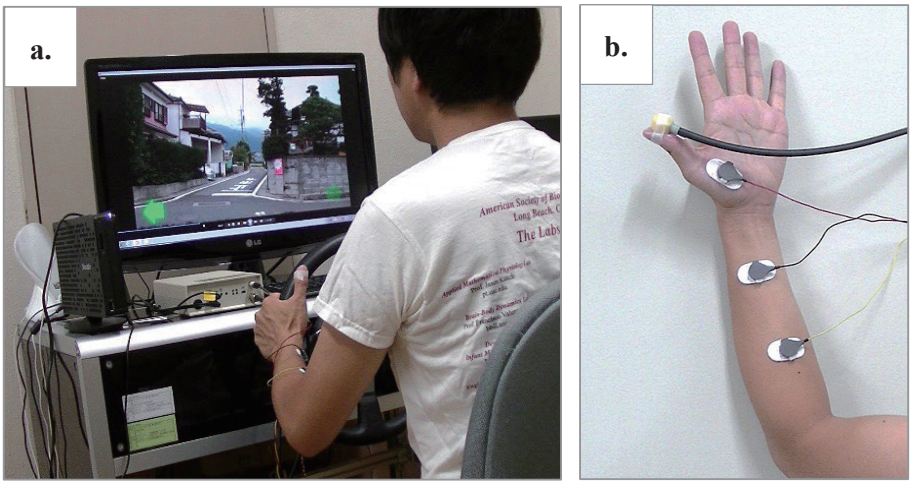

Fig. 1. Driving Simulation Test.
(a) The subject was asked to operate the steering wheel, accelerator, and brake according to the scene displayed on the screen.
(b) PSR was measured by placing a sweating meter probe on the palm of the subject's left thumb. SPR was measured by bipolar induction, in which a skin electrometer electrode was applied to the subject's left forearm and left thumb ball, and a reference electrode was placed between the electrodes.

the car in the footage would not slow. Participants assumed the role of the vehicle's driver and operated the steering wheel, accelerator, and brake consistent with the movements seen on screen. PSR, SPR, and brake operation responses matched to hazard scenes in this type of driving simulation test are largely similar across participants [33]. This study aimed to use a driving simulation test to compare the PSR, SPR, and brake operation performance of older and young adult drivers during hazard and hazard prediction scenes.

Material and Methods

Participants

Older adults above the age of 60 (n = 43; 18 men, 25 women; age range 60−85; M_{age} = 69.8 years, SD = 5.7) and young adults (n = 36; 8 men, 28 women; age range 19−36; M_{age} = 21.3, SD = 2.8) provided written informed consent before participating in this experiment. The older adult group comprised healthy individuals attending health classes in the Matsumoto region. The older adult group had an MMSE of 24 or higher with no observed decline in cognitive function. The older adults drove daily with 10 plus years of experience each. The young adult group comprised primarily college students and all had a driver's license, but their driving experience was within a few years except for one. No one drove daily.

Experimental Design

We defined events in the simulation footage of driving through narrow residential streets as specific types of scenes. The "hazard prediction scene" was where the road narrowed with poor visibility, near a fence and hedge, that required depressing the brake and slowing before making a left turn at a T-junction. The sudden emergence of a pedestrian from a side street to the right while the driver was proceeding straight down an alleyway was termed the "hazard scene". For five seconds from the start of both scenes, we checked for the presence or absence of brake operation and summarized the results in a frequency distribution table. Then we compared the PSRs of the group that activated brakes with the group that did not and examined factors that affected the presence or absence of brake operation. Finally, we compared the latencies of brake operation and SPR responses of the two driver groups during the hazard and hazard prediction scene.

Procedure

The temperature of the experiment was 23−26°C. PSR elicited by the driving simulation test was measured using a sweating meter probe affixed to the palmar side of the participant's left thumb, where the moisture content of 1 cm^2 of skin was measured via the ventilation capsule method. SPR was measured with bipolar leads using a skin potentiometer with electrodes affixed to the participant's left forearm, the ball of the left thumb, and a reference electrode placed in between (Fig. 1-b).

Before the driving simulation test, each participant practiced mock driving in the simulator using footage prepared specifically for practice use. After confirming that the participant could correctly operate the steering wheel, accelerator, and brake pedal, we played the test

footage at a sound pressure of 50−60 dB. The PSR and SPR responses, as well as the analog signals from the steering wheel, accelerator, and brake pedal, were recorded at a sampling frequency of 100 ms after A/D conversion. This research complied with the tenets of the Declaration of Helsinki and was conducted with the approval of the ethics board of the Shinshu University School of Medicine (approval code 2073).

Data Analyses

Brake operation was tracked for five seconds immediately following the appearance of either the hazard or hazard prediction scene on the screen. Participants who successfully operated their brakes were placed in the "operation group" and those who did not were placed in the "non-operation group." For the operation group, the time from the start of the hazard or hazard prediction scene to the appearance of a response waveform was termed brake response latency (Fig. 2-c). PSR volume was evaluated as the mean reaction volume over the five seconds immediately following the beginning of the hazard or hazard prediction scene (Fig. 2-a). SPR response latency was evaluated as the time between the start of the hazard or hazard prediction scene to the appearance of a spike-like negative wave (Fig. 2-b). The data of participants who did not show a clear negative spike in their SPR waveforms were regarded as missing and were excluded from analyses.

We confirmed the independence of the frequency distributions of the operation and non-operation groups using a chi-square test. Intergroup comparison of braking, PSR, and SPR response was evaluated with a student's *t*-test. Multivariate logistic regression analysis with forced entry was used to determine the predictors of brake operation. The Hosmer–Lemeshow test was used to examine the goodness-of-fit of this model, and the significance threshold was set at $p > 0.05$, showing an acceptable fit. All statistical analyses were performed with IBM SPSS Statistics for Windows release 25 (IBM Japan Ltd., Tokyo, Japan). All tests had a significance level of $p < 0.05$.

Results

Response Waveforms Obtained During Driving Simulation Test

Figure 3 shows examples of response waveforms obtained. In scenes with predictable hazards, and scenes where the participant had to suddenly react to avoid hazards, PSR and SPR nearly synchronized responses of steering wheel and brake pedal operation were observed. In stop scenes, during which the brake pedal was continuously depressed, a decrease in PSR and SPR response was seen. SPR also tended to occur a few seconds faster than PSR.

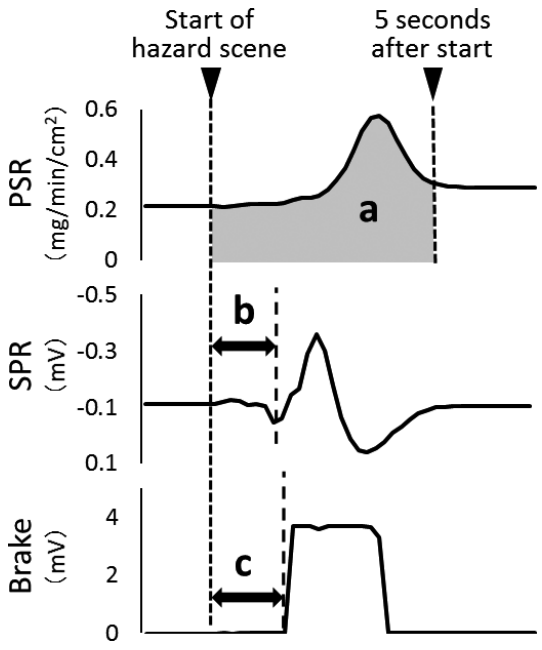

Fig. 2. Measurement Method of PSR Volume, SPR Latency, and Brake Latency.
PSR = palmar sweating response; SPR = skin potential reflex; Brake = brake operation.

Brake Operation and PSR Volume

The presence or absence of brake operation in the hazard and hazard prediction scenes is summarized in Table 1. In the hazard prediction scene, 23 participants from the older adult group were placed in the operation group and 20 in the non-operation group. In contrast, all participants from the young adult group were placed in the operation group. The independence of these frequency distributions was confirmed by a chi-square test ($p < 0.001$). In the hazard scene, all participants operated their brakes.

Table 2 displays the PSR reaction volumes of the older and young adult groups in the hazard and hazard prediction scenes. The following PSR volumes were observed [mg/min/cm^2]—hazard prediction scene: older adults $M = 0.38$ ($SD = 0.26$), young adults $M = 0.20$ ($SD = 0.22$); hazard scene: older adults $M = 0.40$ ($SD = 0.24$), young adults $M = 0.25$ ($SD = 0.28$). In both scenes, the amount of PSR was significantly higher in the older adult group. In the young adult group, the amount of PSR was significantly higher in the hazard scene than in the hazard prediction scene, but the PSR volume of the elderly adult group was not significantly different between the hazard prediction scene and the hazard scene.

We compared the PSR volumes of the operation

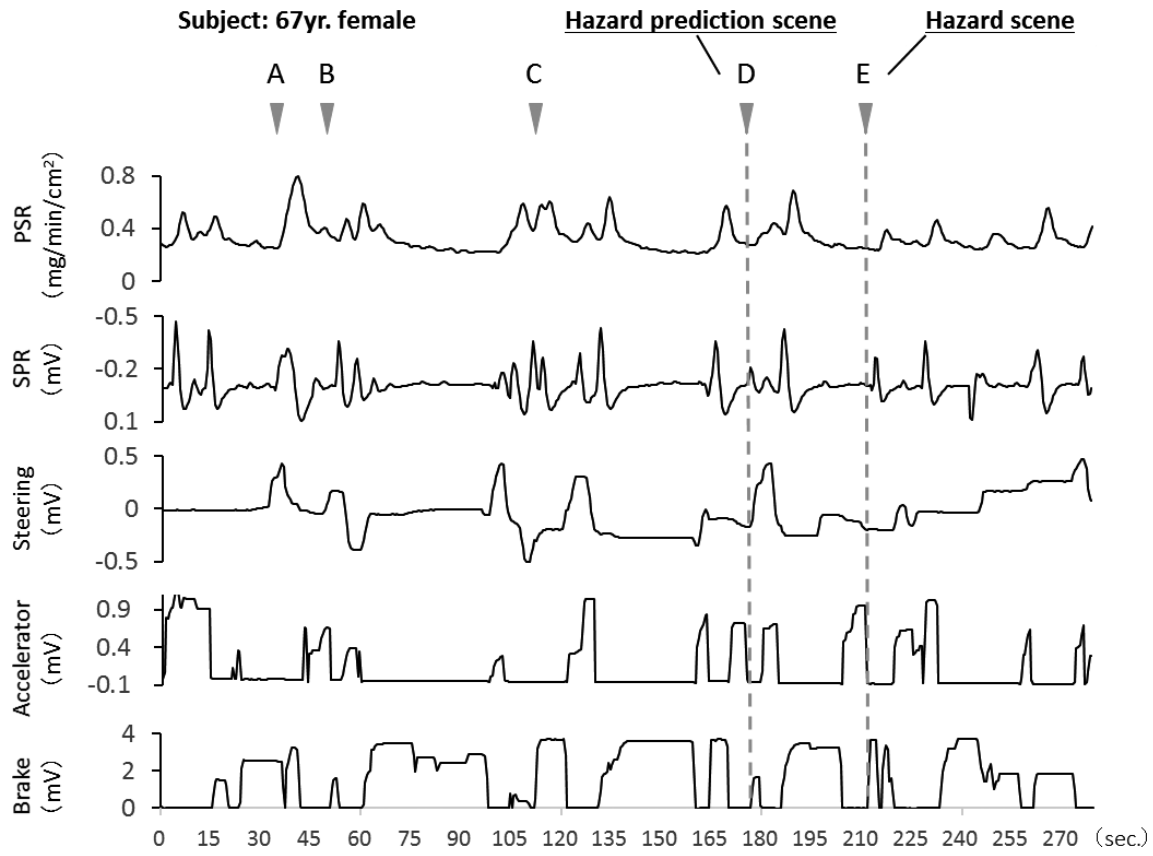

Fig. 3. Changes in PSR, SPR, and Reaction Volume of Steering Wheel, Accelerator, and Brake During Driving Simulation Test.
[A] Jogger approaches from the opposite direction; [B] Vehicle approaches from the opposite direction; [C] Participant's vehicle overtakes a bicycle; [D] Participant's vehicle turns left at T-junction (hazard prediction scene); [E] Pedestrian runs out from a side street (hazard scene).

Table 1 Participant's Brake Operation in Hazard Prediction Scene and Hazard Scene.

	Group	Operation Group *n* (%)	Non-Operation Group *n* (%)	χ^2	*p*
Hazard Prediction Scene	Older Adult *n* = 43	23 (53.5)	20 (46.5)	22.4	0.000*
	Young Adult *n* = 36	36 (100)	0 (0)		
Hazard Scene	Older adult *n* = 43	43 (100)	0 (0)	–	–
	Young adult *n* = 36	36 (100)	0 (0)		

Note. Comparison of Operation Group and Non-Operation Group was conducted using the χ^2 test.
*$p < .01$.

(n = 23) and non-operation (n = 20) subgroups of the older adult group in the hazard prediction scene. PSR volumes (mg/min/cm^2) were operation group M = 0.48 (SD = 0.19); non-operation group M = 0.31 (SD = 0.16). The PSR volume of the operation group was significantly larger (p = 0.004).

Multivariate logistic regression analysis with forced entry was conducted to investigate the factors related to brake operation by the older adults in the hazard prediction scene. Brake operation was used as the dependent variable. The independent variables included age, gender, and PSR. There was a statistically significant

Table 2 Comparison of Palmar Sweating Response Volume of Older and Young Adult Groups.

	Older Adult Group $n = 43$ M (SD)	Young Adult Group $n = 36$ M (SD)	t	p
Hazard prediction scene	0.38 (0.26)	0.20 (0.22)	3.34	0.001**
Hazard scene	0.40 (0.24)	0.25 (0.28)	2.60	0.011*
t	−1.53	−2.14		
p	0.135	0.039*		

Note. Comparison of Older Adult Group and Young Adult Group was conducted using the Student's t test and comparison of Hazard prediction scene and Hazard scene was conducted using the paired t test.
*$p < .05$. **$p < .01$.

Table 3 Multivariate Logistic Regression Analysis for Brake Operation of Older Adult Group in Hazard Prediction Scene.

Variable	OR	95% CI	p
Age	0.93	0.82–1.05	0.247
Gender	0.61	0.12–3.23	0.564
PSR	484.2	2.82–83066.59	0.019*

Note. $N = 43$. PSR = palmar sweating response. OR = Odds ratio. CL = Confidence interval.
*$p < .05$.

association between brake operation and PSR (OR = 484.2, 95% CI [2.82, 83066.6], $p = 0.02$; Table 3).

Brake Response Latency

We compared the brake response latencies of participants who were observed to brake in the hazard and hazard prediction scenes (Table 4). In the hazard prediction scene, brake responses in the older adult group demonstrated a latency of $M = 3.20$ seconds ($SD = 1.51$) and in the young adult group $M = 1.58$ second ($SD = 0.79$); the brake latency of the young group was significantly shorter ($p < 0.001$). Furthermore, in the hazard scene, the older adult group demonstrated a latency of $M = 1.26$ ($SD = 0.57$) and the young adult group $M = 0.83$ ($SD = 0.34$); the brake latency of the young group was significantly shorter ($p < 0.001$). Both the older adult group ($p < 0.001$) and the young adult group ($p < 0.001$) showed shorter brake response latencies in the hazard scene versus the hazard prediction scene.

SPR Response Latency

We compared the SPR response latencies of these participants (Table 4). The SPR response latencies in the hazard prediction scene for the older adult group was $M = 3.22$ seconds ($SD = 2.22$) and the young adult group was $M = 4.49$ seconds ($SD = 2.58$); the SPR response latency of the older adult group was significantly shorter ($p < 0.05$). In the hazard scene, the older adult group had a latency of $M = 2.23$ seconds ($SD = 0.87$) while the young adult group was $M = 1.93$ seconds ($SD = 1.18$). Both the older ($p < 0.001$) and young adults ($p < 0.001$) showed shorter latencies in the hazard scene than in the hazard prediction scene.

Discussion

In the hazard scene, which involved visually identifying a pedestrian running into the path of the vehicle and the sudden movement necessary to avoid this pedestrian, all participants successfully operated their brakes. Their brake and SPR response latencies were significantly shorter than in the hazard prediction scene. These reactions are prompted by different mechanisms than the cognitive processes underlying hazard prediction and may be regarded as automatic responses to HP. However, in the hazard prediction scene, which involved slowing before making a left turn into a narrow alleyway, all young adults operated their brakes consistent with simulation footage, while nearly half (46.5%) of older adults failed to do so.

In the hazard prediction scene, the poor view into the alleyway where the participant was asked to turn necessitated slow, careful driving. We believe that the lack of brake operation in the hazard prediction scene is related to a decrease in predictive ability, possibly the result of overlooking the hazard due to inattentiveness or slowed visual confirmation. It is possible that the older adult group contained participants who did not predict the possibility of a hazard.

While PSR is thought to decline as one ages [34, 35], Table 2 illustrates that the older adult group had higher PSR volumes in both scenes. Increases in PSR magnitude in this group reflect elevated levels of concentration and tension. We also believe that the significant difference in PSR volume between the operation and non-operation groups represents a difference in hazard prediction abilities. The PSR volume of the operation group surpassed the mean value for the older adult

Table 4 Brake and Skin Potential Reflex Response Latencies.

			Older Adult Group *M* (*SD*)	Young Adult Group *M* (*SD*)	*t*	*p*
A	Brake	Hazard Prediction Scene	3.20 (1.51) *n* = 23	1.58 (0.79) *n* = 36	5.39	0.000**
		Hazard Scene	1.26 (0.57) *n* = 43	0.83 (0.34) *n* = 36	3.90	0.000**
		t	7.54	5.25		
		p	0.000**	0.000**		
B	SPR	Hazard Prediction Scene	3.22 (2.22) *n* = 43	4.49 (2.58) *n* = 36	−2.34	0.022*
		Hazard Scene	2.23 (0.87) *n* = 43	1.93 (1.18) *n* = 36	1.31	0.196
		t	2.72	5.40		
		p	0.008**	0.000**		

Notes. Comparison of Older adult group and Young adult group was conducted using the Student's t test and comparison of Hazard prediction scene and Hazard scene was conducted using the paired t test. SPR = Skin potential reflex.
*$p < .05$. **$p < .01$.

group, indicating that the cognitive processes of hazard prediction may have elevated PSR in these individuals. Furthermore, in the non-operation group, the PSR volume was lower than the mean value for the entire older adult group, which suggests the absence of a sense of tension in non-operation participants. The results of the multivariate logistic regression analysis indicated that brake operation in the hazard prediction scene was not related to the age or gender of participants but to the PSR caused by the hazard prediction scene.

In literature where PSR is an index, reports involving videos of a truck coming toward participants showed that PSR and sense of tension vary with the distance between their own car and the truck. Specifically, the closer the truck is to the participant, the higher these values become [36]. Previous research using similar driving simulation tests has reported that while a clear increase in PSR is observed in both hazard and hazard prediction scenes, the timing of brake operation and PSR and/or SPR responses in older adults with impaired cognitive function does not correspond with the average responses seen in healthy older adults [33].

In both scenes, the young adult group operated their brakes significantly quicker (Table 4). Studies on the brake operation practices of older adult drivers showed that they tend to leave their foot on the accelerator longer [37] and tend to delay "switching" the foot from the accelerator to the brake pedal [38]. In addition, it is generally accepted that young adults have better visual search ability and faster cognitive processing than older adults [39]. The rapid brake operation in the young adult group in this study align with these findings, and it suggests age-based differences.

We believe measurement of PSR alongside monitoring of brake operation is useful in evaluating the HP ability of older adult drivers using a driving simulator, particularly when evaluating the presence or absence of hazard prediction ability.

Limitations and Future Research

We could not recruit sufficient participants after controlling for gender ratio. It is possible that the difference in gender and driving experience influenced the driving simulation test outcome. Therefore, future studies should examine the influence of participants' age, sex, and driving experience on driving simulation test performance.

The driving simulator used in this experiment employed footage recorded with a consumer model digital camera and had a limited field of view. Since the simulator steering wheel, accelerator, and brake pedal were not linked to the footage, we could not gather detailed information about the appropriateness of the participants' driving operations. In addition, because standards for PSR, SPR, steering wheel, accelerator, and brake responses have not been predetermined, we would need to collect a large number of samples and establish a range of standard responses to determine which responses would be considered appropriate.

The simulator's capacity to evaluate the HP ability of the driver using biological indicators like PSR and SPR is a one strength though we only used two scenes of footage—one as a hazard prediction scene and the other as a hazard scene. Further research must distinguish which measurements and evaluations are appropriate for

various scene and formulate testing protocols for driving simulations. In addition, it is necessary to examine in detail in the future how much the PSR, SPR and brake responses observed in this driving simulation test reflect the response when actually driving on the road. Further research is needed to clarify the causal relationship between PSR and SPR responses and actual delays and errors in driving.

Conflicts of Interest

The authors declare no conflict of interest.

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■ORIGINAL ARTICLE

Recognition and Intervention of Rehabilitation Professionals Handling the Health Conditions of Syrian Refugees with Disabilities in Jordan

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Abstract: In Jordan, situated to the south of Syria, some 671,919 Syrians are registered as refugees with the UNHCR. Twenty-eight percent of the refugees have some kind of disorder. However, there are no studies regarding the Recognition and Intervention of Rehabilitation Professionals Handling the Health Conditions of Syrian Refugees with Disabilities (Person with Disabilities: PWDs) in Jordan. Therefore, the purpose of this study was to understand the challenges experienced by rehabilitation professionals who were providing rehabilitation services to Syrian refugee with disabilities through semi-structured interviews. The subjects of the study were Fifteen participants. Constant comparative analyses method was performed to assess them. As a result, the recognition and intervention of rehabilitation professionals who work with PWDs in Jordan were categorized under four main themes:【Deterioration of PWDs' health conditions】, 【Lack of rehabilitation programs】, 【Difficulties in continuously providing rehabilitation to PWDs in urban areas】, and【Forthcoming challenges facing rehabilitation programs by community-based organizations】. The study identified that rehabilitation professionals provided outpatient rehabilitation, home-visit rehabilitation and provision orthosis to PWDs. They also recognized the difficulties PWDs faced in accessing health care due to poverty, the spread of disuse syndrome, and the lack of caregivers in PWDs' families. However, the prevention of disuse syndrome, the provision of nursing care methods, and the intervention of Activities of Daily Living (ADL) were not mentioned as future challenges. Therefore, it is essential that rehabilitation professionals conduct prevention of disuse syndrome, provide intervention for ADL.

Keywords: Syrian refugees with disabilities, intervention of rehabilitation professionals, disuse syndrome

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Introduction

The Syrian conflict, which has raged since 2011, has produced 6,100,000 internally displaced people and 5,582,018 refugees who have fled the country, and is said to be the largest humanitarian crisis of this century [1]. Many Syrian refugees have evacuated to the neighboring countries of Jordan, Turkey, Lebanon, Iraq and Egypt. Some 671,919 Syrians are registered as refugees with the UN Refugee Agency (UNHCR) in Jordan, located to the south of Syria. According to a survey by Handicap International, 22 percent of Syrian refugees have some impairment and 6 percent have severe impairment [3]. The UNHCR, international agencies, community-based organizations (CBOs) and the Jordanian government are carrying out support programs for Syrian refugees with disabilities in urban areas. However, in terms of the increase in refugees due to the ongoing conflict in Syria, support for Syrian refugees with disabilities is insufficient [4, 5]. Meanwhile, several studies reported that low social status, poverty, and discrimination influence the health conditions and the social participation of persons with disabilities in developing countries [6, 7].

We have engaged in Grant Aid for Japanese NGO's Projects of Official Development Assistance (ODA) in ministry of foreign affairs of Japan as expert in support

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program for Syrian refugee with disabilities living urban area of Jordan since 2015. The project has been implemented in cooperation and partnership with CBOs approved by the Ministry of Social Development in Jordan.

The Jordanian government has accepted many refugees due to the Syrian conflict, however, recommends that international agencies and CBOs support not only Syrian refugees and but also Jordanians for assistance program [8]. furthermore, there are many reports of problems with employment opportunities and poverty of Syrian refugee in urban area [9, 10]. Meanwhile, due to the prolonged Syrian conflict, there was a shortage of funds for each CBOs handling the health conditions of Syrian refugees with disabilities in Amman. As of 2017, some CBOs have withdrawn their support activities to Syrian refugees with disabilities in urban area. Therefore, there is a tendency to reduce support for Syrian refugee with disabilities in urban area from CBOs in cooperation with ODA. Under these circumstances, it is presumed that Syrian refugees with disabilities in urban area face difficulties on their life.

The authors indicate that Syrian refugees with disabilities exhibited disuse syndrome related to their health conditions, and faced restrictions in terms of social participation through insufficient health literacy, lack of health care services, their vulnerable positions as refugees, and limitations on activities due to their physical disabilities. Therefore, it is essential that rehabilitation professionals support social participation by Syrian refugees with disabilities [11].

However, there is a lack of reports demonstrating support programs for Syrian refugees with disabilities in Jordan. Therefore, we conducted the present study to examine the current state of intervention for Syrian refugees with disabilities in Jordan and the recognition of rehabilitation professionals handling the health of Syrian refugees with disabilities through semi-structured interviews. The purpose of the present study was to clarify the challenges of intervention by rehabilitation professionals, including occupational therapists, on behalf of Syrian refugees with disabilities.

Subjects and Methods

1. Study design

Constant comparative analyses method was used in this study. The method allowed us to obtain comprehensive and diverse data in a short period of time, and allowed us to investigate recognition and intervention of rehabilitation professionals handling the health conditions of Syrian refugee with disabilities in Jordan. Furthermore, there are few CBOs who support Syrian refugees with disabilities in urban area, and rehabilitation professionals who belong to the CBOs. However, very little empirical data are available from previous research related to this study.

Therefore, a qualitative research design was used to clarify challenges through recognition of them in this study.

2. Setting

Amman city is located in the Hashemite Kingdom of Jordan as capital. 196,068 Syrian refugees lived in the city [2]. As of 2017, three CBOs (A, B, C) were providing rehabilitation assistance to Syrian refugees with disabilities in the city. Approximately forty rehabilitation professionals belonged to those CBOs.

3. Participants

The subjects of the study were rehabilitation professionals who had engaged in rehabilitation programs. We requested each CBOs to recruit participant for our research. and then, fifteen participants were chosen randomly for this study from a list of rehabilitation professionals in CBOs. During the recruitment, we excluded rehabilitation professional who do not have a Jordanian work permit or who support rebel. We explained that the study would comprise recorded interviews, followed by analysis of the interview data. We received letters of consent and acceptance from the 15 participants, and conducted study interviews with them.

4. Questionnaire and Interview

This study involved the use of a questionnaire and a recorded semi-structured interview in Arabic. The interview was conducted with each participant individually between April 2016 and August 2017. The questionnaire inquired about the participant's name, sex, age, official position, duration of support for Syrian refugees with disabilities in his/her organization, and length of work experience. The semi-structured interview was conducted with an interview guide.

The interview covered the current situation of Syrian refugees with disabilities ("How are the health conditions of Syrian refugees with disabilities, and in what situations do they face difficulty?"); the details of the participant's support for Syrian refugees with disabilities in urban areas ("What kind of support do you provide for Syrian refugees with disabilities?"); Difficult points of the current support program ("Do you face any difficulties in your program?"); and the recognition of necessary activities for assistance for Syrian refugees with disabilities in the future ("What kind of activities are needed for Syrian refugees with disabilities in urban areas?"). The interviews were recorded by IC recorder

Table 1 Interview guide to rehabilitation professionals of community based organizations.

Topics	Question
1. Current situation of Syrian refugees with disabilities	"How are the health conditions of Syrian refugees in what situations do they face difficulty?"
2. Details of support for Syrian refugees with disabilities	"What kind of support do you provide for Syrian refugees with disabilities?"
3. Difficult points of the current program	"Do you face any difficulties in your program?"
4. Recognition of necessary activities for assistance for Syrian refugees with disabilities in the future	"What kind of activities are needed for Syrian refugees with disabilities in urban areas?"

Table 2 Profile characteristics of participants (April 2016 and August 2017).

No	Professional	Gender	Age	Clinical experience (years)	Support experience (years)	Interview time (min)	Affiliation of CBOs	Contents of Intervention
1	PT	male	forties	22	4	22	A	Outpatient Rehabilitation
2	PT	male	thirties	8	3.4	19	A	Outpatient Rehabilitation
3	PT	female	thirties	7	3.1	30	A	Outpatient Rehabilitation
4	PT	male	thirties	7	2.9	23	A	Home-Visit Rehabilitation
5	PT	male	thirties	8	2.5	26	A	Home-Visit Rehabilitation
6	PT	female	thirties	6	3.1	27	B	Outpatient Rehabilitation
7	PT	male	twenties	4	1.1	21	B	Outpatient Rehabilitation
8	PT	male	twenties	5	3.4	22	B	Outpatient Rehabilitation
9	PT	male	twenties	4	2.1	24	B	Home-Visit Rehabilitation
10	PT	male	twenties	4	1.9	19	C	Outpatient Rehabilitation
11	PT	male	twenties	6	2.2	22	C	Outpatient Rehabilitation
12	PT	female	twenties	4	3.5	27	C	Outpatient Rehabilitation
13	PT	female	twenties	4	2	23	C	Home-Visit Rehabilitation
14	PT	female	twenties	3	2.3	20	C	Home-Visit Rehabilitation
15	OT	female	twenties	3	2.1	19	C	Outpatient Rehabilitation

PT: Physical Therapist OT: Occupational Therapist

(Table 1).

5. Data Analyses

The proceedings of the semi-structured interview were transcribed verbatim, and constant comparative analyses were used to analyze the data. The analyses were conducted by three researchers familiar with the international health field. The researchers listened to the interview data and transcribed the contents. To avoid language bias, we conducted back-translation. The verbatim transcriptions were then coded to identify elements of each participant's comments. The codes were sorted into sub-categories and categories based on the similarities and differences in the responses, and the relevance of each category was analyzed. During the analyses of the qualitative data, specialists (SY, TA and HM) with immense experience in the field of international health including refugee with disabilities issue were discussed to ensure the reliability and validity of this study.

6. Ethical Considerations

The study carried out the research with the approval (Number 757) of the Kobe University Ethical Committee.

Results

1. Characteristics of Participants

There were 15 participants: nine male and six female. The total interview time was 344 minutes. The median interview time per participant was 22.9 minutes. The mean age of the participants was 29.7 ± 3.2 years. Fourteen participants were physical therapists, and one was an occupational therapist. Their duration of clinical experience was 5 ± 4.6 years, and their length of support experience for Syrian refugees with disabilities in community-based organizations was 2.5 ± 0.7 years (Table 2).

Table 3 Recognition and intervention of rehabilitation professionals who work with Syrian refugees with disabilities in Jordan.

Sub-Category [14]	Category [4]
Lack of medical and rehabilitation services for Syrian refugees with disabilities Spread of disuse syndrome Inability to pay for treatment due to poverty Lack of caregivers in families	Deterioration of PWDs' health conditions
Implementation of outpatient rehabilitation Implementation of home-visit rehabilitation Supply of orthosis and assistive products	Lack of rehabilitation programs
Lack of budget for support programs for Syrian refugees with disabilities Lack of transportation for home-visit rehabilitation Lack of knowledge among Syrian refugees with disabilities and their family members about rehabilitation Lack of information about Syrian refugees with disabilities in urban areas	Difficulties in continuously providing rehabilitation to PWDs in urban areas
Development of human resources to work in rehabilitation Acquisition of operation funds Necessity of cooperation with international organizations	Forthcoming challenges facing rehabilitation programs by community-based organizations

2. Current situation of Syrian refugees with disabilities and assistance programs for them

A total of 627 codes relating to the current situation of Syrian refugees with disabilities and assistance programs for them were extracted from the transcriptions. Sub-categories and categories were defined within the codes along with the "Recognition and intervention of rehabilitation professionals who work with Syrians refugees with disabilities in Jordan" (Table 3). Then, the categories, subcategories, codes and personal narratives were described as 【Category】, [Subcategory], and 『*Personal narrative*』, respectively.

The category 【Deterioration of PWDs' health conditions】 comprised four sub-categories: [Lack of medical and rehabilitation services for Syrian refugees with disabilities], [Spread of disuse syndrome], [Inability to afford treatment costs due to poverty], and [Lack of caregivers in families]. One therapist discussed the [Lack of medical and rehabilitation services for Syrian refugees with disabilities] as follows: 『*In some patients, their health condition often became worse, because they didn't receive medical treatment or rehabilitation services in Jordan after evacuating from Syria*』. One therapist discussed [Spread of disuse syndrome] as follows: 『*Many patients suffer from contracture and disuse muscle atrophy, because they don't know about disuse syndrome and are unaware of the need to prevent it…*』. One therapist discussed [Inability to pay for treatment due to poverty] as follows: 『*Almost all refugees with disabilities are poor, as is the case with healthy refugees. So they don't have money to pay for treatment. And if they need to take care of a family member, it is difficult for them to work*』. One therapist discussed [Lack of caregivers in families] as follows: 『*One of my patients has no caregiver, because he evacuated from Syria without his family. Another patient can't visit our rehabilitation center. His family members are working every day, so they can't bring him here (to the rehabilitation center)*』.

The category 【Lack of rehabilitation programs】 comprised three sub-categories: [Implementation of outpatient rehabilitation], [Implementation of home-visit rehabilitation], and [Supply of orthosis and assistive products]. One therapist discussed [Implementation of outpatient rehabilitation] as follows: 『*Our unit supports Syrian refugees with disabilities in an urban area at our rehabilitation center. Once or twice a week, patients visit our center. However, there aren't enough therapists registered because we don't have enough money to pay their wages, so we can't handle many patients. However, we provide rehabilitation services, for example, standing training, walking training and so on*』. One therapist discussed [Implementation of home-visit rehabilitation] as follows: 『*Some patients can't visit our center for rehabilitation, because their impairment is so severe, and it is difficult for their family members to bring them. Therefore, we visit to their house and perform rehabilitation there, for example, a various movement exercises, muscle training, and PNF for dysfunctions on the bed.*』 One therapist discussed [Supply of orthosis and assistive products] as follows: 『*Among the wounded refugees, there are many amputees. They need orthosis and assistive products. So we provide them for some patients. However, lack of funds means we can't provide prosthetics to all person with disabilities.*』

The category 【Difficulties in continuously providing rehabilitation to PWDs in urban areas】 comprised

four sub-categories: [Lack of budget for support programs for Syrian refugees with disabilities], [Lack of transportation for home-visit rehabilitation], [Lack of knowledge among Syrian refugees with disabilities and their family members regarding rehabilitation], and [Lack of information about Syrian refugees with disabilities in urban areas]. One therapist discussed [Lack of budget for support programs for Syrian refugees with disabilities] as follows: 『*As you know, the conflict has been continuing for six years. At the beginning of the conflict, many people were interested in this support. But recently…it's been difficult to secure funds for our programs. So we can't provide enough support for Syrian refugees with disabilities. For example, there aren't enough health professionals, rehabilitation equipment or assistive products*』. One therapist discussed [Lack of transportation for home-visit rehabilitation] as follows: 『*We don't have transportation for home visits. Sometimes we visit to patients' homes at our own expense. And the family of the patient can't afford the transportation cost for visiting the rehabilitation center, so it is difficult for us to continue providing them with rehabilitation*』. One therapist discussed [Lack of knowledge among Syrian refugees with disabilities and their family members regarding rehabilitation] as follows: 『*They don't understand the necessity of rehabilitation. Generally speaking, their doctors often do not give them an adequate explanation of rehabilitation. So sometimes they are reluctant to receive rehabilitation*』. One therapist discussed [Lack of information about Syrian refugees with disabilities in urban areas] as follows: 『*In urban areas, it is difficult to figure out where they live, unlike in refugee camps. Since many families are isolated in the region, it is hard for us to grasp their information*』.

The category【Forthcoming challenges facing rehabilitation programs by community-based organizations】comprised three sub-categories: [Development of human resources to work in rehabilitation], [Acquisition of operation funds], and [Necessity of cooperation with international organizations]. One therapist discussed [Development of human resources to work in rehabilitation] as follows: 『*We must provide rehabilitation for various diseases. There are amputations, spinal cord injuries, peripheral nerve injuries and so on. Therefore, we also want to gain knowledge ourselves, and we must develop more human resources for our program*』. One therapist discussed [Acquisition of operation funds] as follows: 『*Many donors who supported us thus far have already left our program. So, securing funds is a high priority for us*』. One therapist discussed [Necessity of cooperation with international organizations] as follows: 『*Unlike refugee camps, partnerships with international organizations are scarce in urban areas. It is important to cooperate with international organizations, not only for our support in the future*』.

Discussion

The study identified that rehabilitation professionals of community-based organizations (CBO) recognized deterioration in the health conditions of Syrian refugee with disabilities (PWDs: Person with Disabilities) in urban areas. They carried out programs of outpatient rehabilitation and home-visit rehabilitation for Syrian refugees with disabilities to alleviate their dysfunction. Furthermore, they faced difficulties relating to the poverty of PWDs, lack of management funds, lack of information about Syrian refugees with disabilities in urban areas, and lack of health literacy among PWDs and their family members.

In general, refugees face restrictions in terms of social participation (e.g., socio-economic deprivation or lack of access to fundamental human rights) in their new communities [12]. Syrian refugees are also in a vulnerable socio-economic position in Jordan. Therefore, they need various support, basic needs, education, food security, health, shelter, water, sanitation, and hygiene through humanitarian aid [13]. According to a previous study, disasters and conflict can result in increased incidence of impairment and subsequent disability. However, their dysfunction and restriction in terms of social participation prevent PWDs from accessing mainstream humanitarian assistance programs [14].

1. Deterioration of PWDs' health conditions

Regarding the situation of Syrian refugees with disabilities in urban areas, rehabilitation professionals recognized that the deterioration of their health conditions correlated with difficulty accessing health care due to poverty, lack of caregivers, and spread of disuse syndrome. We previously reported that lack of health care and insufficient health literacy may contribute to the deterioration of their health conditions and the high risk of disuse syndrome [11]. Furthermore, previous studies clearly indicate the cycle by which poverty and disability are mutually reinforcing [15]. Therefore, it was estimated that the deterioration of their health conditions was related not only to their dysfunction but also to poverty, lack of caregivers, disuse syndrome, and their vulnerable position in Jordan.

2. Lack of rehabilitation programs

Regarding support programs for Syrian refugees with disabilities by rehabilitation professionals of community-based organizations, most of the rehabilitation

professionals engaging in these support programs were physical therapists. The reason is that a training school for physical therapy and occupational therapy has been established in Jordan; however, there are fewer qualified occupational therapists than physiotherapists, and many occupational therapists go and work abroad after acquiring qualification [16, 17]. In the present intervention by CBO, rehabilitation professionals have provided orthosis, outpatient rehabilitation and home-visit rehabilitation for improvement of dysfunction and transfer motion for Syrian refugees with disabilities in Amman. Those contents have been classified under "rehabilitation" and "assistance devices" in the CBR matrix of the World Health Organization [18]. There are no contents under "medical services," "promotion" and "prevention." The WHO recommends rehabilitation not only for impairment but also for intervention relating to restrictions in activities and participation [19]. However, it was shown that a lot of the current assistances for Syrian refugees with disabilities were interventions intended to improve dysfunction. There was also a lack of intervention in activity limitations including self-care, prevention of disuse syndrome, education for nursing care, and participation restrictions.

3. Difficulties in continuously providing rehabilitation to PWDs in urban areas

Rehabilitation professionals of community-based organizations recognized personnel expenses and movement expenses for visiting rehabilitation due to the lack of funds for management, and lack of information on Syrian refugees with disabilities in urban areas due to the fluid situation of the Syrian conflict as difficult points. Furthermore, rehabilitation professionals identified insufficient access to necessary health care services due to poverty and lack of health literacy among Syrian refugees with disabilities and their family members as problems.

4. Forthcoming challenges facing rehabilitation programs by community-based organizations

According to a report on the economic situation of support for Syrian refugees, a chronic shortage of management funds for support programs for Syrian refugees has been reported [20]. In this way, rehabilitation professionals faced economic difficulty in providing continuous support for Syrian refugees with disabilities. Therefore, rehabilitation professionals recognized that securing management funds, and collaborating with international support organizations were necessary. Persons with disabilities in urban areas presented a variety of diseases, disorders and conditions due to war injuries, congenital disorders and non-communicable diseases [21]. Therefore, rehabilitation professionals regarded the development of human resources for intervention in various diseases as a future challenge. However, they did not recognize the prevention of disuse syndrome, the provision of nursing care methods for family members, or intervention in self-care as future challenges. In general, persons with disabilities are at significant risk of disuse syndrome. It is important that comprehensive health promotion be included in the rehabilitation program [22]. In addition, recently we reported that Syrian refugees with disabilities in urban areas of Jordan have a high risk of disuse syndrome, and disuse syndrome is associated with restrictions on activities and participation [11]. Furthermore, rehabilitation professionals in Jordan tend to focus on approaches to the dysfunction of persons with disabilities [23]. Therefore, those results suggested that intervention in the case of disuse syndrome or restrictions on activities or participation are really needed in support programs for Syrian refugee with disabilities in urban areas of Jordan.

In general, occupational therapy plays an important role in intervention in the case of restrictions on activities including self-care and participation [24]. Effective intervention using occupational therapy have also been reported for disuse syndrome [25]. Therefore, it can be suggested that occupational therapists need to guide preventive measures of disuse syndrome, and intervention in the case of restrictions on activities and participation among PWDs. Our study was limited by the small size of the sample, because there are few rehabilitation professionals undertaking support for Syrian refugees with disabilities living in urban areas. However, this was the first time for a study to be conducted on the current situation of support programs for Syrian refugees with disabilities by rehabilitation professionals in community-based organizations in Jordan.

Limitation

Our study had four major limitations: the sampling bias for participants in a limited area, The small sample size, The limited geographic area, and the lack of statistical analysis. because there are few rehabilitation professionals engaged in support for Syrian refugee with disabilities living urban area in Jordan. However, this study was the first survey to identify current state of intervention for Syrian refugees with disabilities in Jordan and the recognition of rehabilitation professionals handling the health of Syrian refugees with disabilities, and the challenges that they face in providing rehabilitation services. however, in our results, there was only one occupational therapy professional and no nursing or psychologist. Therefore, in occupational therapy point

of view how lack of occupations, routines, habits, crafting, and group-work can promote health and well-being, these knowledges are missing from this rehabilitation professionals. those can evade disuse syndrome. Further research is necessary to explore these issues.

Furthermore, participants in this study were rehabilitation professionals in the capital Amman. Syrian refugee with disabilities also lives in other large cities [2]. In the future, it is necessary to investigate rehabilitation professionals who are engaged in support activities in large cities other than the capital Amman.

As of 2019, The conflict in the Syrian Arab Republic has been ongoing. Furthermore, it is estimated that the situation of Syrian refugee with disabilities in urban areas of Jordan change in the future due to social conditions. Therefore, additional research is needed to confirm the situation of Syrian refugee with disabilities and intervention of rehabilitation professionals handling the health of Syrian refugees with disabilities in Jordan.

Conclusions

Our current study concluded that rehabilitation professionals of community-based organizations in urban areas of Jordan provided outpatient rehabilitation, home-visit rehabilitation and provision orthosis to Syrian refugees with disabilities in urban areas. They also recognized difficulties in access to health care due to the poverty of Syrian refugees with disabilities, the spread of disuse syndrome, and the lack of caregivers in PWDs' families. Furthermore, they faced a lack of funds for their programs, and difficulty grasping information of Syrian refugees with disabilities in their field. Therefore, they regarded securing management funds, collaboration with international support organizations and development of human resources as challenges. However, the prevention of disuse syndrome, the provision of nursing care methods, and intervention in the case of restrictions on activities and participation were not mentioned as future challenges.

It is essential that rehabilitation professionals including occupational therapists engage in preventing disuse syndrome, and provide intervention in the case of restrictions on activities and participation for Syrian refugees with disabilities in urban areas of Jordan. therefore, there is a need to study the disuse syndrome and health status of Syrian refugee with disabilities in urban area. furthermore, it was suggested that rehabilitation professional should consider effective countermeasures for support programs.

Conflicts of Interest

We declare no conflicts of interest.

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■ORIGINAL ARTICLE

Factors Affecting Changes in Social Activities of People with Stroke Living in The Community: Follow-Up 1 to 3 Years after Being Discharged Home

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Abstract: Purpose: This follow- up study by questionnaire aimed to identify factors associated with social activity levels of stroke patients by investigating their activities between 1 and 3 years after discharge.
Materials and Methods: Participants included 191 people with stroke who were living in their home. Their social activity levels at 1 and 3 years post-discharge were investigated using the Frenchay Activities Index (FAI: an index for evaluating social activities such as housework, leisure, and work). Factors associated with inactivity at 3 years post-discharge, and with a decline in activity levels from 1 to 3 years post-discharge were analyzed by logistic regression analysis.
Results: The median FAI was 23 points after 1 year; however, it declined significantly to 19 points after 3 years. Cognitive dysfunction [odds ratio (OR) = 11.61, $p < .001$] and dependency in activities of daily living (ADLs) [OR = 8.46, $p < .001$] were identified as factors associated with inactivity after 3 years. Moreover, dependence in ADLs (OR = 0.10, $p = .027$) was identified as a factor associated with a decline in activity level from 1 to 3 years post-discharge.
Conclusions: Patients with stroke living at home tend to be inactive in the long term; this could be attributed to cognitive dysfunction and ADL dependency. Therefore, occupational therapists need to pay more attention to the social activities of patients with stroke in the community; providing activities tailored to the patient's abilities is vital. Furthermore, interventions are needed to prevent long-term decline in social activities in patients with stroke living at home, who show independence in ADL.

Keywords: stroke, social activity, predictors, long-term outcome, rehabilitation

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Introduction

The incidence of stroke increases with age; while mortality rates have been declining owing to advances in acute treatment, long-term care is required at home owing to persistent paresis and cognitive dysfunction [1]. The number of patients requiring long-term care at home is also rising in proportion to the population age [2]. Therefore, it is essential to identify methods to improve the lives of people with stroke living at home.

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The aging population in developed countries and Japan in particular, has been increasing in recent years. The Ministry of Health, Labor, and Welfare introduced a community-based integrated care system to support the rapidly increasing number of elderly people in provincial regions [3, 4]. The goal of the system is to develop a local framework to provide comprehensive support services enabling elderly people in the community to continue living accustomed lifestyles as far as practicable until the end of life [4]. Moreover, for rehabilitation of elderly people in the community, the system aims to promote "activities" and "participation," as defined by the International Classification of Functioning, Disability, and Health [5]. Support and rehabilitation frameworks must similarly be developed for people with stroke; however, the current status of social activities directly associated with accustomed lifestyles, activities,

and participation, such as housework, leisure, and work remains unclear in people with stroke living in provincial regions of Japan; relevant studies with long-term follow-up are scarce.

Several longitudinal studies of social activities have been conducted in Europe and North America [6–11]. Most evaluated patients from 1 to 3 years after stroke onset; others have identified various factors associated with social activities, including stroke severity, complications, cognitive dysfunction, and activities of daily living (ADLs). On univariate analysis, leg function 1 year after stroke onset was associated with a decline in social activities [9]. However, as social activities are strongly influenced by cultures, results from studies conducted in Europe and North America may not be generalized to Japan, and similar studies should therefore be conducted in this setting.

It is essential to investigate the social activities of patients with stroke, who account for most individuals requiring long-term care in Japan; the Japanese population is aging at unprecedented rates compared to others. This will facilitate rehabilitation with a focus on future support frameworks and on the promotion of activities and participation, especially for those living in local communities. Therefore, we investigated the social activities of people with stroke living at home at 1 and 3 years after hospital discharge, and performed a multivariate analysis to identify related factors and changes in social activity levels at these time points.

Materials and Methods

Participants

This follow-up study included 191 stroke people living at home. They were selected from 338 consecutive stroke patients discharged home between October 2012 and October 2014; all responded to a questionnaire after 1 year. Our hospital is a general hospital in a provincial city, and treats several patients with stroke who are brought in by ambulances and subsequently admitted to a ward in the Department of Neurology or Neurosurgery, where they undergo acute-stage therapy with comprehensive rehabilitation based on full-risk management. Patients without serious complications receive physical and occupational therapies. Physical therapy includes physical exercise and training in basic activities. Occupational therapy involves training for ADL and cognitive function. Patients with aphasia and/or dysphagia receive speech therapy. Approximately 50% of patients are discharged home from the acute ward, and 20% of patients with moderate-to-severe motor-induced paralysis and cognitive impairment are transferred to a rehabilitation ward in the same hospital for long-term rehabilitation. Approximately 80% of patients in the rehabilitation ward are discharged home, and the remaining are transferred to another hospital or a nursing home.

Patients with ischemic or hemorrhagic strokes diagnosed by clinical and radiographic findings were included, while those with serious impairments of consciousness, unstable medical complications, or other diseases that could impede active rehabilitation were excluded from the study.

Assessment

Subjects were followed-up at 1 and 3 years after hospital discharge. Questionnaires were mailed for the subjects to fill out, and were returned by either the patients or their representatives, if they were unable to reply themselves. We sent a postcard three weeks after the questionnaire was sent, that served as both, a thank-you letter and a reminder. Follow-up surveys were conducted, which included assessment of social activities using the Frenchay Activities Index (FAI). Fifteen different items related to social activities were evaluated; each item was scored from 0 to 3 (total score, 0–45 points) [12, 13]. The items were categorized as follows: domestic (preparing meals, washing up, washing clothes, and light or heavy housework), outdoor (local shopping, walking outdoors, driving/train travel, gardening, and house/car maintenance), and leisure/work (social outings, pursuing hobbies, outings/car rides, reading books, and gainful work). Activity levels were classified according to the score as follows: inactive (0–15), moderately active (16–30), and highly active (31–45). A subscale score of 0–5 was defined as inactive, 6–10 as moderately active, and 11–15 as highly active; scores for individual items were classified as inactive (0–1), moderately active (2), and highly active (3). Basic ADLs were assessed using the Barthel Index (BI) [14]. The BI assesses 10 items related to basic ADLs, with a score ranging from 0 to 100 points; subjects with 100 points are classified as being more independent, and those with scores $\leq$ 95 points are classified as having dependence in ADLs. We used self-reported BIs [15, 16]. Mental function was assessed using the Hospital Anxiety and Depression Scale (HADS). The HADS is a self-administered questionnaire with subscales measuring anxiety (HADS-A) and depression (HADS-D). Each subscale includes seven questions; each is scored from 0 to 3 (total score, 0–21 points). Subjects with high scores generally exhibit more severe symptoms of anxiety or depression [17]. A score of $\geq$ 11 points on either scale was considered to indicate the presence of symptoms. We also investigated the cohabitation (living alone or with family) and social service usage (long-term care

insurance) status.

Subject Characteristics

Patient characteristics at hospital discharge were obtained from the medical records of our hospital. We investigated the following parameters: age, sex, stroke type (lacunar, others, or ischemic of non-lacunar and hemorrhagic type), stroke event (first or recurrent), medical complications (hypertension, ischemic heart disease, diabetes mellitus, or atrial fibrillation), Stroke Impairment Assessment Set (SIAS), and Functional Independence Measure (FIM). The SIAS evaluates stroke severity, with a score ranging from 0 to 75. A lower score indicates less severe stroke [18]. Paresis was assessed using the paresis-related items of the SIAS. The maximum scores for the arms and legs were 10 and 15 points, respectively, with a score of ≤ 9 for the arms and ≤ 14 points for the legs indicative of paresis. FIM is one of the most commonly used methods for evaluating function in patients with stroke, and enables functional assessment using the twin perspectives of motor and cognitive functions. The motor FIM score ranges from 0 to 91 points, while the cognitive FIM score ranges from 0 to 35; higher scores indicate better function [19, 20]. The Mini-Mental State Examination (MMSE) is the most widely used assessment tool for cognitive function; however, it is difficult to use with aphasic patients. Therefore, we used the cognitive FIM to assess cognitive function, with a score of ≤ 29 points indicating cognitive dysfunction. The MMSE and cognitive FIM scores were correlated [21].

Statistical Analyses

Kruskal-Wallis and χ^2 tests were used to compare subject characteristics at hospital discharge and at 1 and 3 years post-discharge. These tests were also used to compare the follow-up data of the subjects at home who responded 1 year after discharge, those at home who responded 1 and 3 years after discharge, and those at home who responded 3 years after discharge. Post-hoc analyses were performed using the Dunn's method; the Bonferroni correction was used for multiple comparisons. Proportions of subjects who were inactive according to the FAI at 1 and 3 years post-discharge, were compared using the χ^2 test; the median FAI at 1 and 3 years post-discharge was compared using the Wilcoxon signed-rank test.

To identify factors associated with inactivity according to the FAI at 3 years post-discharge, binomial logistic regression analysis of the FAI was performed at 3 years post-discharge. Binomial logistic regression analysis was conducted to identify factors associated with a decline in the activity level from 1 year to 3 years post-discharge. A decline in the activity level was defined as a decrease from moderate to low or from high to moderate/low levels. Explanatory variables used during analysis included sex, stroke type, stroke event, cognitive impairment (cognitive FIM at discharge), paresis (the paresis-related items of the SIAS at discharge), age at 1 year post-discharge, family dynamics (living alone/other), ADLs (independent/requiring assistance), and depression (yes [HADS-D score of ≥ 11]/no).

For all analyses, statistical significance was set at < 5%. Statistical analyses were conducted using the IBM SPSS Statistics version 25 (IBM Corp., Armonk NY) software package.

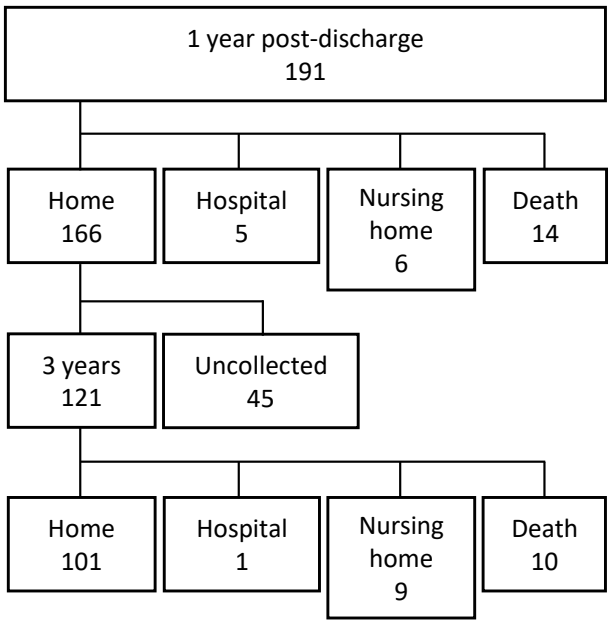

Fig. 1. Flow diagram of the data collection over the course of the study.

Ethics

The appropriate ethics review boards approved this study on October 2, 2012 (approval No. 2122). Written informed consent was obtained from all subjects or their relatives if the patient was unable to provide consent.

Results

Among 191 subjects discharged home, 166 were living at home, 5 had been admitted to the hospital, 6 had entered nursing homes, and 14 died at 1-year post-discharge. Overall, 121 subjects responded to the survey at 3 years post-discharge, of whom 101 were living at home, 1 had been admitted to hospital, 9 had entered nursing homes, and 10 had died (Fig. 1).

A comparison of patient characteristics at discharge

Table 1 Comparison of Characteristics at Discharge between the groups during and at 1 and 3 Years After Discharge.

Characteristics		At discharge (n = 191)	1 year (n = 166)	3 years (n = 101)	*p*
Age		76 (69–84)	74 (68.25–82)	73 (69–81)	.223
Sex	Female	75 (39.3)	65 (39.2)	37 (36.6)	.895
Stroke type	Lacunar	66 (34.6)	58 (34.9)	32 (31.7)	.801
Stroke event	First	139 (72.8)	122 (75.8)	83 (82.2)	.202
Medical complication	Hypertension	94 (49.2)	80 (48.2)	52 (51.5)	.872
	Ischemic heart disease	14 (7.3)	9 (5.4)	2 (2.0)	.160
	Diabetes mellitus	25 (13.1)	21 (12.7)	12 (11.9)	.957
	Atrial fibrillation	15 (7.9)	12 (7.2)	9 (8.9)	.885
SIAS		72 (62–75)	73 (65.25–75)	73 (70–75)	.073
Motor paresis	U/E	74 (38.7)	57 (34.3)	26 (25.7)	.081
	L/E	80 (41.9)	64 (38.6)	33 (32.7)	.274
FIM	Total	105 (79–118)	108 (88.75–118)	112.5 (101–121)	.024*
	Motor	75 (56–85)	77 (61–87)	79.5 (69–87)	.034*
	Cognitive	31 (23–35)	32 (25–35)	33 (28–35)	.016*
Cognitive dysfunction	Cognitive FIM < 30	81 (42.6)	60 (36.4)	27 (27.0)	.032*

* $p < 0.05$. Values are presented as median (Q1–Q3) for continuous data and n (%) for nominal data.
SIAS: Stroke Impairment Assessment Set; FIM: Functional Independence Measure; U/E: upper extremity; L/E: lower extremity.

Table 2 Comparison of Follow-up Assessment at 1 and 3 Years.

		1 year (n = 166)	1 year[a] (n = 101)	3 years (n = 101)	*p*
Cohabitation status	Alone	13 (7.8)	5 (5.0)	8 (7.9)	.622
Social service	Use	72 (43.4)	35 (34.7)	38 (37.6)	.336
HADS					
Anxiety score		6 (3–8)	5 (2–8)	4 (2–7)	.146
Anxiety symptoms	HADS-A ≥ 11	25 (15.1)	8 (7.9)	9 (8.9)	.312
Depression score		7 (4–11)	6 (3–9)	6 (4–9)	.119
Depression symptoms	HADS-D ≥ 11	45 (27.1)	15 (14.9)	18 (17.8)	.042
BI		90 (65–100)	100 (80–100)	100 (80–100)	.113
ADL Dependence	BI < 95	84 (50.6)	41 (40.6)	40 (39.6)	.159
FAI	Total	16 (3–29)	23 (5–33)	19 (4–31)	.149

Values are presented as median (Q1–Q3) for continuous data and n (%) for nominal data.
HADS: Hospital Anxiety and Depression Scale; BI: Barthel Index; FAI: Frenchay Activities Index.
[a] Patients who responded both at 1 year and 3 years post-discharge.

with those of respondents living at home at 1 and 3 years post-discharge revealed significant differences in FIM (total, motor, and cognitive) scores and cognitive dysfunction; post-hoc analysis revealed significant differences between subjects at discharge and those who responded at 3 years post-discharge (Table 1). A comparison of follow-up assessments of respondents living at home 1 and 3 years post-discharge showed a significant difference in the incidence of symptoms of depression. Post-hoc analysis also revealed a significant difference between respondents living at home at 1-year post-discharge and those living at home 3 years post-discharge (Table 2).

Figure 2 shows the proportions of patients living at home at 1 and 3 years post-discharge, who were inactive according to the FAI. Activities in which a low proportion of patients were classified as inactive were outings/car rides (1 year and 3 years, 34.0% and 38.8%, respectively), walking outdoors (41.2% and 43.9%), and local shopping (47.4% and 49.0%). Conversely, activities in which a high proportion of patients were classified as inactive included driving/train travel (80.4% and 84.7%) and gainful work (84.5% and 85.7%). A comparison of the proportions of patients who were classified as inactive in each activity at 1 and 3 years post-discharge did not yield any significant differences. However, a comparison of the median values at 1 and 3 years post-discharge revealed significant decreases in total score after 3 years (23 vs. 19, $p = .005$), leisure/work (5 vs. 4, $p = .006$), and reading books (2 vs. 1, $p = .024$).

Table 3 shows the results of the binomial logistic analysis of factors associated with inactivity according to the FAI 3 years post-discharge using patient char-

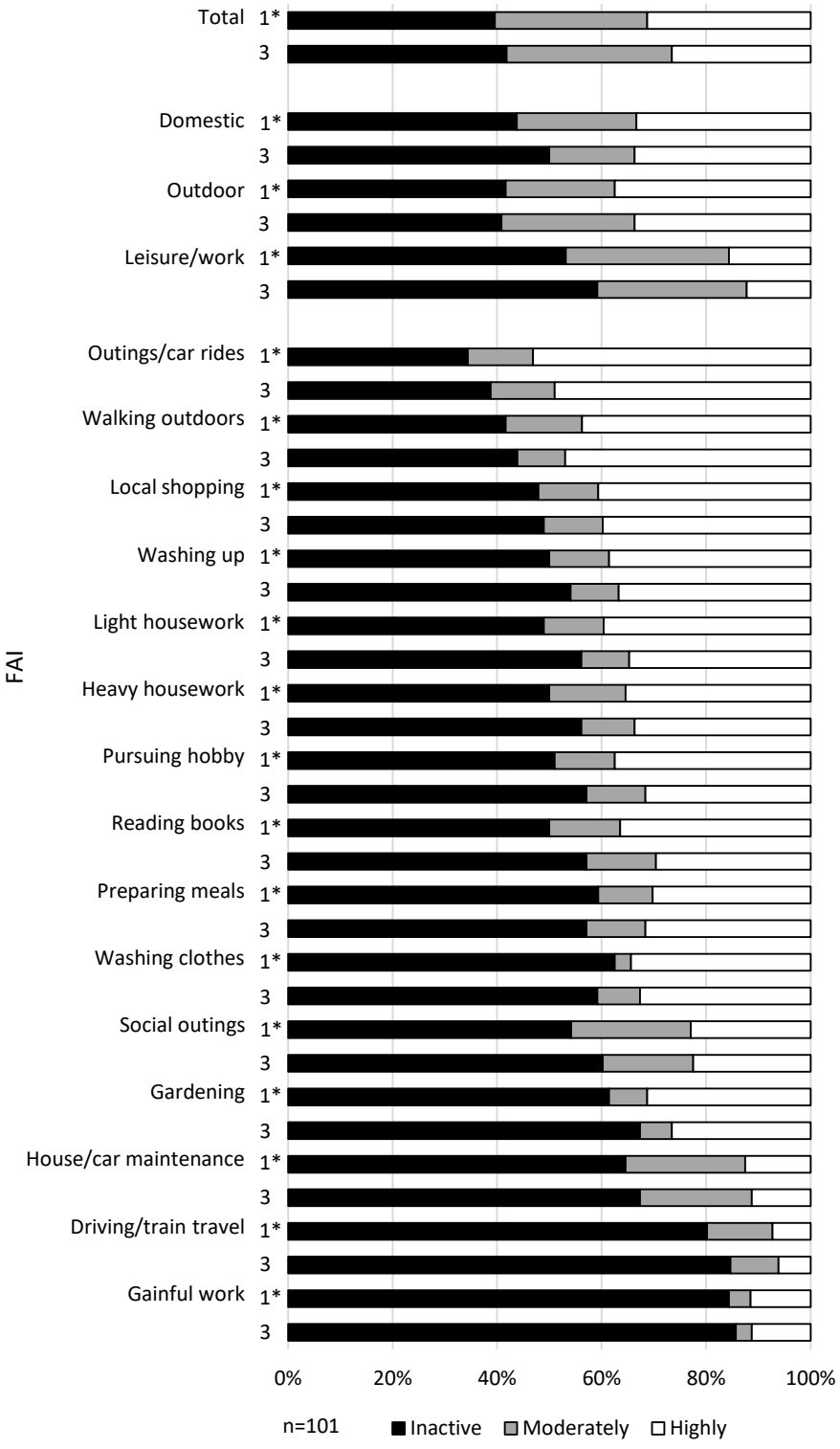

Fig. 2. Proportions of activity levels for each FAI item 1 and 3 years post-discharge.
1*, patients at home who responded at 1 and 3 years after discharge; 3, all patients who responded at 3 years post-discharge.

acteristics and survey results 1 year post-discharge as explanatory variables. Cognitive dysfunction [odds ratio (OR) = 11.61, 95% confidence interval (CI) 3.13–43.09, $p < .001$] and dependence in ADLs (OR = 8.46, 95% CI 2.86–25.00, $p < .001$) were identified as factors associated with the total score. Male sex (OR = 8.48, 95% CI 2.41–29.41, $p = .001$), cognitive dysfunction (OR = 7.70, 95% CI = 1.97–30.09, $p = .003$), and dependence in ADLs (OR = 4.41 95% CI 1.46–13.26, $p = .008$) were identified as factors associated with the domestic

Table 3 Factors Associated With Inactivity According to FAI at 3 Years.

	Predictor	OR	95% CI	*p*	R^2
Total	Cognitive dysfunction	11.61	3.13–43.09	< .001	.513
	Dependence in ADL	8.46	2.86–25.00	< .001	
Domestic	Men	8.48	2.41–29.41	.001	.426
	Cognitive dysfunction	7.70	1.97–30.09	.003	
	Dependence in ADL	4.41	1.46–13.26	.008	
Outdoor	Cognitive dysfunction	14.92	6.16–70.34	< .001	.540
	Dependence in ADL	7.99	2.57–24.83	< .001	
Leisure/work	Dependence in ADL	6.35	2.30–17.59	< .001	.324
	Depression	12.27	1.45–103.64	.021	

FAI: Frenchay Activities Index; ADL: activities of daily living; OR: odds ratio; CI: confidence interval

subscale score; cognitive dysfunction (OR = 14.92, 95% CI 6.16–70.34, $p < .001$) and dependence in ADLs (OR = 7.99, 95% CI 2.57–24.83, $p < .001$) were associated with the outdoor subscale score; dependence in ADLs (OR = 6.35, 95% CI 2.30–17.59, $p < .001$) and depression (OR = 12.27, 95% CI 1.45–103.64, $p = .021$) were associated with the leisure/work subscale score.

Binomial logistic regression analysis of factors associated with a decline in the activity level based on the FAI from 1 to 3 years post-discharge, identified dependence in ADLs as a factor significantly associated with a decline in the total FAI (OR = 0.10, 95% CI 0.01–0.76, $p = .027$), outdoor subscale score (OR = 0.10, 95% CI 0.01–0.83, $p = .033$), and leisure/work subscale score (OR = 0.09, 95% CI 0.01–0.50, $p = .009$). No factors were associated with the domestic subscale score.

Discussion

We investigated the social activity level among patients with stroke 1 and 3 years after discharge following rehabilitation. In the assessment of social activities using the FAI, the median scores were 23 and 19 points at 1 and 3 years post-discharge, respectively. The factors associated with social inactivity at 3 years post-discharge were cognitive function decline and ADL dependence. The factor associated with decreased social activities from 1 to 3 years post-discharge was independence in ADLs.

Social Activity Level

A number of previous studies have used the FAI to assess social activities after periods of time ranging from 1 to 3 years following discharge, and have found minimal differences in scores between these time points. For instance, Patel et al. [8] reported a mean score of 15.4 points at 1 year and 15.8 points at 3 years, and Jansen et al. [9] found that the mean score did not change at 1 year and was 19.5 points at 3 years post-discharge. Our results were similar or somewhat higher than the previously reported values at 1 and 3 years post-discharge, with a significant decline from 23 points to 19 points. Moreover, our results were substantially lower than the mean score of 26.4 points reported in a study of FAIs among healthy older individuals in Japan [13].

Although the overall activity level was low in our study, the patients were relatively more engaged in outdoor activities, such as outings/car rides, walking outdoors, and local shopping. The patients in our study received instructions on walking exercises by rehabilitation staff at the time of discharge; this had possibly established a habit of going for walks in their local neighborhoods, parks, and other areas with the goal of improving and maintaining motor function. Shopping and outings/car rides to nearby destinations are difficult or even impossible to be performed alone; performed with other family members provided opportunities for the patients to go out. Conversely, our patients' engagement in driving/train travel or gainful work was extremely limited. Driving among patients with stroke has become a prevalent social issue in Japan, and considering the damages in the event an accident happens, the criteria for resuming driving have become more rigid. Moreover, the very low scores for gainful work could be attributed to the high number of elderly patients; the usual retirement age for Japanese workers ranges from 60 to 65 years and a number of patients had already retired before their stroke occurred. Although driving and gainful work may be difficult activities for older patients with stroke, the possibility of these patients performing indoor activities, such as light housework and pursuing hobbies with family support, must be explored. In addition, social activities are associated with family roles and individuals' reasons for living and are important for the prevention of mental and physical frailties and improvement in the overall quality of life. Occupational therapists, in particular, should be involved in the seamless transition from providing instructions at the time of discharge to performing intervention activities at home.

Factors Associated With Social Activities at 3 Years Post-Discharge

Previous reports have identified several predictors of FAI in the long-term, including stroke severity [6, 22], complications [7, 23], cognitive function [7], depression level [22–24], and ADLs [7]. Our study showed that cognitive dysfunction and dependence in ADLs are associated with inactivity according to the total FAI, and these predictors were consistent with those in previous studies. Similar to our findings, Pettersen et al. demonstrated that cognitive dysfunction and low BI score are associated with inactivity according to the FAI 3 years post-discharge [7]. Social activities are complex processes that may involve the use of tools (e.g., vacuum cleaners, washing machines, and cars), demanding a higher cognitive function level. Therefore, cognitive dysfunction may be a strong predictor of social inactivity. When providing support for social activities to patients with stroke with cognitive dysfunction, family members and occupational therapists must not immediately assume that the patients are incapable of performing social activities; instead, they should first analyze the activities that the patients can perform and subsequently assist them accordingly. Many studies have also suggested that a low BI score is a predictor of inactivity at 1-year post-discharge [25, 26]. Schepers et al. [26] stated that patients who are more independent (in terms of self-care) have a better FAI, which is similar to our results at 3 years post-discharge.

Furthermore, in this study, we categorized the activities based on the following activity contents: domestic, outdoor, and leisure/work, and investigated the factors associated with low activity levels in each category. Although a few studies have also investigated FAI based on separate categories [24, 25, 27], their results are inconsistent, and none have surveyed patients 3 years post-discharge. In our study, we were able to elicit a number of factors associated with the different categories. Sex was only associated with domestic activities, such as cooking, laundry, and cleaning; men tended to be more inactive in these. As domestic activities are usually regarded as women's work, especially in elderly people, the results may have been affected by this social standard [26]. Moreover, depression was only associated with leisure/work activities. A previous study showed that approximately 30% of patients with stroke develop post-stroke depression [28], and patients with stroke living at home may be poorly treated for depression. Although studies have emphasized the importance of screening for depression from the time of discharge and providing appropriate treatment [29], the identification of symptoms of depression in patients with stroke and the appropriate treatment methods warrant further investigation. Other studies have reported that post-stroke depression is improved by encouraging participation in leisure activities through leisure education programs [30]. Creating environments and opportunities for patients with stroke to participate in leisure activities may help improve symptoms of depression.

Factors Associated With a Decline in the Social Activity Level From 1 Year to 3 Years Post-Discharge

Studies investigating factors associated with a decline in the social activity level from 1 to 3 years post-discharge are scarce, and none of the existing studies have used multivariate analysis. One study employed univariate analysis [9] and found that leg function and social inactivity at 1 year are predictors of a decline in social activities from 1 to 3 years post-discharge. On multivariate analysis, we identified independence in ADLs 1 year post-discharge as a predictor of a decline in total FIM scores, and in outdoor and leisure/work subscale scores from 1 to 3 years post-discharge. Most patients whose social activity level had declined 3 years post-discharge showed independence in ADLs 1 year post-discharge. Rehabilitation interventions focus on individuals whose functions are gradually declining; therefore, those who are functioning well tend to be overlooked. Our results showed however, that attention must be paid to all patients over the long-term to prevent declines in social activity levels of high-functioning individuals. Therefore, interventions to maintain or improve social activities of comparatively high-functioning elderly patients with stroke must be considered in community-based integrated care systems in local communities in Japan.

Limitations

This study has some limitations. The lack of FAI data on the social activities of study patients prior to stroke onset prevented us from identifying whether they had been socially inactive before onset or had become inactive since the event. Future studies are required to track the outcomes of patients whose status had been assessed before stroke. Furthermore, many patients who did not respond 1 or 3 years after discharge possibly have had poor function; they may have dropped out as they had entered an assisted living facility or had died. Therefore, our results must be considered in light of the possibility that our study population included a high proportion of patients whose function was comparatively good.

Since we used BI as a self-report, the reliability of the data may be lower than that rated by clinicians; the results should therefore be interpreted with caution.

Conclusions

We investigated the social activities of patients with stroke living at home 1 and 3 years post-discharge following inpatient rehabilitation. The median FAI declined significantly from 23 points at 1-year post-discharge to 19 points at 3 years post-discharge. The negative factors associated with inactivity according to the total FAI at 3 years post-discharge were cognitive dysfunction and dependence in ADLs; sex (specifically male) and depression were characteristic negative factors associated with the domestic subscale and leisure/work subscale scores, respectively. Independence in ADLs was associated with a decline in the FAI from 1 to 3 years post-discharge. Maintaining and increasing the social activity level are essential for the prevention of mental and physical frailties and for improving the quality of life. Therefore, health and social welfare-associated professionals, and particularly occupational therapists working in local communities must tailor interventions individually considering the identified negative factors; long-term changes in social activities in high-functioning patients should also be considered.

Declaration of Interest

No potential conflict of interest was reported by the authors.

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■ORIGINAL ARTICLE

Cost-Effectiveness of Individualized Occupational Therapy for Schizophrenia: Results from a Two-Year Randomized Controlled Trial

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Abstract: Objective: To evaluate the cost-effectiveness of adding individualized occupational therapy (IOT) to group occupational therapy (GOT) as standard care versus GOT alone for prevention of rehospitalization for patients with schizophrenia.

Methods: Data were collected from our previous randomized controlled trial from baseline psychiatric discharge to 2-year follow-up. The effectiveness was measured as the number of patients who were not rehospitalized, and the cost outcome was defined as direct medical costs.

Results: A total of 109 patients were included: 53 in GOT + IOT and 56 in GOT alone. The number of patients who avoided rehospitalization was significantly higher in the GOT + IOT (n = 37) condition compared with the GOT alone condition (n = 16) ($p < .001$). Adding IOT to GOT was associated with a 56.76% probability of being more effective at reducing the rehospitalization rate and a 26.93% probability of being less costly than GOT alone. GOT + IOT had high outpatient costs, but lower inpatient costs due to the lower rehospitalization rate; as a result, total medical costs were lower than for GOT alone.

Conclusions: Our results demonstrate that adding IOT to GOT is likely to reduce costs and the rehospitalization rate; thus, GOT + IOT is more cost-effective than GOT alone.

Keywords: schizophrenia, cost-effectiveness, rehabilitation, occupational therapy

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Introduction

In the treatment of schizophrenia, it is important not only to reduce psychiatric symptoms but also to improve cognition and to prevent relapse and rehospitalization. To accomplish these aims, individualized intervention in occupational therapy (OT) is needed. However, the existing medical fee system for psychiatric OT in Japan considers group treatment as standard practice. To improve the current situation of psychiatric OT in Japan, it is necessary to demonstrate the effectiveness of individually tailored OT intervention.

The individualized occupational therapy (IOT) program was developed to facilitate proactive participation in treatment and improve outcomes for patients with schizophrenia [1–3]. To evaluate the effect of adding IOT to group occupational therapy (GOT) as standard care, we conducted a multicenter, single-blind, randomized controlled trial, in which we assessed cognition using the Brief Assessment of Cognition in Schizophrenia (BACS) [4, 5] and the Schizophrenia Cognition Rating Scale (SCoRS) [6, 7], intrinsic motivation using the Intrinsic Motivation Inventory (IMI) [8], social

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functioning using the Global Assessment of Functioning (GAF) [9], psychiatric symptoms using the Positive and Negative Syndrome Scale (PANSS) [10], and treatment satisfaction using the Client Satisfaction Questionnaire (CSQ-8) [11, 12] among patients with schizophrenia. Furthermore, we utilized a multicenter 2-year prospective cohort study to evaluate the impact of the type of occupational therapy (GOT + IOT or GOT alone) that patients received on their subsequent rehospitalizations [3]. Findings of these studies demonstrated that adding IOT to GOT resulted in significant improvements in cognition and intrinsic motivation [2] and could prolong the time to rehospitalization and reduce the risk of rehospitalization in comparison to GOT alone, in addition to supporting good cognition at discharge and favorable medication adherence [3]. Details of the IOT study have been published [1–3].

Therefore, the costs associated with rehospitalization for patients receiving GOT + IOT may decrease, but the outpatient cost associated with averted rehospitalization may increase compared with GOT alone. However, the cost-effectiveness of adding IOT to standard care has been not examined. This study evaluated cost-effectiveness from the perspective of the health care system using our previous study data [2, 3] for GOT + IOT and GOT alone during a 2-year follow-up.

Methods

Participants and sites

Eligibility criteria for this study and patient disposition have already been reported [2, 3]. Of 260 patients who were assessed for eligibility, 136 patients with schizophrenia or schizoaffective disorder (DSM-5) who were recently hospitalized in a psychiatric hospital met the criteria for the previous study and, of these, 68 were randomly assigned to each of the GOT + IOT and GOT alone groups [2]. Seven of these participants dropped out at different points in that study [2]. Of those who completed the intervention, 18 did not meet the criteria [3]: 13 were hospitalized for over 1 year, 4 emigrated to other regions after discharge, and 1 was excluded for another reason [3]. In addition, two were excluded during the 2-year follow-up period. Therefore, 109 patients comprised the final sample used for analysis. Of them, 53 (48.62%) were from the GOT + IOT and 56 (51.38%) from the GOT alone groups.

This study was conducted between February 2016 and March 2019 at six Japanese psychiatric hospitals: one prefectural hospital, one general hospital department of psychiatry, and four private hospitals in Nagano, Japan. This study was approved by the ethics committees of the School of Medicine, Shinshu University (3256); Medical Corporation Seitaikai Mental Support Soyokaze Hospital; North Alps Medical Center Azumi Hospital; Nagano Prefectural Mental Wellness Center Komagane; Social Medical Corporation Ritsuzankai Iida Hospital; Medical Corporation Aiseikai Matsuoka Hospital; and Medical Corporation Akitsukai Nanshin Hospital. All participants provided written informed consent. This study was registered in the University Hospital Medical Information Network Clinical Trials Registry (UMIN-CTR) (UMIN000019569).

Interventions

The OT intervention methods have been reported elsewhere [1–3]. We only describe the main features here. The IOT is part of the hospital treatment that is provided via a one-on-one approach by occupational therapists. It consists of a combination of motivational interviews, self-monitoring, individualized visits, craft activities, individualized psychoeducation, and discharge planning. The main component of the program specific to the OT profession was the incorporation of craft activities with individualized coaching by occupational therapists, which is designed to address and improve cognition, the details of which were described in our previous study [2]. The GOT is a standard activity-oriented group treatment that was already being implemented at each study site and included the following programs: physical fitness, handicraft activities, cooking, music, recreation, and psychoeducation [2]. The patients voluntarily selected any desired program from among these options and participated at an individualized rate. Craft activities are also used in the GOT program; however, each patient voluntarily completes the craft activities based on their preferences, and occupational therapists assist only when the patient requests it.

Outcome measures

Clinical data on rehospitalization

Clinical data consisted of our previous study data [2, 3]. The primary clinical outcome was the number of patients who were not rehospitalized. This was calculated as the patients who did not rehospitalize from baseline psychiatric discharge to the 2-year follow-up.

Service use

Service uses and medication (antipsychotics) were investigated through diverse medical resources of inpatient and outpatient care.

Cost data

Cost data were defined from the mental health care

system perspective and involved only direct medical costs, which were defined using receipts collected by each study site collaborator. When a patient did not rehospitalize, the total cost was calculated as only the outpatient cost. When a patient rehospitalized, the total cost was calculated by adding the inpatient cost due to rehospitalization to the outpatient cost. If a patient experienced multiple rehospitalizations during the follow-up period, all inpatient and outpatient costs were included. These were collected separately for inpatient and outpatient costs. Costs were collected as Japanese Yen (JPY) based on the reference year from 2016 to 2018, and were then converted to US dollars using the exchange rate for the reference year June 7, 2019 (US$ 1.00 equals to JPY 108.43).

Statistical analyses

The calculation of the planned sample size was described in our previous study [2]; it indicated that 150 patients with 75 patients randomly allocated to each group were needed.

The Mann-Whitney U test for continuous variables and χ^2 analyses for the categorical variables were used to compare the groups with regard to demographic and clinical values. The analysis of cost-effectiveness assessed the average direct medical costs per patient. Analyses of service use, cost components, and total costs compared GOT + IOT and GOT alone groups on average costs per patient from baseline psychiatric discharge to 2-year follow-up. If the GOT + IOT group as the experimental condition had higher cost outcomes than the GOT alone group as the control condition, the incremental cost-effectiveness ratio (ICER) was calculated as the difference in the average annualized total costs per patient divided by the difference in effectiveness (the number of patients who were not rehospitalized). The ICER was calculated as $(C_{GOT + IOT} - C_{GOT\ alone})/(E_{GOT + IOT} - E_{GOT\ alone})$, where C is the average per patient cost and E is the effectiveness. The uncertainty of differences in the effectiveness and cost data was estimated using 95% confidence intervals (CIs).

Results

Participant characteristics

Data on participant characteristics were collected at the baseline (psychiatric discharge) and during a 2-year follow-up after discharge. Of 109 patients (53 GOT + IOT, 56 GOT alone), which were collected with 2-year follow-up, were used in this study [2, 3]. The GOT + IOT group was significantly lower age ($p = 0.03$) and rehospitalization rate ($p < .001$) than GOT alone group, and scores of BACS composite ($p = 0.01$), IMI ($p < .001$), PANSS ($p < .001$), and CSQ-8 ($p < .001$) were significantly higher in the GOT + IOT group than in the GOT alone group.

Outcomes

A total of 53 (48.62%) patients were not rehospitalized during the 2-year follow-up period, of whom 37 (69.81%) were from the GOT + IOT group and 16 (30.19%) from the GOT alone group. GOT + IOT group patients experienced significantly lower rehospitalization frequency during the 2-year follow-up period than did the GOT alone group ($\chi^2 = 18.54$, $p < .001$).

Service use

Measures of service use by treatment group (GOT + IOT; GOT alone) are described in Table 1. For mental health inpatients, all inpatient days and occupational therapy times for the GOT + IOT group were significant shorter than those in the GOT alone group. In addition, for mental health outpatients, all outpatient days, consultation with psychiatrists times, and home visit nursing times were significantly longer in the GOT + IOT group than those in the GOT alone group.

Costs

Measures of service use and related costs by treatment group (GOT + IOT; GOT alone) are summarized in Table 2. The GOT + IOT group generated significantly lower costs (US$ 116 454.66; 95% CI = 106 088.42–126 820.89) than did the GOT alone condition (US$ 159 379.89; 95% CI = 146 579.61–172 180.18), representing a significant cost reduction of US$ 42 925.24 per patient ($p < .001$) (Fig. 1). GOT alone generated higher total costs than GOT + IOT, with 26.93% of the increased costs attributable to increased inpatient service costs (Table 2). There was a significant difference (U = 212.0, $p = .020$) between patients who were rehospitalized following GOT + IOT (n = 16; US$ 162 137.07; SD = 30 857.44) versus those hospitalized following GOT alone (n = 40; US$ 183 739.39; SD = 31 452.93). Costs associated with patients without rehospitalization did not differ significantly (U = 224.0, $p = .154$) between GOT + IOT (n = 37; US$ 95 465.44; SD = 16 188.75) and GOT alone (n = 16; US$ 96 958.69; SD = 16 501.89). Total inpatient costs for GOT + IOT were US$ 32 952.24 (95% CI = 18 334.90–47 569.58) significantly lower than inpatient costs associated with GOT alone (US$ 107 166.53; 95% CI = 86 387.54–127 945.53) ($p < .001$). Total outpatient costs for GOT + IOT were US$ 83 502.42 (95% CI = 78 056.27–88 948.56) significantly greater than those for GOT alone (US$ 52 213.36; 95% CI = 43 906.32–60 520.40) ($p < .001$). The difference between GOT + IOT and GOT alone in services re-

Table 1 Measures of service use by treatment group (GOT + IOT; GOT alone).

	GOT + IOT (n = 53)	GOT alone (n = 56)	Statistic[a]	Effect size[b]	*p*
	Mean (SD)	Mean (SD)			
Mental health medical inpatient					
All inpatient days	93.30 (160.90)	331.79 (249.53)	712.5	0.49	< .001**
Occupational therapy times	53.24 (90.90)	167.02 (136.70)	783.0	0.45	< .001**
Mental health medical outpatient					
All outpatient days	636.70 (160.90)	398.21 (249.53)	712.5	0.49	< .001**
Consultation with psychiatrist times	44.78 (12.39)	30.96 (22.27)	819.0	0.43	< .001**
Outpatient occupational therapy times	41.48 (59.50)	35.58 (54.80)	1526.0	0.01	.937
Day care times	57.11 (122.59)	33.89 (74.31)	1499.5	0.03	.775
Home visit nursing times	30.11 (23.45)	22.11 (18.78)	1250.0	0.17	.085

[a] Comparison of GOT + IOT and GOT alone was conducted with Mann–Whitney U test.
[b] Effect sizes were calculated using r coefficient.
** $p < 0.01$

Table 2 Measures of costs by treatment group (GOT + IOT; GOT alone).

	GOT + IOT (n = 53)	GOT alone (n = 56)	Statistic[a]	Effect size[b]	*p*
	Mean (SD)	Mean (SD)			
Mental health medical inpatient costs, US$					
Occupational therapy	1,080.23 (1,844.23)	3,388.72 (2,773.67)	783.0	0.45	< .001**
Medication	10,879.23 (18,782.21)	38,720.50 (29,120.22)	712.5	0.49	< .001**
Inpatient total costs	32,952.24 (53,553.68)	107,166.53 (78,312.09)	725.0	0.49	< .001**
Mental health medical outpatient costs, US$					
Outpatient occupational therapy	858.55 (1,214.88)	721.88 (1,111.90)	1519.0	0.01	.903
Day care	3,370.94 (7,235.61)	2,000.61 (4,385.84)	1499.5	0.03	.775
Home visit nursing	1,604.72 (1,258.81)	1,182.43 (1,004.73)	1258.0	0.16	.094
Medication	75,024.21 (18,600.81)	46,471.97 (29,120.22)	695.0	0.50	< .001**
Outpatient total costs	83,502.42 (19,953.09)	52,213.36 (31,307.65)	766.0	0.44	< .001**
Total costs, US$	116,454.66 (37,978.86)	159,379.89 (48,241.85)	717.0	0.47	< .001**

[a] Comparison of GOT + IOT and GOT alone was conducted with Mann–Whitney U test.
[b] Effect sizes were calculated using r coefficient.
** $p < 0.01$

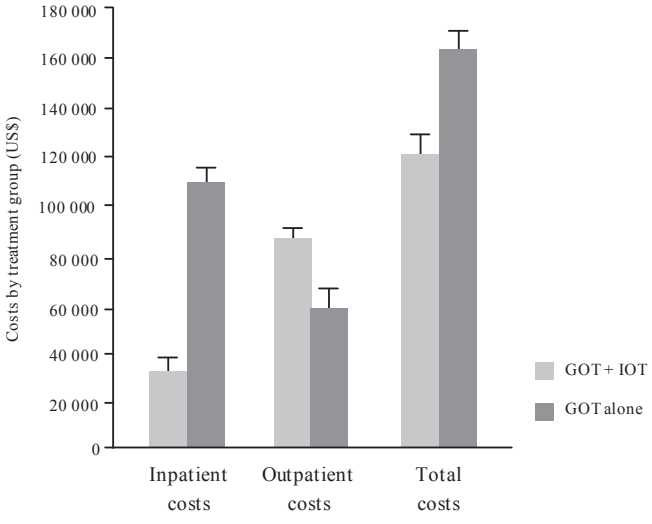

Fig. 1. Comparison of inpatient total costs, outpatient total costs, and total costs by treatment group (GOT + IOT; GOT alone). Means ± standard error.

ceived is partly explained by the lower rehospitalization rate in the GOT + IOT group and the higher inpatient service use costs in GOT alone group.

Discussion

Main findings

This is, to our knowledge, the first study to evaluate the cost-effectiveness of adding IOT to GOT in comparison to GOT alone. Our results of cost-effectiveness analyses demonstrated that adding IOT to GOT had greater potential cost-effectiveness than GOT alone. This cost saving was brought about by the addition of IOT to GOT, which improved cognitive functioning and intrinsic motivation [2] and reduced rehospitalization rates [3]. GOT + IOT had high outpatient costs, but lower inpatient costs with a lower rehospitalization rate; consequently, total medical costs were lower than for

GOT alone. The main drivers of differences in costs between GOT + IOT and GOT alone were inpatient costs due to rehospitalization (Table 2). Furthermore, GOT + IOT cost US$ 42 925.24 less per patient than GOT alone, representing 26.93% more cost-effectiveness of the former approach. Sensitivity analyses, using 95% CIs, attested to the robustness of the findings of benefits and costs for IOT. Therefore, adding IOT to standard care during hospitalization should be recommended not only in terms of prevention of rehospitalization [3] but also in terms of cost-effectiveness.

Clinical and cost-effectiveness relevance

Treatment choices to improve outcomes for schizophrenia have been explored to alleviate personal suffering and to reduce the high health care costs associated with the illness [13]. Schizophrenia is associated with frequent rehospitalization during its clinical course, with considerable economic burden [14–20]. Hospitalization has been identified as a significant cost driver [21, 22]. Estimates of the annual economic burden of schizophrenia in Japan in 2008 were JPY 2.77 trillion (US$ 23.8 billion) for total costs, while the total cost per patient was JPY 3 538 751 million (US$ 30 298) [18]. Hence, rehospitalization prevention is an important element in schizophrenia treatment, not only in terms of functional improvement [23–25], but also with respect to cost-effectiveness.

Adding IOT to standard care might help prevent rehospitalization [2, 3]; as IOT intervention during hospitalization is cost-effective and perhaps even cost saving, IOT should readily be accepted as a component of schizophrenia treatment.

Issues of medical fee system

The existing medical fee system for psychiatric OT in Japan considers group treatment as standard. For this reason, GOT intervention is widely practiced for patients with schizophrenia in many Japanese psychiatric hospitals, but IOT is rarely implemented in Japan. To improve the current situation, it is necessary to demonstrate the effectiveness of individually tailored OT interventions.

In our clinical experience, the number of patients who can be treated with OT in the time permitted by the medical fee system is 10–12 for GOT, but only 2–3 for IOT. Therefore, it is necessary to ensure IOT is added to the medical fee system to ensure that IOT is practical in psychiatric hospitals in Japan. As shown in our previous studies [2, 3] and this study, our findings provide robust evidence for shifting from traditional OT, which is based on group treatment, to individualized OT, not only to improve rehospitalization rates of patients with schizophrenia but also for cost savings due to less frequent rehospitalization.

Limitations

Some limitations should be noted. First, our method for determining the costs was a simple comparison of direct medical costs of GOT + IOT and GOT alone groups. For cost-effectiveness analysis, although the Quality Adjusted Life Year (QALY) is recommended as the outcome variable, we could not use QALY, because quality of life values were not obtained in this study. Second, we measured only direct medical costs in this study, and did not include direct non-medical costs and indirect costs. The analysis was conducted from the perspective of the health care system, and thus did not address costs incurred by patients' families or other social welfare systems. In addition, costs for medications other than antipsychotics were not measured. Therefore, costs might be slightly underestimated and savings slightly overestimated. Third, because IOT is provided one-on-one with an occupational therapist, the case load during hospitalization of adding IOT to GOT is less than that for GOT. However, the cost due to the difference in case load for GOT + IOT versus GOT alone was not collected. Therefore, it was not possible to investigate whether conditions differed in terms of health service utilization at the start of the trial. Finally, because this study was conducted in Japan, the results may not be generalizable to countries that have different health care systems.

Conclusion

This study provides support that adding IOT to standard care results in reduced rehospitalization rates at lower cost. Cost savings appeared probable for most of the study participants. Although further confirmation is needed, the results of our studies of IOT provide data that encourage the revision of Japanese psychiatric occupational therapy's medical fee system.

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Occupational Therapy Profession for Women Health– Challenges for its Under Developed Services

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Abstract: Occupational therapy has a pivotal role in the organization of health care, and has important role to improve the health and quality of life of women by facilitating participation in meaningful occupations. The aim of this paper is to present a summary of occupational therapy role for health of women, and an analytical perspective of the current issues eroding its professional autonomy and contributing to a critical lack of progress in Malaysia. Three key root-causes – with an emerging summative theme of "triple whammy", was identified using *root cause analyses* technique. The root causes were related to two internal and 1 external root-source:- (1) Low numbers of occupational therapists, (2) Low university- education occupational therapy programs, and (3) Entrenched medical governance hindering the progress of therapy professionals. These interrelated key issues (roots) play a detrimental role in the advancement of a cost-effective, evidence-based best practice of the profession, and reduces its significant contributions towards the healthcare of all, including the issues of women health care. As a young profession compared to many other health disciplines, occupational therapy needs a mandate to protect its role autonomy, with enhance visionary pathway for growth, and to expand its roles, including for the underserved area of women health, in Asia's male dominated world.

Keywords: Occupational Therapy, women health, autonomy, medical dominance, Challenges, medical hagemony

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Background

Occupational therapy has a pivotal role in the organization of health care, and improves health and quality of life by facilitating participation in meaningful occupations [1, 2, 8, 9]. The steep rise in non-communicable chronic health conditions and the aging population (which are typically not curable through traditional medical approaches), have resulted in significant limitations in daily participations [5]. This calls for the involvement of the currently, underdeveloped and also underutilised occupational therapy services [6]. Occupational therapists use activities to impact patients' physical, sensory, cognitive, psychosocial, and emotional health, through patient self-management, joint-protection, splint-fabrication, adaptive-technology, wheelchair-modification, mindfulness, lifestyle activities and environmental-modification are fundamental to patient population [7–9].

The growth of the health profession contributes to better, newer services and more expanded roles – including women's healthcare. A basic element driving its profession to advance in its deliveries, is 'job-autonomy' – a concept closely related to workers' motivation, satisfaction and well- being [10], which can translate to better performance and subsequently, effective care for patients [11]. Professional autonomy or, the right to use discretion and judgment within the scope of practice of a profession, or an individual's freedom to exercise professional judgment in practice activities [12, 13] has been observed as one of the numerous key challenges faced by occupational therapists in an entrenched medical model across Asia. Although some physicians justified '*job-autonomy*' as fundamentally essential for good patient care and embedded it in the national governance

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structures as documented in the 2000 Warsaw Declaration [14], this idea has, ironically not been translated into their practices with other health professions. The World Federation of Occupational Therapy has issued position statement that clearly stipulates the importance of professional autonomy of the Occupational Therapy profession [15]. Paradoxically, although the profession champions independence and empowerment for its clients, it is losing its own autonomy status in less developed countries like Malaysia [16, 17]. Occupational therapists are denied the same level of autonomy and are governed by policy makers who are solely (if not predominantly) represented by medical practitioners. This level of control means that occupational therapists are not able to assert their professional autonomy and may experience repercussions if they do [18]. Since 2009, most Occupational Therapy department have not progress (but in fact, has regressed) and are reorganized from being an autonomous department, and placed under the governance of medical rehabilitation doctors [16, 19]. Historically, such medical dominance took place in the health care system in the USA more than three decades ago [20, 21], where the documented 'tug-of-war' for autonomy has been detailed as the struggle between occupational therapy and physical medicine – an occupational injustice attempt to control occupational therapy [21]. Evidence shows that the health profession was coerced into the medical dominance over their affairs with restrictions on their practice [20, 22, 23]. Nevertheless, occupational therapists elsewhere have made significant progress with regards to autonomy of the profession. In Canada, the University of Alberta has pioneered the Faculty of Rehabilitation Medicine which was championed by three autonomous health professions –i.e. the Occupational therapy, Physiotherapy and Speech Therapy [24]. In sharp contrast, Malaysia is encountering severe oppressive trend of medical dominance, with its healthcare budget for rehabilitation channelled into a medical program. The unprecedented rise of rehabilitation doctors in Malaysia possibly to address the shortages of health manpower in rehabilitation, has unanimously led to a serious decline in the job autonomy of occupational therapists [16]. This non-evidence strategy to address shortage of health professionals for rehabilitative services, aggravates a medical governance system that stifles further development of the profession. In short, occupational therapists in developed countries have enjoyed significant advancement, job autonomy and job recognition [25], but not those from developing countries [26, 27].

Healthcare Changes in Malaysia

Globally, improvement in health care has resulted in more people living with chronic conditions for indefinite periods of time. With this change, approaches to manage chronic condition and its symptoms for maintaining patient independence and quality of life over longer periods of time is needed [28, 29]. A shift from the traditional doctor–patient relationship (curative-focused) to a paradigm of, patients working in partnership with health and therapy professionals (independence and function-focused) can only occur if there are sufficient number of health professionals who are autonomous and trained [4, 28]. In the 2018 fiscal year [43], Malaysia was classified as an upper-middle-income economy with a GDP of USD358.582 billion. The Malaysia Economic Transformation Programme identified healthcare as one of its 12 National Key Economic Areas in 2010, and highlighted a priority to ensure training of health personnel to address the behavioural component of lifestyle issues [30, 31]. Yet, health professions like occupational therapy were still neglected, and a reason may well be the low number of leaders in the discipline and poor representation at the policy levels. With a shrinking healthcare budget, the grossly underutilised and underdeveloped therapy services must be expanded, while the exaggerated focus on the expensive medical personnel for curative care model must be for a more balanced and cost-effective workforce [28, 29].

The World Health Organization (WHO) estimates that non-communicable diseases accounts for 80 percent of global burden of disease, and it's the leading cause of death and disabilities in Asia [32]. The associated rise of lifestyle-related chronic diseases (attributed to a complex constellation of social, economic, and behavioral factors) can be better managed with direct, interdisciplinary approach and patient self-management [29], – which therapy services can help address with their wide range of therapeutic and preventive services. For both clinical and economic reasons, addressing women's health with patient self-management is a cost-effective paradigm model across the prevention spectrum (primary, secondary, and tertiary). Establishing a pattern for health early in life, providing strategies for mitigating illness and managing it in later life, and for the wellbeing of the family unit (as women tend to care and cook for the families), and ensuring mental health, occupational health while intervening lifestyle related NCD should be steeped up. Stakeholders must take into consideration the social-political, occupational and economic forces (including a lack of job awareness, autonomy and acknowledgement to the health profession) that has resulted in inequalities between medical vs health

disciplines in high and low income countries. Engaging the therapy professionals should be the way forward for better and cost-effective care management.

Occupational therapy role for the health and wellbeing of women

The sub-specialization in advancing women health is a natural progression for this profession with predominantly female dominated profession. As an example, with breast cancer as the number one cancer for women, therapeutic services are much needed which include the more innovative, patient self-management to educate and empower female patients in their health [34], hand therapy like lymphedema-management and upper-limb function, pelvic and sexual wellbeing health, pre/post natal care and psychosocial health [33–37]. Occupational therapy can contribute to the occupational participation intervention of women in the continuum of cancer care. Enabling engagement in occupational performance of mothers, and adapting their social environment to intervene and address mothers' occupational needs are linked to physical and mental health [58]. Many other women-related health areas which greatly requires therapeutic health services to improve the quality of life, includes domestic violence, vulnerable mothers [37, 38], and those with sleep disorders, weight-obesity issues [39, 40], and the ever increasing functional issues from the many non-communicable diseases with comorbidities that limits functional abilities in daily living.

Purpose

The aim of this paper is to present an analytical perspective of the current phenomenon and challenges affecting health professional's job autonomy and, to identify key root-causes that stifled its progress. The paper focus on key services for female population which are grossly underutilized, as an emerging area of targeted healthcare.

Method

A core group of four occupational therapy leaders (with involvement in their country's professional association, or has participated in the World Federation of Occupational Therapists' meeting or leading/advocating occupational therapy education in their countries) were specially invited to a focussed discussion. They reflected and reviewed the problems hindering the profession's growth in Malaysia. An analytical approach to the issues were deliberated, and references to their home countries and data from the World Federation of Occupational therapists were gathered to compare and contrast between countries. The four leaders utilized a simple "root-cause analysis" technique [57]. This is a management technique that systematically appraise the problem-at-hand to get to the bottom of the problem or the unexpected event (ie. the dwindling job autonomy of occupational therapists).

The *root-cause* analyses [57] aim at improving products or processes, via a sequential steps of i) describe the problem (dwindling job autonomy), ii) gathering data associated with the problem (data on therapists in the country and from a world body), iii) identifying potential causes for the problem (concurring on key problem and brainstorming the causes), iv) identifying which causes to be removed/changed in order to prevent problems, v) identify solutions that will be effective in preventing repeat problems, [vi) implement changes and v) observe changes to eliminate the problem]. We will propose recommendation/s from these steps.

Findings on key issues

Most developed countries have made good progress to address shortages of occupational therapy manpower in the last few decades. In Canada, great progress is seen in the University of Alberta who have consolidated their three key healthcare professionals into a Faculty of Rehabilitation Medicine [24]. In Malaysia, progress is slow and a strategic root-analyses of this area, help us to pinpoint fundamental root-cause issues in this female-populated profession, link to low job autonomy. The root-cause technique enumerated two internal and one external root causes in line with the erosion of professional autonomy. An emerging key theme was, a debilitating low job autonomy in the health professions when compared to healthcare scenario in Canada, USA, UK and Australia.

Two Internal Root Cause

The two internal issues were- i) 'low numbers (low quantity)' of occupational therapists in Malaysia, and ii) 'low-qualification/low-University level education provision' at university-based institution. Both these root factors are identified as contributors to the erosion of professional autonomy. Majority of the therapists in Malaysia are still educated under the old British apprenticeship model of training by the Ministry of health. In contrast, all developed countries have good progress in addressing these two issues by improving training at degree levels, and providing access to University programs in Universities under the Ministry of Education

(versus ministry of Health).

One External Root Cause

Malaysia have an additional strong external root-cause of 'medical governance' – which contributes to the erosion of job autonomy and most decision makings were made by a hierarchical medical discipline. This external root cause is contributed by a strange policy that utilizes the dwindling health budget to produce more rehabilitation doctors (instead of addressing a lack of therapy workforce for the nation).

Discussion

A contributing external factor is a prevailing medical hegemony phenomenon, unique to the occupational therapy professions who are predominantly female and are newer discipline to the healthcare scenario in Malaysia [16, 18, 21, 42]. As it's a phenomenon not common in developed countries, the leaders came up with a final theme of "*triple whammy*" to capture the magnitude of the root-cause problem and they reflected iteratively on how it has contributed to stifles the progress in Malaysia. The four educational leaders concurred on these root causes, and agreed that they were interrelated, and together they posed a strong structural barrier to the therapists' autonomy within its rather traditional healthcare governance. These three 'internal and external root causes' are deliberated below.

i) Internal root cause of Low manpower (low number) of occupational therapists in Malaysia

Malaysia has an exceedingly low 1,395 occupational therapists (for over 32 million population), compared with 16,000 occupational therapists in Australia (a population of 25 million) and 33,383 occupational therapists in United Kingdom (for 65 million population) [41]. This figure translates to a ratio of one Malaysian occupational therapist to 17,777 people, compared to 1: 556 for medical practitioners and 1:305 for nurses in Malaysia [19]. Occupational therapists therefore have a tremendous challenge in being able to provide the necessary interventions to improve the occupational participation and quality of life for Malaysians. With less than 2000 occupational therapists, they are servicing primarily public hospital (see Table 1), and are grossly under-represented in many services as well as in non-traditional key service areas such as women care, community health services. This inability to expand their services will have a detrimental effect on holistic cost-effective patient outcomes.

Malaysia, despite being classified as upper-middle-income economy does not compare well to other countries in terms of number of registered occupational therapists [43, 44]. Figure 1 presents an overall diagram of the census of occupational therapists in the world with USA leading as the number one country with the highest number of occupational therapists. The Malaysian health care system highlights doctors and nurses, and often missed out many of its long neglected healthcare disciplines (Fig. 2)

Table 1 Occupational therapists per practice setting in Malaysia, 2008–2014 (MOH 2016).

No	area	No of therapists in 2008 (25 million population)		No of therapists in 2014 (30 million population)	
1	Public hospitals	387	76%	1050	75.2%
2	Private settings	40	8%	250	17.9%
3	Educational settings	80	16%	95	6.9%
	TOTAL	507	100%	1395	100%

ii) I nternal root cause of low access to university-based occupational therapy education in Malaysia

In Malaysia, educational programs for Occupational Therapy is predominantly under the Ministry of Health, which is still offering the outdated diploma-status programs–equivalent to certificate in the USA. Only two higher education institutions (the National University of Malaysia, and the University Technology Mara) offer bachelor degree programs [16, 44]. A premier university in Malaysia, The University of Malaya does not offers discipline-specific program for occupational therapy, despite having an academician fully qualified in the field. It offers generic (Master/PhD Medical science) research-based postgraduate program, but the intake is greatly limited by the low numbers of potential applicants with the needed bachelor degree level qualification. Compounding the issue in the country, one of its University (UiTM) enforced race-based policy that accepts only Malay ethnic students. Therefore, the numbers of occupational therapists are grossly under-supplied. Table 1 showed the census of therapists in the country, and Table 2 showed the ratio of occupational therapists in relation to the general population.

In short, there is a serious, debilitating lack of university-level educational programs of international standing which must be addressed urgently. In contrast, Japan has 160 schools offering Occupational Therapy programs. A sample of programs (Table 3) in at least 5 other countries showed progress in number of schools (quantity) and ii) availability of postgraduate program (quality). University education is important in the professional education of occupational therapists [45]. The

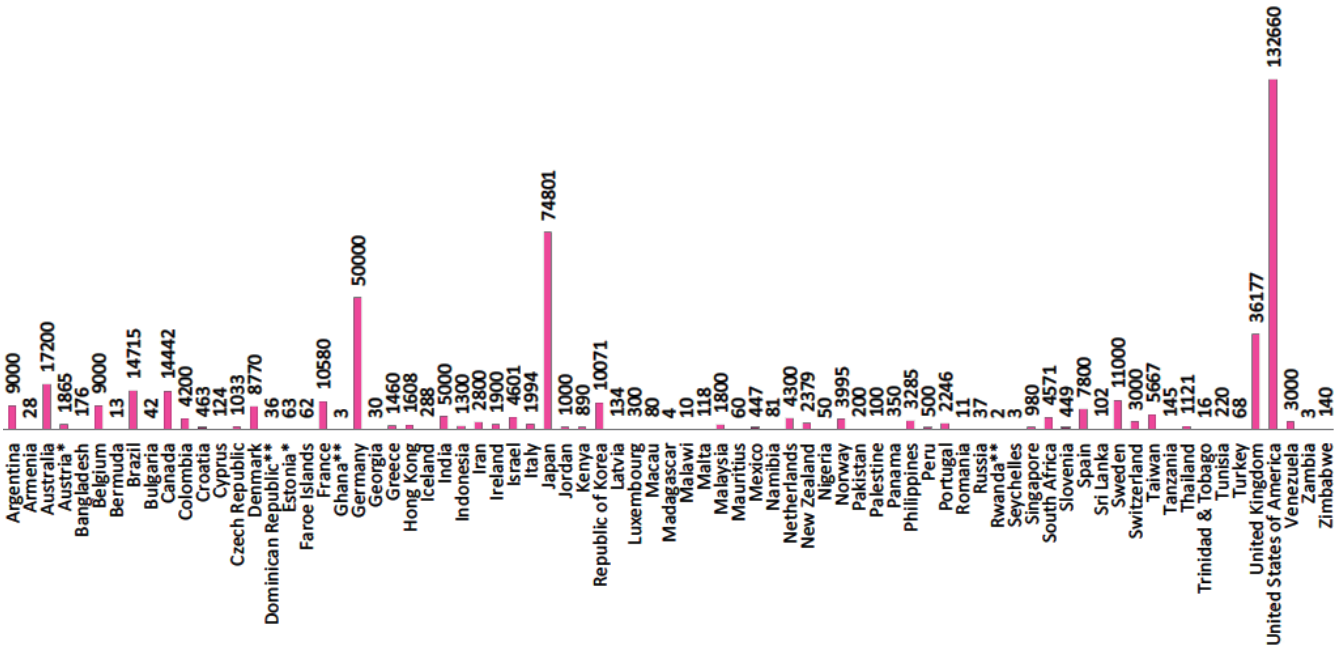

Fig. 1. The number of practicing occupational therapists in the world.
Source: https://www.apeto.com/assets/vision-internacional-de-los-recursos-humanos-to-2016.pdf

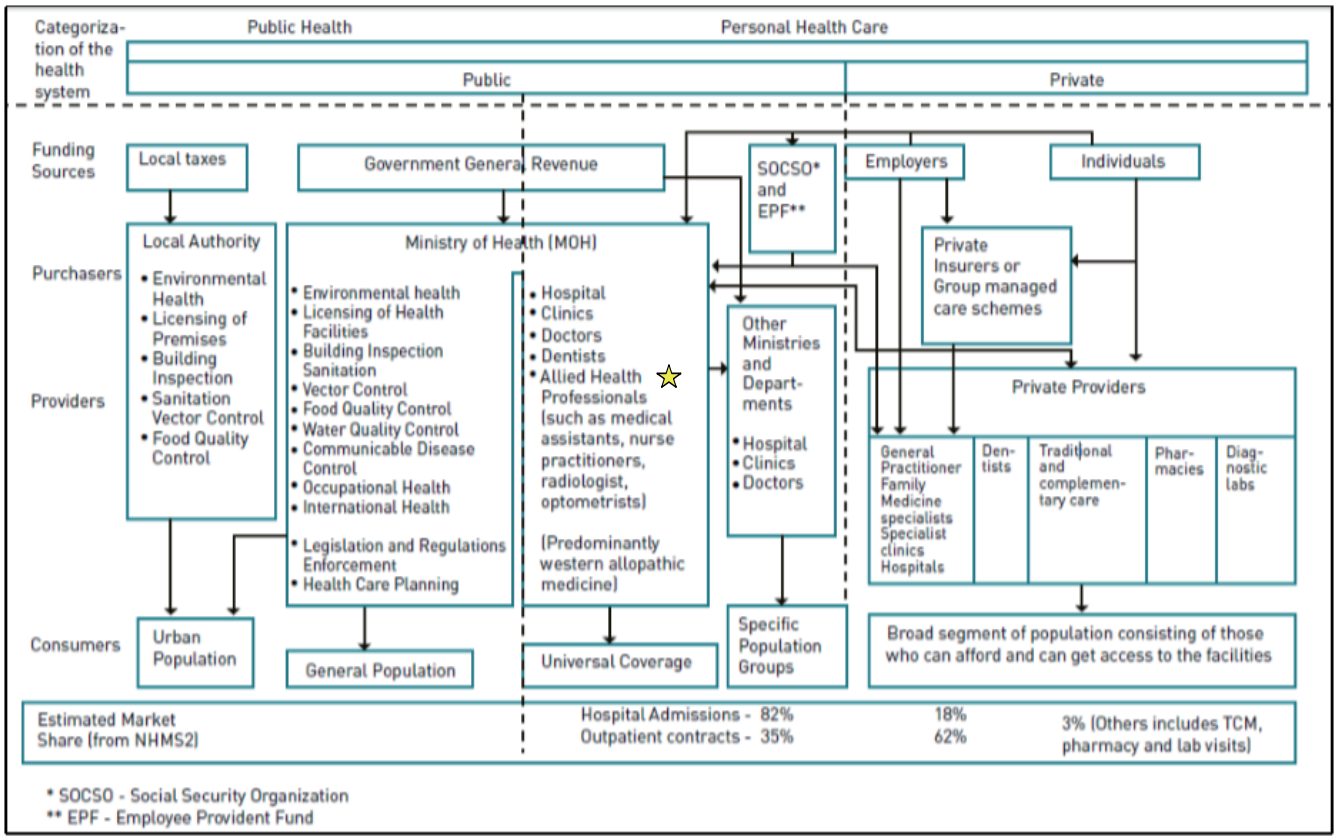

Fig. 2. Schematic Overview of the Malaysia Health System; Source: Hussein RH (2016).

Table 2 Occupational therapists/population - across a sample of countries

Country	No of OT (2016)	Population (2016)	OT per 100,000 (2016)
Malaysia	1,500	30,187,896	5
USA	113,200	322,583,006	35
Canada	9,827	35,524,732	27
United Kingdom	36,043	63,489,234	56
Australia	16,000	25,323,000	63
Japan	47,759	126,999,808	37
Sweden	9,000	9,631,261	93

WFOT 2016

Table 3 Number of Occupational Therapy programs in selected WFOT member countries.

Country	Total population 2017	No of OT programs	Level
Canada	36,286,378	15	Masters, PhD
New Zealand	4,604,871	2	Bachelors, PhD
Sweden	9,920,624	10	Bachelors, Master, PhD
UK	65,336,540	59	Bachelors, Master
USA	326,474,013	160	Master, PhD
India	1,349,516,523 (1.34 billion)	19	Bachelors, Master
Japan	126,323,715	140	Bachelors, Master
Malaysia	31,025,632	3	Diploma, Bachelors,
Australia	24,641,662	17	Bachelors, Master, PhD

OT = Occupational therapy. Source: WFOT (2016)

World Federation of Occupational therapists or WFOT provides information about WFOT-approved Occupational Therapy programs from its member countries, to meet the Occupational Therapy needs for the respective countries in the world [41].

With a projected growth rate of 27 percent (between 2014 and 2024), occupational therapy is one of the fastest growing career fields in the United States [46, 47]. In the USA and Canada, a Masters level has now become the entry level qualification for licensing [48]. Table 4 showed the characteristics of occupational therapists in a very large hospital in central Kuala Lumpur. There were 175 health professionals (speech, physio and occupational) and 85 of them are occupational therapists. Of these 85 mostly female occupational therapists, and mostly diploma holders but only five percent are pursuing postgraduate studies. More than 56 percent of the current therapists surveyed are in service for less than three years indicating that the profession is still young in comparison with other health disciplines, and has many potentials to be developed.

As with many countries, the Malaysian occupational therapy population is uniquely female dominated, and research should also be initiated if gender issue could be a contributing root-cause among its prevailing male

Table 4 The background of therapists in University Malaya Medical Centre (Dec 2016) n = 175.

Characteristic	All	%	Occupational therapist (n = 85)
Female	136	77.7	89%
Malay	158	90.3	91%
Work duration at UMMC of 1–3 years	99	56.6	80%
Highest qualification = Diploma	124	70.9	85%
Pursuing post graduate studies	34	13.7	5%

dominated decision makers in Asia. Thus, unlike their mainly postgraduate-qualified western counterpart countries, almost two third of the small number of therapists in Malaysia are diploma holders. The training of health professionals under Ministry of Health (an initiative during the British Colonial rule) should be moved into Universities. The Malaysian government has been extremely slow to acknowledge and advance the therapy professions.

iii) External root cause on medical dominance- eroding the professional autonomy

Occupational therapists, are educated to deliver patient-centered care, emphasizing evidence-based practice, quality improvement approaches, and informatics [49]. In developed countries, occupational therapy is an autonomous profession [24, 50]. The autonomy of the profession is characterised by the level of responsibility the therapists have for the care of their patients, the level of accountability in the profession (through registration boards /professional bodies of associations/the public), having a university level preparation for practice, having a sound theory base with specialised skills for practice, having control over the quality of their own work, and working within their own code of ethics [51]. Direct collaborative and interdisciplinary health team shares power equally and members are empowered to make their own informed evidence-based decisions in partnership [52]. With better University educated health professionals, the redundant medical supervision and hegemony can be removed for cost-effective access to rehabilitation services and for effective outcomes to be achieved [11, 21, 42]. There is good evidence that many countries have proven the cost-effectiveness of occupational therapist led services, with good outcomes [52–54]. However, the medical-model governance in Malaysia seems to erode autonomy and hindered progress of these health disciplines, and where, healthcare budget are redirected to produce rehabilitation when the country's needs for therapy personnel are long neglected. Such occupational injustice is seen as a violation on basic occupational right towards inclusive participation in everyday occu-

pations for all persons (profession) in our society [55], whereby the therapists' rights and responsibilities to independently plan and advance their services in autonomous manner are violated. Piece (2009) alerts that such situation can lead to occupational-deprivation (i.e denied opportunities and resources to engage in therapy provision), oppression (i.e. disempowered/marginalised by the oppressive rehabilitation doctors), job dissatisfaction and demoralisation in the workplace [56]. Consequently, this affect not only the profession, but their services to patient care and the financial economic health outcomes of the nation.

The 'triple whammy' burden

Internationally, the healthcare changes that have contributed to the rise and advancement of Occupational Therapy profession are i) the alignment of the Occupational Therapy professional core philosophy with the recommendations of the World Health Organisation suggesting its important role for health- social care, ii) an aging population, iii) rising cancer incidences and iv) increased non-communicable chronic diseases, and v) the renewed significance of the value of occupation-based interventions in daily life to improve health and wellbeing of the population. However, this landscape shift has not exerted much changes to the development of occupational therapy in Malaysia. In fact, we acknowledged a serious lack of progress of the profession in Malaysia. The three key root causes, which we categorized as the 'triple whammy burden' seems to project the magnitude of the root-cause problem, that has 'strangled' the growth of occupational therapy in Malaysia. Addressing the two internal root causes individually may be difficult, if the external root cause (on medical governance) is not collectively tackled. Stakeholders including the Ministry of Higher Education, Ministry of Health, Ministry of women and social welfare and the local professional body, as well as its associated international body would need to meticulously reorganised the organisational chart of the rehabilitation medicine services. The model of rehabilitation medicine in University of Alberta should be used as the goal for management. Implementing and observing changes needed include providing University degree program for therapy, ensuring the Public service department acknowledge and give due recognition, rewards and promotion to therapy professionals including professorship at par with western counterparts.

Conclusion

Using Malaysia as a case study, a root-cause analyses with four international health educators have identified three root-causes related to its professional autonomy of occupational therapy profession. The magnitude of the root-cause problem with its thematic 'triple whammy burden' label, justify the huge challenges that hinders its growth in Malaysia. The value of occupation-based interventions in daily life to improve health has been recognized in the social landscape changes that include rising aging, cancer, non-communicable chronic diseases, and in specialised area of women health issues. Occupational therapy services are particularly well-positioned to address the needs of the person, the activities and occupations which people engage in to fulfil their roles functionally and independently. The current medical-model under which occupational therapy works in Malaysia greatly reduced its role to better serve the needs of diverse population including women care. Sole medical doctors and curative care is no longer the answer to an increasing non-communicable diseases across the globe, innovative patient self-management in direct partnership with better trained health professionals to improve their independence in daily activities and for better quality of life is needed.

Recommendations

A manifesto for improving therapy services as front liners, to address the rising chronic diseases is needed. The medical dominance and occupational injustices over therapy services must be stopped, to make way for professional growth. An Asian-EU dialogue with more research to highlight effective therapeutic deliveries in today's shrinking healthcare organisation is needed, to address the bulk of chronic disease conditions, prevent illness, and promote wellness. International profession-related bodies can provide the evidence-based outcome findings to support practices, clinically and economically.

In terms of education, the model of autonomous governance of Occupational therapy clinical and educational services (such as in USA, Canada, UK, Australia) can be used as a guide for Malaysia. The American Council on OT Education, autonomously sets the standards for the academic curricula and accredited the occupational therapy degree to be conferred to their graduates, while an independent national examination for certification (i.e. upon graduation from an accredited program) provides the check and balance to safe practice in the field of occupational therapy. Every state has licensure, and, a final determiner is what the payers will pay for therapist's key significant services. Malaysia needs to emulate and incorporate these self-governance model which has been build-up over the years. More university-based education for better healthcare deliveries must be

put in place, starting at its premier university. Occupational therapy as a science-based health discipline, aims to i) make valuable contribution for reducing disabilities that affects the health and well-being of people, ii) positively influence health, welfare, education and vocation, and iii) positively influence the development of excellence within the profession, locally and internationally. Job autonomy must be recognised to enable direct cost-effective healthcare services in Malaysia.

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■ORIGINAL ARTICLE

A Systematic Review and Meta-Analysis of Cognitive Functions Predicting Employment of Individuals with Acquired Brain Injury

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Abstract: Background: Only 20% of the hospitals in Japan currently provide work support services for patients with acquired brain injury (ABI). Since the new employment quota system in Japan requires private companies to hire individuals with psychiatric disabilities as of April 2018, the number of employees with ABI is expected to increase. This social background would encourage medical staff to rely more on neuropsychological assessment test scores to understand the cognitive abilities of those patients who need vocational support to transition from hospital to work.
Purpose: The purpose of the study was to clarify the subcategories of the Wechsler Adult Intelligence Scale that would predict the work ability of individuals with ABI.
Methodology: A systematic review and meta-analysis were conducted to identify specific cognitive functions related to work ability. Four original articles from MEDLINE, CINAHL, ERIC, CiNii, and the ICHUSHI database that met study inclusion criteria were analyzed.
Results: Results showed that there were four tasks under the verbal test—"vocabulary," "digit span," "arithmetic," and "similarities"—and two tasks under the performance test—"block design" and "coding"—that were predictive variables of work ability.
Conclusion: Assessing cognitive functions of individuals with ABI, such as "working memory," "continuous attention," "abstract thinking," "vocabulary and expression," and "time series processing," could more effectively predict work ability.

Keywords: acquired brain injury, work support, meta-analysis, neuropsychological assessment tool, cognitive function

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1. Introduction

There are an estimated 270,000 individuals with acquired brain injury (ABI) in Japan, and there are 70,000 in the labor force population between the ages of 18 and 65 [1]. According to a 2005 study, only 13.2% of all hospitals in Japan provided work support for individuals with ABI, which increased to 20% in 2015, though this was limited to certain types of hospitals, such as recovery phase rehabilitation hospitals [2]. Recently, more individuals with ABI have been expected to work since the new legal employment provision of 2018 was enacted to include those with psychiatric disabilities in the legal quota system. This provision requires private companies employing more than 45.5 employees to meet an employment rate of over 2.2% for individuals with disabilities. Further, it requires these companies to include individuals with psychiatric disabilities who have been diagnosed as part of the disability certification system—in addition to those with physical disabilities and intellectual disabilities—in this quota rate [3].

In Japan, part of the role of occupational therapists (OTs) is to act as work supporters who provide transition services from hospital to work using neuropsychological assessment tools, which provide necessary information about individual cognitive functions. The present authors conducted a meta-analysis of the effectiveness

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of neuropsychological assessment tools in providing "work support" transition services from hospital to work for individuals with ABI [4]. Results showed that the Wechsler's Adult Intelligence Scale (WAIS) "verbal test" scores of the employment group were significantly higher than those of the unemployment group. Although some studies showed a significant difference in intellectual functions between employment groups and unemployment groups [5–12], other studies demonstrated no such difference [13, 14]. Many previous studies used three test scores ("verbal test," "performance test," and "full scale test"), but these WAIS scores are often measured by therapists in a quiet room and not in a real workplace. Therefore, they are not practically usable with specific work environments in the vocational rehabilitation process. Furthermore, even though some previous studies used more detailed subtest items [15–18], no consensus has been reached among them as to which WAIS subtest items can predict the employability of individuals with ABI.

Therefore, the purpose of this meta-analysis and systematic review is to identify useful WAIS subtest items that can predict employability of individuals with ABI. In our study, such "useful" items were defined as the items that contributed to the significant difference in the WAIS subtest item scores between the employment and unemployment groups.

2. Materials and methods

2.1 Material selection and eligibility criteria

The eligibility criteria for the targeted studies were as follows: (1) studies that examine people with brain injuries, (2) studies that examine an employment and unemployment group using the results from WAIS-R or WAIS-III subtest items, (3) studies that list the average, standard deviation, and number of samples for the employment and unemployment group WAIS subtest items, (4) studies that have been published in academic journals, and (5) studies featured in original papers written in English and Japanese. The papers used in this study comply with the ethical standards of the Declaration of Helsinki.

3. Methods

3.1 Data collection

Using MEDLINE (1971), CINAHL (1981), ERIC (1966), ICHUSHI of the Japan Medical Abstracts Society (1977), and CiNii Articles (2005), we selected research articles that examined useful WAIS subtest items that could predict the employability of individuals with ABI. In addition to the database search, hand searches were conducted to exhaustively collect articles. Search terms for causal diseases of ABI were: "stroke," "brain damaged," "head injury," "cerebrovascular accident," "cerebrovascular disease," "brain injury," "subarachnoid hemorrhage," "cerebral infarction," "cerebral hemorrhage," "encephalitis," "cerebral hypoxia," "brain tumor," "CVA," and "CVD." Search terms related to work were: "return to work," "getting a job," "employment," "workplace resettlement," "social reintegration," and "vocational rehabilitation." These searches were performed on October 19, 2019.

3.2 Measures

The Risk of Bias Assessment Tool for Nonrandomized Studies (RoBANS) was used for qualitative evaluation of the collected research articles. The validity and reliability of the RoBANS has been verified [19]. Based on the criterion judgment of the RoBANS, the risk of bias was assessed for the following six domains: (a) selection of participants, (b) confounding variables, (c) measurement of intervention (exposure), (d) blinding of outcome assessment, (e) incomplete outcome data, and (f) selective outcome reporting. Research articles were evaluated using "High⊖," "Low⊕," and "Unclear⍰." More "Lows⊕" indicated better article quality.

3.3 Data Integration

Using Review Manager (RevMan) version 5.3.5 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014), we tested the means and standard deviations of the predictive WAIS subtest items, as well as some of the data obtained from the research articles, at a significance level of 5%. Given that continuous variables were collected for the present article, mean values were used as a scale for effect size calculations. Meta-analysis was conducted with the DerSimonian and Laird method, a statistical method for integrating the collected data, to enable the results of the present study to be utilized for the prediction of employability of other groups.

The results of the sensitivity and significance tests of all integrated data for the fixed effect model and random effect model were produced using Comprehensive Meta-Analysis Version 3 (Biostat Incorporated). When the results were consistent, we supposed the presence of sensitivity and those results were included in the present study. When the results were inconsistent, we supposed the absence of sensitivity and those results were excluded from the study. Statistical specificity was also tested using Review Manager (version 5.3.5), and the I^2 statistic was calculated. According to the Higgins et al. study [20], specificity should be high when the I^2 statistic is above 50%, which was the case in the present

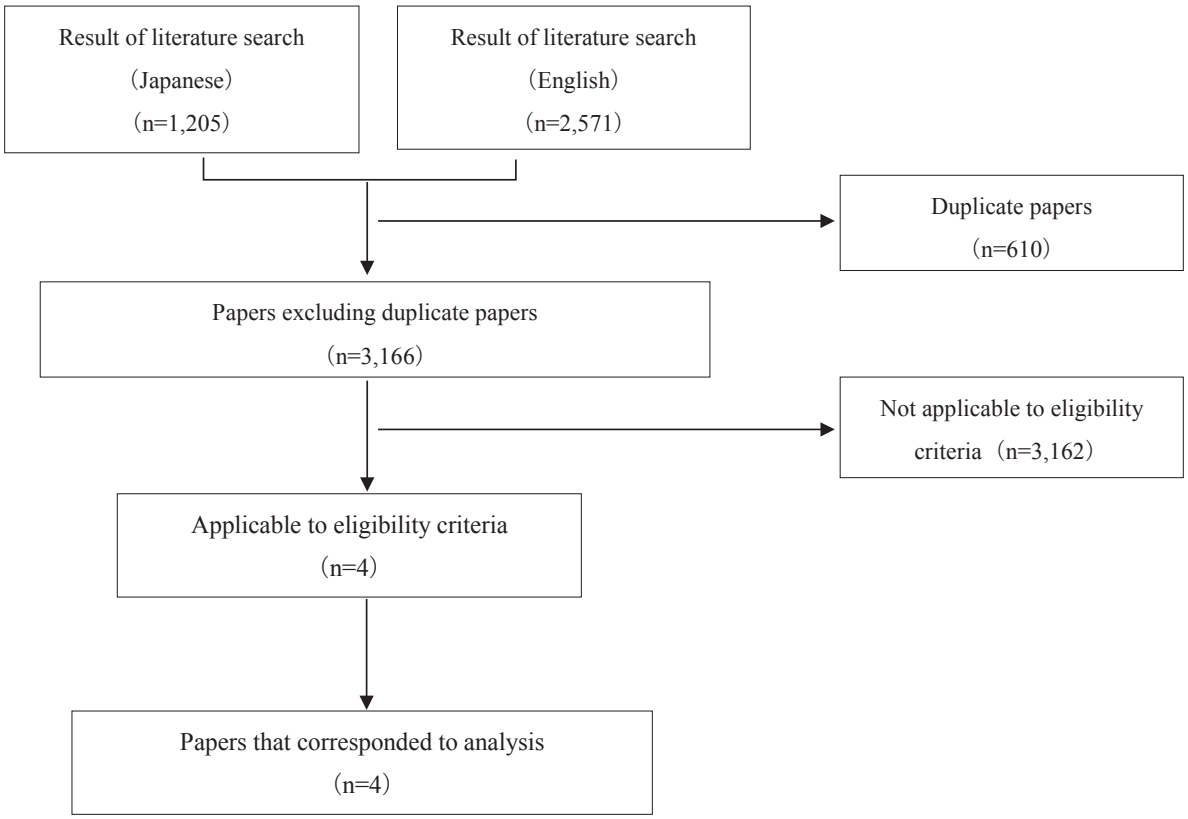

Fig. 1. Selection process for the literature search.

study.

3.4 Testing Publication Bias

A symmetric Funnel plot was produced from all the integrated data, using a 10% level of significance, as suggested by Egger's test [21].

4. Results

4.1 Collecting and selecting the studies

From the literature database, 3,776 articles were extracted. There were 1,677 MEDLINE, 808 CINAHL, 86 ERIC, 718 CiNii, and 487 ICHUSHI articles. However, 3,162 studies did not meet the inclusion criteria, and 610 were duplicates. No studies were obtained through a hand search and only four studies met the inclusion criteria set by the present study (Fig. 1).

4.2 Characteristics of the selected studies

Selected studies included three case-controlled studies (75%) and one prospective cohort study (25%). Table 1 shows that most of the cases included brain injury or stroke. All of the selected studies showed that the criterion judgment of the RoBANS was evaluated as "Low⊕" in (a) selection of participants, (b) confounding variables, and (c) measurement of intervention (exposure), "Unclear?" in (d) blinding of outcome assessment, and (e) incomplete outcome data (with the exception of one study, which was evaluated as "Low⊕"), and Low⊕" in (f) selective outcome reporting. The time elapsed since the occurrence of brain injury was 12.5 to 51.7 months, and the employment rate of individuals with brain injury was 34.5 to 52.6% (Table 1).

4.3 Efficiency of the WAIS subtest items

4.3.1 Verbal test

As a result of data integration from the four studies, there was a significant difference between the employment and unemployment groups' test scores in "vocabulary" (mean difference of 0.97; 95% CI [0.16, 1.78], $p = 0.02$); no statistical heterogeneity was found ($p = 0.64$, $I^2 = 0\%$; Fig. 2). Further, integration of the data resulted in a significant difference in "similarities" (mean difference of 1.42; 95% CI [0.56, 2.28], $p = 0.001$). Again, no statistical heterogeneity was found ($p = 0.56$, $I^2 = 0\%$; Fig. 2). There was also a significant difference in "arithmetic" (mean difference of 1.16; 95% CI [0.42, 1.91], $p = 0.002$); no statistical heterogeneity was found ($p = 0.78$, $I^2 = 0\%$; Fig. 2). Additionally, significant

Table 1 Research papers that corresponded to the analysis

Author	Year	Country	Research design	Disease and quantity of data	Average age (SD)	Male/ Female	Elapsed period after brain injury (SD)	Neuropsychological examination used	Employed/ Unemployed	Employment rates (%)
Tomita et al.[15]	1999	Japan	Case-control study	Traumatic head injury 60	28.1 (10.7)	56/4	employment group: 12.5 (27.3) months unemployment group: 25.4 (39.7) months	WAIS-R	26/34	43.3
Youine et al.[16]	2008	Japan	Case-control study	Traumatic head injury 26, Cerebral vascular disease 6, Hypoxia encephalopathy 3, Brain tumor 3	36.0 (11.3)	29/9	employment group: 51.7 (83.2) months unemployment group: 18.0 (19.4) months	WAIS-R, WMS-R, RBMT, TMT, Kanahiroi test, CAT, BADS	20/18	52.6
Sawada et al.[17]	2010	Japan	Case-control study	Traumatic head injury 70, Stroke 37, Hypoxia encephalopathy 3, Encephalitis & Meningitis 3	40.9 (14.3)	91/22	50.6 (72.4) months	WAIS-R, RBMT, TMT	40/73	35.4
Akamine et al.[18]	2015	Japan	Prospective cohort study	Traumatic head injury 18, Cerebral vascular disease 9, Brain tumor 1, Hypoxia encephalopathy 1	32.1 (10.7)	20/9	41.7 (57.1) months	WMS-R, WAIS-III, WCST, BADS	10/19	34.5

SD: standard deviation
WAIS-R (III): Wechsler Adult Intelligence Scale-Revised (III), WMS-R: Wechsler Memory Scale-Revised, RBMT: The Rivermead Behavioral Memory Test, TMT: Trail Making Test, CAT: Clinical Assessment of Attention, BADS: Behavioral Assessment of the Dysexecutive Syndrome, WCST: Wisconsin Card Sorting Test

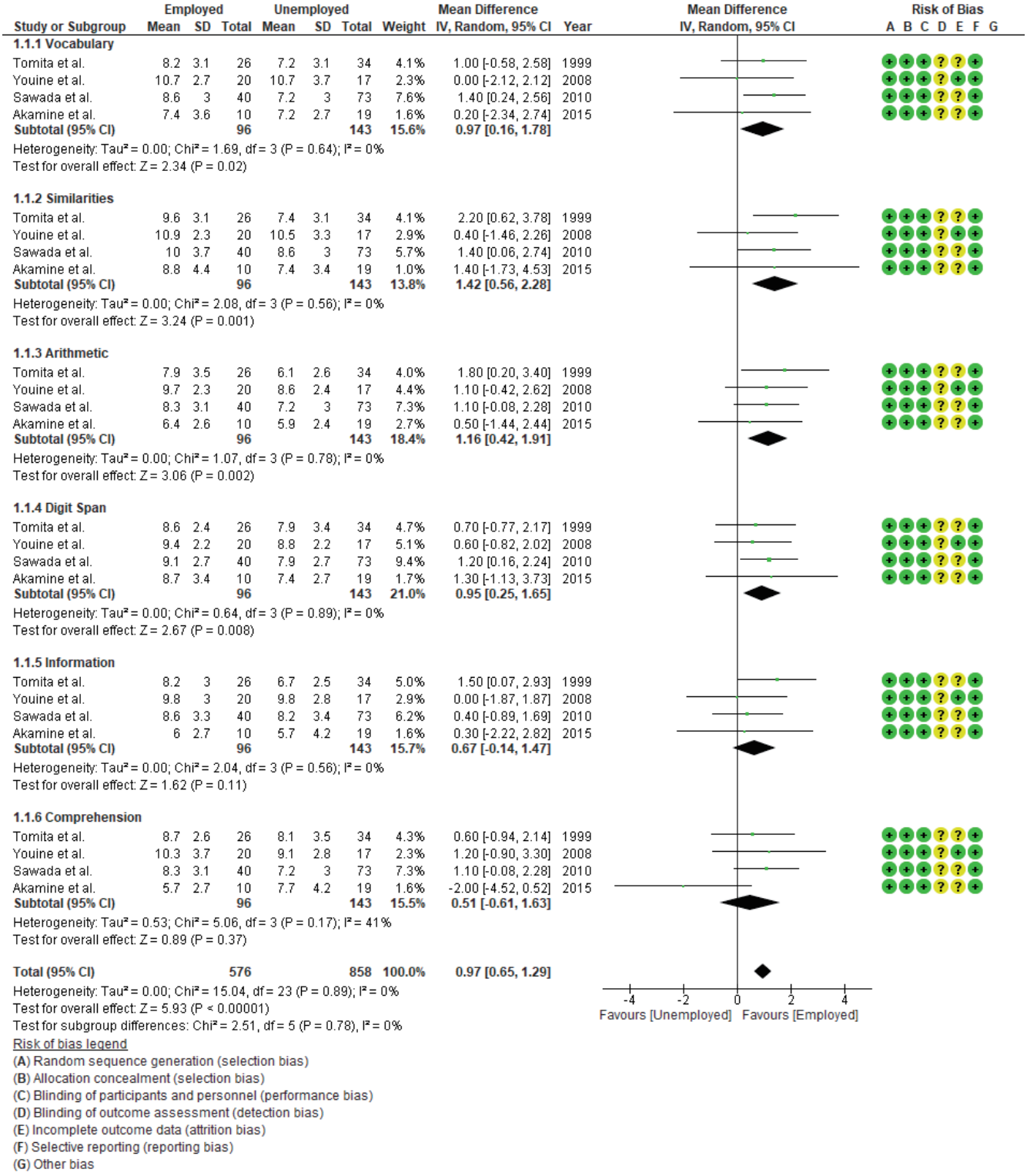

Fig. 2. Results of the meta-analysis of the employment and unemployment groups using the WAIS "verbal test" subtest items.

difference was found in "digit span" (mean difference of 0.95; 95% CI [0.25, 1.65], $p = 0.008$), and no statistical heterogeneity was found ($p = 0.89$, $I^2 = 0\%$; Fig. 2). There was no significant difference in "information" (mean difference of 0.67; 95% CI [−0.14, 1.47], $p = 0.11$); no statistical heterogeneity was found ($p = 0.12$, $I^2 = 49\%$; Fig. 2). Finally, there was no significant difference in "comprehension" (mean difference of 0.51; 95% CI [−0.61, 1.63], $p = 0.37$), and no statistical heterogeneity was found ($p = 0.17$, $I^2 = 41\%$; Fig. 2).

4.3.2 Performance Test

Data integration from the four studies resulted in a significant difference between the employment and unemployment groups' test scores in "picture completion" (mean difference of 1.05; 95% CI [−0.26, 2.36], $p = 0.12$), and statistical heterogeneity was found ($p = 0.06$, $I^2 = 59\%$; Fig. 3). There was also a significant difference in "coding" (mean difference of 1.37; 95% CI [0.63, 2.11], $p = 0.0003$), but no statistical heterogeneity was found ($p = 0.71$, $I^2 = 0\%$; Fig. 3). A significant difference was found in "block design" (mean difference of 1.91; 95% CI [0.99, 2.83], $p < 0.0001$); no statistical heterogeneity was found ($p = 0.64$, $I^2 = 0\%$; Fig. 3). In addition, there was no significant difference in "picture arrangement" (mean difference of 1.11; 95% CI [−0.76, 2.98], $p = 0.25$); statistical heterogeneity was found ($p = 0.002$, $I^2 = 80\%$; Fig. 3). There was no significant difference in "object assembly" (mean difference of 0.61; 95% CI [−0.31, 1.53], $p = 0.20$), and no statistical heterogeneity was found ($p = 0.43$, $I^2 = 0\%$; Fig. 3). Finally, no significant publication bias was found across all tests.

5. Discussion

The useful WAIS subtest items that could predict employability of individuals with ABI included four tasks under the verbal test ("vocabulary," "digit span," "arithmetic," and "similarities") and two tasks under the performance test ("block design" and "coding").

The "vocabulary" and "digit span" tests require one to have abilities such as working memory or continuous attention [22]; however, jobs that require employees to have considerable working memory assets can pose difficulties for ABI people in the workplace [23]. Recent studies clarified that the working memory of individuals with ABI could predict job retention two years after disability occurrence [24]. Other studies showed that 50% of ABI functional limitations are related to attention deficit, and that even typing becomes a vocational limitation in the workplace [23]. Furthermore, attention deficit has repeatedly been shown as one of the negative factors affecting employment of individuals with ABI [12, 17].

The "similarities" subtest requires abstract thinking through identification of commonalities among multiple sources of information [24]. The "block design" subtest in the perceptual reasoning index also requires abstract thinking. Sawada et al. [17] suggest that a certain decrease in abstract thinking abilities would make it difficult for an individual to cope with unknown tasks. One study shows that 73.1% of workers with ABI reported their difficulties in the workplace through the following statement: "when I face some new problems, I tend to get confused and have no idea how to cope with them" [23]. We can learn from this study that abstract thinking abilities in the workplace may significantly impact job retention. Moreover, "vocabulary" ability has been repeatedly identified as an important workplace asset where tasks such as paperwork and communication with coworkers using appropriate expressions are required to perform the job properly [14].

The "coding" subtest in the perceptual reasoning index requires one to cope with sequential tasks correctly and in a timely manner [24]. One study shows that 53.4% of workers with ABI reported that they might receive attention due to their impairments and supervisors might indicate that "their work is rather slow" [23]. This implies that sequential and systematic coping abilities are some of the key assets for retaining one's job. "Block design," as mentioned earlier in terms of abstract thinking, requires one to have a capacity for trial-and-error when new problem-solving skills are needed to perform challenging tasks [24]. It has also been shown that 53.4% of workers with ABI reported that "it was hard to change the working behavior accordingly when such a sudden change in my thinking and my flexible behavior is expected" [23]. For workers with ABI, limitations in their capacity for trial-and-error thinking and behavior change might negatively affect their ability to keep their jobs.

Given these cognitive requirements, test items such as "vocabulary," "digit span," "arithmetic," "similarities," "block design," and "coding" may be related to key cognitive functions necessary for the employability of individuals with ABI. It is suggested that occupational therapists use these findings to more effectively and efficiently assess and train their patients with ABI.

The employment rate of individuals with brain injuries was 40.7% one year after injury occurrence, and 40.8% two years after injury occurrence; as such, the time elapsed after brain injury was found to have no effect on employment rate [25]. On the other hand, it has been reported that the unemployment rate increases when the support period extends long after brain injury occurrence [26]. The employment rates in the four studies examined in this paper were similar to those of previous studies, and the employment rates didn't tend to change in the period after brain injury.

Given that the present study analyzes only Japanese papers, its generalizability is limited. Further research is needed to accumulate the results of WAIS subtest items from various countries, and to analyze these with respect to differences in social policy, welfare systems, work support programs, racial heterogeneity, test-taking culture, and other confounding factors between coun-

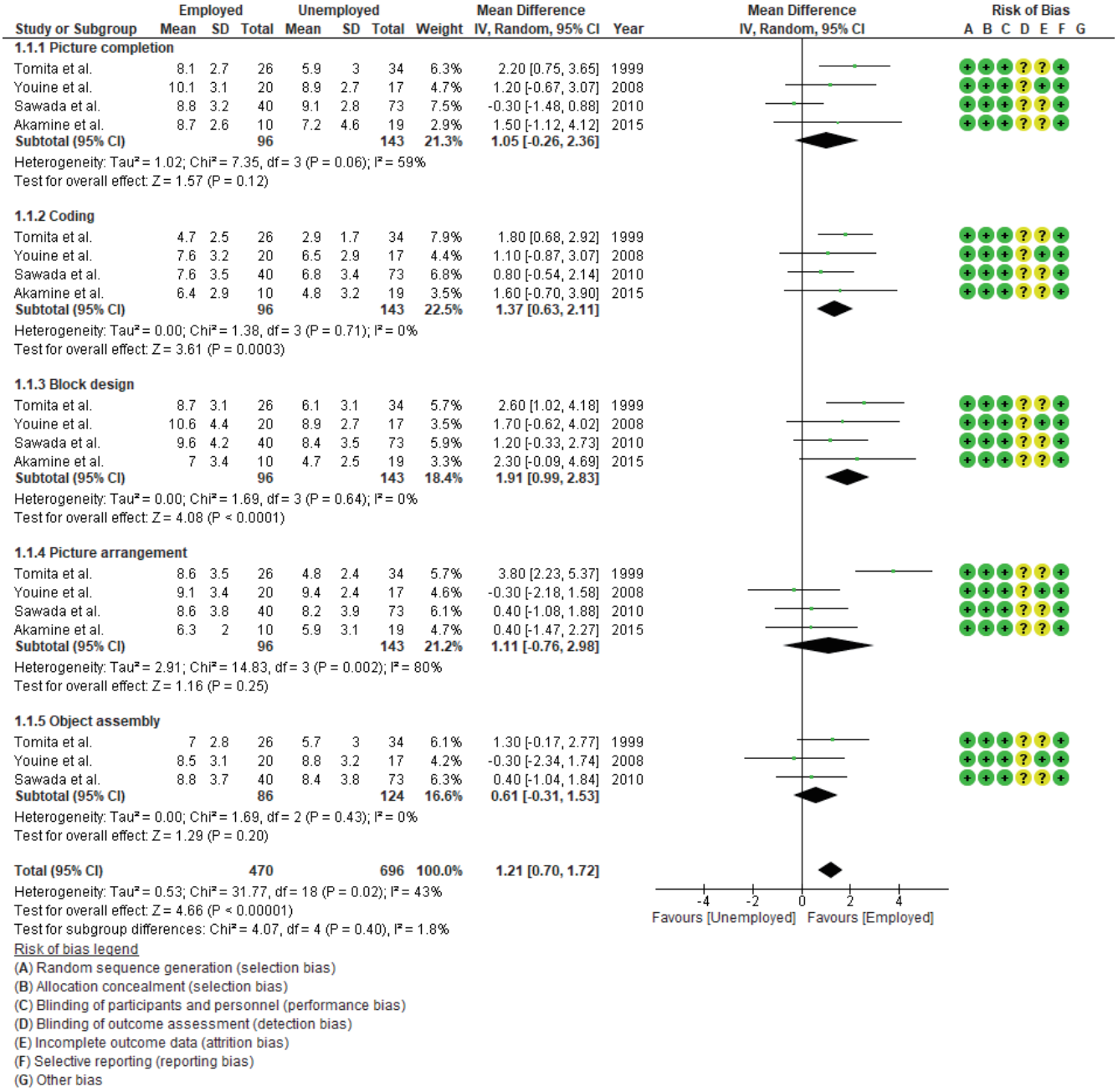

Fig. 3. Results of the meta-analysis of the employment and unemployment groups using the WAIS "performance test" subtest items.

tries. Such differences may affect the employability of ABI patients, their performance on neuropsychological tests, and the strategies and resources they utilize to procure and retain employment. We have endeavored to begin this process with a Japanese sample, and hope that others will follow in due course. One possible reason for why we could not find English articles on the WAIS subtest items is that some Western academics have been critical about using neuropsychological test results to predict employability [27]. Rather than excluding neuropsychological test results from these considerations, it is necessary to study these in tandem with the perspectives of family members, employers, and employees.

The present study is also limited because it included the results of only four studies in its analysis. However, identifying the useful WAIS subtest items related to specific cognitive functions that predict employability of individuals with ABI has practical implications for medical and vocational rehabilitation processes. Further studies are encouraged to use these neuropsychological subtests for daily assessment and intervention when planning and developing evidence-based vocational

rehabilitation programs for individuals with ABI.

6. Summary and Conclusions

A systematic review and meta-analysis were conducted to identify specific cognitive functions, as measured by the WAIS subtest items, that would predict work ability of individuals with ABI. As a result, we found that the cognitive functions of "working memory," "continuous attention," "abstract thinking," "vocabulary and expression," and "time series processing" were relevant for predicting employability.

In previous studies, there was no consensus on the relationship between WAIS scores and employment. Based on the results of this study, we think that the "vocabulary," "digit span," "arithmetic," "similarities," "block design," and "coding" subtests, which test the cognitive functions specified above, are useful WAIS subtests for predicting employability. These findings can be used effectively in vocational rehabilitation to design efficient and effective work support services for individuals with ABI. Further studies are encouraged to explore the relationship between these neuropsychological subtests and employability for other populations, and to examine its potential applications in rehabilitation settings.

Conflicts of Interest

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

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■ORIGINAL ARTICLE

Usefulness of the Dual-Task Stepping Test to Determine the Independent Toileting Ability of Patients with Stroke Who Could Perform Stepping in a Seated Position

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Abstract: Introduction: This study aimed to identify the usefulness of the dual-task stepping test to determine the independent toileting ability of patients with stroke.
Method: Sixty-seven stroke in-patients who were able to perform stepping in a seated position were enrolled in the study and underwent the dual-task stepping test. The relationships of the test results with other assessments (Berg Balance Scale, Mini-Mental State Examination, and the Attentional Rating Scale) with toileting ability, and with factors affecting toileting ability were investigated by regression analysis.
Results: Patients with low dual-task performance tended to have poorer balance, attentional, and cognitive abilities. The results of the dual-task stepping test and rates of independent toileting were distributed as follows: severe dual-task disability, 15.6% (5/32), mild dual-task disability, 64.7% (11/17); and normal dual-task ability, 94.4% (17/18). The dual-task stepping test results revealed a significant relationship between dual-task disability and toileting ability ($p < 0.01$). Logistic regression analysis showed that the dual-task stepping test had the highest odds ratio for toileting ability ($p = 0.00$; odds ratio, 14.50).
Conclusion: The dual-task stepping test was useful for determining independent toileting ability. This assessment is rapid and does not require special equipment or infrastructure, and has the potential for wide application in clinical practice.

Keywords: stroke, toileting, dual-task, assessment, rehabilitation

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Introduction

Independent toileting is an important activity of daily living (ADL) [1, 2]. For in-patients with stroke, independent toileting ability is essential for independent living because it is an activity that normally requires a standing position, and therefore, has a high risk for falls [3]. However, it is difficult to determine independence in this area owing to the number of components involved in toileting, such as motor function required to transfer between a toilet and a wheelchair, lower body dressing while standing, cognitive function required to control urination and defecation, and attention required to perform some of these functions simultaneously. The association between toileting ability and several rehabilitation evaluations have been reported, including the evaluation of motor function, Berg balance scale (BBS) [4], the Stroke Impairment Assessment (SIAS) [5], and the Functional Assessment for Control of the Trunk (FACT) [6]. Evaluations of cognitive function, such as the Mini-Mental State Examination (MMSE) [6],

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hemispatial neglect [7], and aphasia [8] have also been included. The BBS score is a significant predictor for the independent performance of most activities of toileting [4]. BBS cannot be considered a strong predictor for toileting ability, because it does not relate to the ability to control urination and defecation, which is an essential component of toileting. By clinical experience, even a patient with good physical balance does not always have independent toileting ability. Therefore, to evaluate independence in toileting, it is important to assess motor, cognitive, and attention functions simultaneously.

In recent years, dual-tasking (performing a motor and cognitive task simultaneously) has attracted attention as an indicator of performance ability. Patients with stroke have decreased dual-task ability compared with that of healthy elderly [9, 10] Also, independent walking and falls among patients with stroke are associated with changes in motor performance when a cognitive task is added, such as counting backward while walking or performing repetitive utterance tasks while sitting unsupported [11–18]. Therefore, it is important to assess motor performance ability during dual-task conditions. Although there are reports regarding dual-task ability and ADL [19–21], we are unaware of any reports that have investigated the role of dual-task assessment methods in determining the independent toileting ability of patients with stroke.

We previously investigated 55 patients with stroke and identified a relationship between toileting ability and the results of a dual-task assessment involving a cognitive task that was performed while the subject stepped in place in a seated position [22]. During this test, we observed the participants' ability to perform the task in the seating position with a comfortable speed for 30 seconds. The evaluation was performed by using a simple calculation wherein the associations among variables were statistically evaluated. The results showed that while motor performance was poorer during the dual-task compared with during a single task, there was no change in cognitive performance. We found that independent evaluation of toileting ability using dual-task was possible with 93.8% probability and when using BBS probability was 74.2%. In our previous study, the assessment required a personal computer monitor and other equipment. Furthermore, it was challenging to find an assessment method that could be easily performed in clinical practice. Accordingly, there is a need for an easy-to-administer assessment in clinical conditions. Therefore, this study aimed to identify the usefulness of the dual-task stepping test to determine the independent toileting ability of patients with stroke who can perform stepping in a seated position.

Table 1 Subject characteristics (n = 67).

Age (years)	–	67.5 ± 13.5
Sex	M/F	38/29
Diagnosis	Cerebral infarction	42
	Intracranial hemorrhage	16
	Subarachnoid hemorrhage	9
Disability	Right hemiplegia	23
	Left hemiplegia	27
	No paralysis	17
Leg BRS	III	2
	IV	5
	V	23
	VI	20
Time since onset (days)	–	57.9 ± 43.0
Means of mobility	Ambulatory/wheelchair	31/36
Toileting ability	Independent/assisted	33/34
Attentional rating Scale (points)	–	15.0 ± 16.4
BBS (points)	–	36.1 ± 16.0
MMSE (points)	–	23.3 ± 8.3
FIM, total of motor items (points)*	–	67 (46.0–80.5)
FIM, total of cognitive items (points)*	–	29 (24.5–33.5)

* Median (interquartile range).
BBS, Berg balance scale; BRS, Brunnstrom's recovery stage; F, female; FIM, Functional Independence Measure; M, male; MMSE, Mini Mental State Examination.

Subjects and Methods

Subjects

All patients were recruited from the 128 patients with stroke admitted to our hospital between January and December 2017. Exclusion criteria were as follows: patients were excluded if they were within 2 weeks of onset or when the onset of stroke was more than 6 months prior, history of brain injury, no ADL independence prior to onset, inability to follow simple verbal instructions, presence of pain that would affect the assessment, and instructions from the attending physician to restrict sitting up. Following exclusions, a total of 90 patients were enrolled. Among them, only those participants who could successfully step in place for 30 seconds while seated in a 40-cm-high chair were included in the study. Sixty-seven patients who were able to complete this task became the study subjects. The study subjects' characteristics are shown in Table 1. All participants provided informed consent. This study was approved by the Ethics Committee of Showa University School of Health Sciences (approval number: 366). The study was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Methods

Developing the Dual-Task Stepping Test

We developed, in the following order, the motor tasks, cognitive tasks, and the dual-task. The motor task included a common denominator for toileting that required the involvement of autokinetic movements of the lower limbs, including maintenance of balance, and could be performed in a seated position. These requirements would ensure testing of a wide range of subjects, including wheelchair users. Further, the task required a series of repeated motions to enable performance assessment, and performance assessment had to be simple and require minimal equipment. Consequently, the task that was selected was stepping in place for 30 seconds while seated in a 40-cm-high chair. This task was performed at a comfortable and constant pace and allowed for synkinesis. Stepping was also used as a motor task in a previous study [22] and had obtained highly valid results for an independent evaluation of toileting. To select the cognitive task, we aimed to create a task that included the following requirements: 1) requires a certain degree of effort, even by those who have maintained cognitive function, 2) allows for multiple repetitions of tasks with an identical level of difficulty to create a minimum learning effect, and 3) has reassessment reliability to provide an estimate of the patient's independent toileting ability during hospitalization. Consequently, the task we selected was to have the subjects recall the components of the lunch they ate on the assessment day (or breakfast, if the assessment was performed before noon). For subjects who did not take their food orally, the task was to list the types of medications they were currently taking. The usefulness and validity of these cognitive tasks have been confirmed in a previous study [23]. The subject's toileting ability assessment consists of dual-task: the motor task (stepping in place) and an cognitive task (to answer the lunch menu).

Data-gathering procedures

The subjects' dual-task ability was assessed by the performance of the motor task under the dual-task conditions based on results that have been established in previous studies [22, 24]. The examiner assessed three signs: (1) stepping stopped for 1.0 second or longer midway through the task; (2) stepping did not stop, but the feet were not more than half of the foot lifts before subjects answered the question; and (3) irregular pace. Sign 1 was indicative of severe dual-task disability, and signs 2 and 3 indicated mild dual-task disability. An absence of these signs indicated normal dual-task ability. The assessment procedure started with the subject seated in a 40-cm-high chair in a quiet private room. Assessors were provided with a predetermined assessment form for the dual-task stepping test (Fig. 1). Assessors carefully read the assessment procedures to the subject who was seated in the assessment chair and then carried out the evaluation. A single time assessment was performed for each patient. Assessors did not know the toileting ability of the subject.

Methods of Analysis

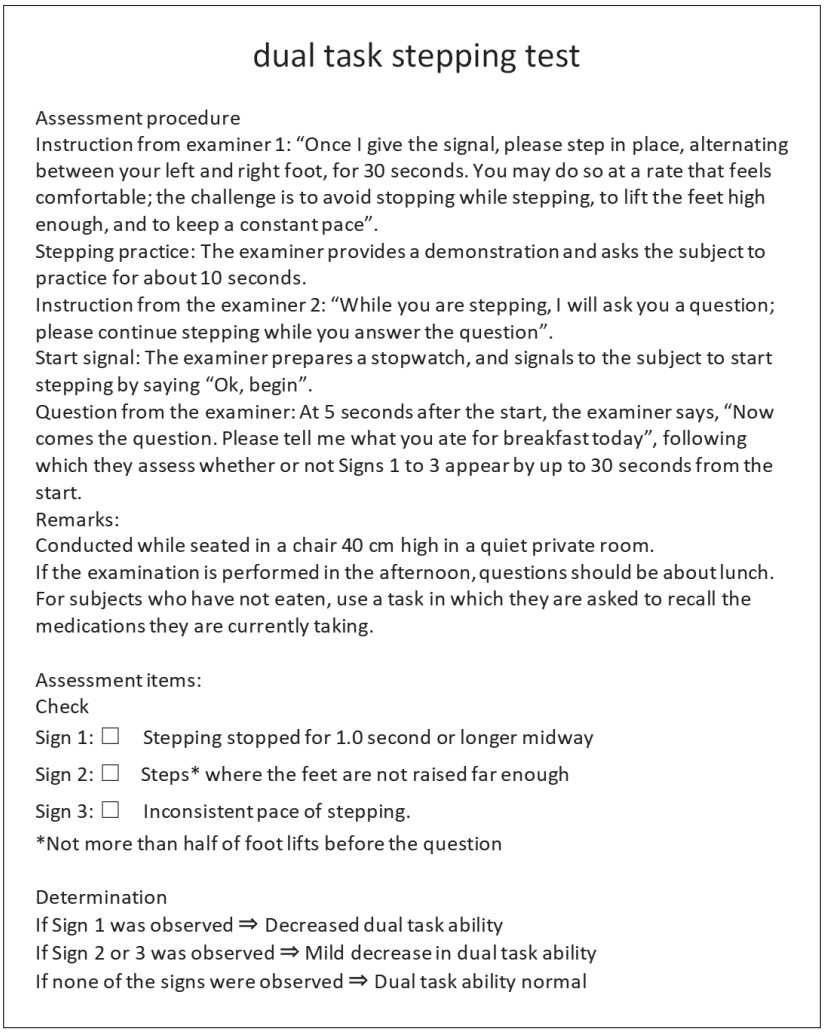
1. Comparisons of the groups classified according to the results of the dual-task stepping test and each assessment

Data collected at the time of the evaluation included baseline data regarding age, sex, diagnosis, stroke-affected side, Brunnstrom's recovery stage for the legs, time since the onset of stroke in days, means of mobility, toileting ability, and the total score of motor-related and cognitive-related items of the Functional Independence Measure (FIM), that were available from the subjects' medical records. The toileting ability for individual patients was determined using three procedures: (1) ability assessment in the toileting training scene by a therapist, (2) nurse assessment of the performance of toileting within ward life, and (3) attending physician's independent judgment of toileting ability following daily morning conferences. These procedures were identical for all subjects. Assessment methods used as part of data gathering included dual-task stepping test and BBS [25], MMSE [26], and attentional rating scale (ARS) [27], which are generally used in our clinic. The data from BBS, MMSE, and ARS were extracted from the hospital records of each research participant, classifying research subjects according to the dual-task stepping test. Comparisons of the groups classified (severe dual-task disability, mild dual-task disability, normal dual-task ability) basic information, and the different assessments were compared statistically.

Fisher's exact test was used to compare the three dual-task stepping test groups (severe dual-task disability, mild dual-task disability, normal dual-task ability) and each assessment to examine concurrent validity. The findings were with regards to the dual-task stepping test groups and sex, diagnosis, side affected by stroke, and means of mobility. The Steel-Dwass test was used for comparisons between the dual-task stepping test groups and age, Attentional Rating Scale, BBS, and MMSE.

2. Relationship between the seated position dual-task stepping test and toileting ability

The standard for independent toileting was a score ≥ 6 on the FIM. Findings from the dual-task stepping test and the rates of independent toileting were statistically compared. The accuracy of the determination of



dual task stepping test

Assessment procedure
Instruction from examiner 1: "Once I give the signal, please step in place, alternating between your left and right foot, for 30 seconds. You may do so at a rate that feels comfortable; the challenge is to avoid stopping while stepping, to lift the feet high enough, and to keep a constant pace".
Stepping practice: The examiner provides a demonstration and asks the subject to practice for about 10 seconds.
Instruction from the examiner 2: "While you are stepping, I will ask you a question; please continue stepping while you answer the question".
Start signal: The examiner prepares a stopwatch, and signals to the subject to start stepping by saying "Ok, begin".
Question from the examiner: At 5 seconds after the start, the examiner says, "Now comes the question. Please tell me what you ate for breakfast today", following which they assess whether or not Signs 1 to 3 appear by up to 30 seconds from the start.
Remarks:
Conducted while seated in a chair 40 cm high in a quiet private room.
If the examination is performed in the afternoon, questions should be about lunch. For subjects who have not eaten, use a task in which they are asked to recall the medications they are currently taking.

Assessment items:
Check
Sign 1: ☐ Stepping stopped for 1.0 second or longer midway
Sign 2: ☐ Steps* where the feet are not raised far enough
Sign 3: ☐ Inconsistent pace of stepping.
*Not more than half of foot lifts before the question

Determination
If Sign 1 was observed ⇒ Decreased dual task ability
If Sign 2 or 3 was observed ⇒ Mild decrease in dual task ability
If none of the signs were observed ⇒ Dual task ability normal

Fig. 1. Dual-task stepping test assessment form and instructions.

independent toileting was assessed using the dual-task stepping test classification (severe dual-task disability, mild dual-task disability, normal dual-task ability). Furthermore, the groups classified by the BBS (score ≤ 35, severe balance disability; 36–45, mild balance ability; and ≥ 46, normal balance) [28] and the rates of independent toileting were statistically compared.

Logistic regression analysis was performed using independent toileting ability or inability as the dependent variable. The independent variables were normal/low dual-task stepping test results (sign 1 not observed/observed), normal/low BBS score (cut-off, 46 points) [25], normal/low MMSE score (cut-off, 24 points) [26], young/old age (relative to 70 years), and normal/low Attentional Rating Scale score (cut-off, 0 points) [27]. Fisher's exact test was used for comparing the relationships between dual-task stepping test groups or BBS and toileting ability. Logistic regression analysis was performed to identify factors determining independent toileting ability. The software used for this analysis was JMP Pro version 13, with statistical significance set to less than 5%.

Results

Comparisons of the Groups Classified According to the Results of the Dual-Task Stepping Test and Each Assessment

All 67 subjects willingly completed the cognitive and dual-task stepping tests. The classification of the groups according to the dual-task stepping test was as follows: 32 subjects had a severe dual-task disability, 17 had a mild dual-task disability, and 18 had a normal dual-task ability. There were no significant differences between the groups for sex, diagnosis, and side affected by stroke. There were significant differences between the groups regarding their means of mobility ($p < 0.01$). There was a significant correlation between the groups

Table 2 Comparison of classifications according to the dual-task stepping test and each assessment.

		Severe dual-task disability (n = 32)	Mild dual-task disability (n = 17)	Normal dual-task ability (n = 18)	Test statistic	p-value
Sex	Male	14	12	12	−	0.14*
	Female	18	5	6		
Diagnosis	Cerebral infarction	18	12	12	−	0.81*
	Intracranial hemorrhage	8	4	4		
	Subarachnoid hemorrhage	6	1	2		
Side affected by stroke	Right hemiplegia	8	7	8	−	0.27*
	Left hemiplegia	17	4	6		
	No paralysis	7	6	4		
Means of mobility	Wheelchair	24	9	3	−	< 0.01*
	Ambulatory	8	8	15		
Age (years)	−	71.8 ± 12.5	66.0 ± 13.9	61.0 ± 12.5	S-N: 2.52 S-M: 1.38 M-N: −1.17	0.03† 0.34† 0.46†
Attentional rating Scale (points)	−	26.6 ± 16.4	7.3 ± 9.8	2.4 ± 4.4	S-N: 5.71 S-M: 4.74 M-N: −1.97	< 0.01† < 0.01† 0.11†
BBS (points)	−	32.0 ± 18.1	42.7 ± 9.5	46.8 ± 8.8	S-N: −4.04 S-M: −3.24 M-N: 1.42	< 0.01† < 0.01† 0.32†
MMSE (points)	−	18.9 ± 9.5	25.9 ± 4.9	28.5 ± 2.1	S-N: −4.51 S-M: −2.90 M-N: 1.86	< 0.01† 0.01† 0.14†

* Fisher's exact test.
† Steel-dwass test. BBS, Berg balance scale; MMSE, Mini Mental State Examination; S, Severe dual-task disability; M, Mild dual-task disability; N, Normal dual-task ability

regarding age; older patients demonstrated poorer dual-task performance compared to younger patients (p = 0.03). There were significant differences between groups regarding their BBS, MMSE, and the Attentional Rating Scale scores ($p < 0.01$). In conclusion, participants with poorer dual-task assessment scores tended to have poor motor, attentional, and cognitive functions and were of higher age (Table 2).

Relationship Between the Dual-Task Stepping Test and Toileting Ability

The rates of independent toileting for the three groups were as follows: severe dual-task disability, 15.6% (5/32); mild dual-task disability, 64.7% (11/17); and normal dual-task ability, 94.4% (17/18). This relationship between the groups and toileting ability was statistically significant ($p < 0.01$). The rates of independent toileting for the groups classified by the BBS were as follows: severe balance disability, 24.1% (7/29); mild balance disability, 40.0% (6/15); and normal balance, 87.0% (20/23) ($p < 0.01$). The dual-task stepping test classification was more accurate than that of the BBS, and the rate of independent toileting in the group identified as having normal dual-task ability was very high (94.4%).

Analysis of Toileting Ability Using Logistic Regression

The results of the logistic regression analysis with independent toileting ability or inability as the dependent variable revealed that the dual-task stepping test ($p < 0.01$), BBS ($p = 0.01$), and MMSE ($p = 0.03$) were significant indicators of toileting ability (Table 3). The odds ratio was 14.50 for the dual-task stepping test, 9.69 for BBS, and 9.25 for the MMSE, indicating that the dual-task stepping test was the strongest indicator of toileting ability.

Discussion

Dual-task ability is assessed by the performance of a motor task under dual-task conditions. Woollacott et al. [24] reported that elderly persons tended to give priority to a cognitive problem under dual-task conditions, with the result that their motor performance was diminished by the secondary task. In our previous study involving the dual-task evaluation of in-patients with

Table 3 Logistic regression analysis with toileting ability as a dependent variable

	Likelihood ratio (chi-square)	Odds ratio	p-value
Age	0.57	1.94	0.45
Dual-task stepping test	11.61	14.50	< 0.01
BBS	7.28	9.69	0.01
MMSE	5.57	9.25	0.03
Attentional Rating Scale	0.40	1.84	0.53

BBS, Berg balance scale; MMSE, Mini Mental State Examination

stroke, although there was a drop in motor performance under dual-task conditions, there was no change identified in cognitive performance [22]. In attempting to classify patients, we assumed that sign 1 (stopped stepping) represented a clear decrease in dual-task ability because the cognitive task of remembering the last meal caused a temporary but total loss of attention to the stepping activity, while sign 2 (feet were not more than half of the foot lifts before subjects answered the question) and sign 3 (irregularly pace) represented a milder decrease in dual-task ability because signs 2 and 3 indicated their reduced attention paid to stepping. Patients who did not have any of these signs had the normal dual-task ability because they were able to distribute their attention to both tasks adequately. This assessment involved simultaneous motor and cognitive tasks, and participants' dual-task ability was assessed based on their motor performance. Because the elements of motor, cognitive, and attentional functions were involved from the beginning of the test, we predicted that all the tested functions would be reflected in the results. Following the classification of our subjects based on the results of the dual-task ability test, we found that the groups were significantly different for BBS, MMSE, and Attentional Rating Scale scores. This confirmed that our assessment could accurately test for motor, cognitive, and attentional functions, and provided criterion-related validity that our test was actually a dual-task assessment. Further, we also found significant differences in the mean ages between the groups. Our findings that aging reduces dual-task ability are consistent with previously published research [29–31].

In this study, we were able to assess dual-task that appealed to using physical and cognitive functions used simultaneously, which differs in the quality of movement when compared to walking or standing (commonly used motor tasks). There were three possible reasons for this. First, many of the study subjects required assistance with ADL and had a total score of 67.0 points for FIM motor items; therefore, they experienced a high degree of difficulty with movement even while seated and required an increased amount of attention to perform motor tasks. Second, we used a relatively difficult cognitive task of recalling the contents of the last meal, which may have created a high level of interference. Third, there are differences in the way the brain works when walking and when stepping in a seated position. Apart from the initiation of walking and changing directions, walking is performed subconsciously by central pattern generators of the spinal cord [32]. This involves minimal activation of the prefrontal area, where conscious decisions are made that require an additional amount of attention [33]. On the other hand, stepping while seated involves a high level of conscious activity during the lifting of the feet. Therefore, interference from the recall task, which requires activation of the prefrontal area, is expected to affect performance. For these reasons, the dual-task ability can be assessed even when an activity is performed in a seated position, supporting the relevance and applicability of the dual-task stepping test among patients with stroke who have physical impairments, including wheelchair users.

The results of this study demonstrated a relationship between dual-task assessment and toileting ability. Assessments related to toileting ability that included other evaluations, such as the BBS, have also been noted [4–8]. However, unlike our study, other studies have not reported a relationship between dual-task assessments. Dynamic standing is associated with an increase in body sway, activates the prefrontal area, and requires conscious postural control [34]. In this study, patients with stroke who had some physical disability needed a certain level of attention to maintain dynamic standing while their clothes were pulled down. To perform this function, they must also focus their conscious attention on other events, such as pulling their clothes down with one hand. Additionally, greater cognitive and attention functions are required to control urination and defecation. This may be why toileting ability was determined with higher accuracy by the dual-task assessment that included elements of motor, cognitive, and attentional functions, unlike the BBS, which is an assessment of motor function. Only this test was developed with the goal of reflecting the ability to simultaneously focus attention on two events while assessing motor, cognitive, and attentional functions; therefore, the extent of these disabilities was not controlled when the subjects were being selected. It is therefore difficult to determine whether the cause of low scores for the dual-task assessment was increased attention given to the action due to motor function impairment, increased attention given to the recall task due to decreased cognitive function, or impairment of the ability to properly divide one's attention between two tasks. In all cases of disability, motor,

cognitive, and attentional functions need to be assessed in greater detail to investigate its underlying cause.

Toileting for persons who had a stroke can involve a high risk of falling. Generally, elaborate observations are necessary to judge independence in toileting. However, an evaluation can be easily divided into sections by observers. This assessment is significant for clinical practice because it can be used to evaluate toileting ability, and will be helpful when considering whether the independence level based on the dual-task ability is normal. In Japan, the level of toileting independence of an in-patient with stroke is often decided during a team conference. When team members insist that a patient with poor balance has toileting independence, they can use the results of this evaluation as objective evidence to support their judgment.

This study had some limitations. Interpretations of the results were limited to the subjects of the present study, and it was a single-center study; therefore, it lacked external validity. Additionally, the sample size was rather small. Only one measurement was performed, and the reassessment reliability was not studied. Additionally, the movements were not observed in the real toilet setting; therefore, whether patients were able to perform toileting activities is not known. Finally, it was difficult to obtain normative values for dual-task assessments.

Conclusion

Toileting ability of patients with stroke can be evaluated using a dual-task assessment. Our dual-task stepping test was useful for determining independent toileting ability. This study found that toileting ability was affected more than balance, attention, or cognitive functions by the dual-task stepping test, which has widespread use in clinical practice.

Conflicts of interest

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Abbreviations

ADL, Activities of Daily Living
BBS, Berg Balance Scale
CPG, Central Pattern Generator
FACT, Functional Assessment for Control of Trunk
FIM, Functional Independence Measure
MMSE, Mini Mental State Examination
SIAS, Stroke Impairment Assessment

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■ORIGINAL ARTICLE

Out-of-home Activity Accessibility Checklist for Parents of Children with Gross Motor Dysfunction

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Abstract: Background: Parents of children with gross motor dysfunction often face obstacles when performing out-of-home activities with their children. However, little is known concerning their situation.
Objective: This study aimed to develop an out-of-home activity accessibility checklist for parents of children with gross motor dysfunction that clarifies their situation during these activities.
Method: Parents of children with gross motor dysfunction participated in semi-structured interviews to generate a tentative accessibility checklist. Then, Delphi questionnaire survey was conducted to determine appropriate checklist items.
Result: Fifteen participants involved in the semi-structured interview and 124 tentative checklist items were generated. Then, 56 participants involved in Delphi questionnaire survey and tentative checklist items was reduced to 39. These checklist items were grouped under the domains of obstacles, coping strategies, and required assistance and resources. Most obstacles were caused by the lack of equipped infrastructures.
Discussion: Most obstacles faced by parents of children with gross motor dysfunction were caused by the lack of infrastructures that were barrier-free. The parents had to collect extensive information prior to outings as coping strategies. Therefore, parents require society level environment improvement in order to participate in out-of-home activities. The checklist may provide local communities with valuable information to construct more accessible environments and inclusive communities.

Keywords: gross motor dysfunction, family support, social participation, parents

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Introduction

Children with gross motor dysfunction face various obstacles when participating in out-of-home activities; activities performed outside the home such as leisure activities and IADLs, compared with children without. Furthermore, their parents may face additional obstacles during outings with their children.

There are several factors that would limit the participation of children from out-of-home activities such as gross motor dysfunction [1], maladaptive behaviours [1], family relationships [2], parent fatigue [3, 4], unsuitable environments [3, 5–7], and attitude and behaviours of the general public [4–6, 8]. Previous studies mostly examined the participation in out-of-home activities that were focused on leisure or school activities.

In terms of environmental assessment, many accessibility checklists had been developed and applied [9–11]. These checklists aimed to evaluate how a community, specific place, event and activity etc. accessible for people with disabilities to generate inclusive environment. Therefore, these checklist items did not reflect their individual factors that disturb their participation.

The participation in out-of-home activities is also limited for parents when they go out together with their children who have gross motor dysfunction. For example, Davis et al. (2010) indicated that some families of children with gross motor dysfunction gave up leisure activities, such as family trips, due to difficulties in finding convenient barrier-free destinations. In addition to leisure activities, parents may need to go out with their

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children for instrumental activities of daily living (IADL) such as shopping, financial management, or child rearing [12].

Currently, it is unclear what specific obstacles parents of children with gross motor dysfunction encounter in social settings of IADLs compared with leisure activities. Therefore, the purpose of this study was to establish an out-of-home activity accessibility checklist for these parents to document their obstacles, coping strategies, and required resources when they perform out-of-home activities with their children.

Method

Study design

The Delphi technique, an established method to develop diagnostic criteria or new evaluation tools for diseases and medical conditions, was used to determine the appropriate checklist items to evaluate the out-of-home activity accessibility for parents of children with gross motor dysfunction [13, 14]. In this study, parents were recruited if they (a) had children with gross motor dysfunction; children with physical disability (e.g., cerebral palsy, spina bifida, etc.) and that affect their mobility aged between two and 18 years, (b) were the primary caregiver, (c) had children who lived with them, and (d) had children who, at least once a month, visited a paediatrician, occupational, or physical therapist at our cooperating institutions.

The Delphi questionnaire was developed using the following process that would establish the out-of-home activity accessibility checklist items. First, face-to-face semi-structured interviews were conducted with some participants. The transcribed data were analysed to generate a tentative accessibility checklist. Through a revision process, the first-round Delphi questionnaire was developed by assessing the appropriateness of each tentative checklist item. Other participants were asked to answer the three rounds Delphi questionnaires in order to reach a consensus in the tentative items by rating them on a five-rank Likert Scale. Finally, the accessibility checklist items to be used were obtained from those that achieved a consensus of $\geq 80\%$. The protocol for the research project was approved by the Ethical Committee of the university. Informed consent was obtained from all participants prior to data collection.

Procedure to establish the out-of-home activity accessibility checklist items

Qualitative study to formulate first-round Delphi questionnaire

Step 1. Generate tentative out-of-home activity accessibility checklist items

Participants residing in the central and west-central region of Japan participated in this process between October 2014 and March 2015. Face-to-face semi-structured interviews were conducted to explore any possible items for the accessibility checklist. By considering concrete examples of outings for IADLs and leisure activities, the participants answered the following questions: obstacles encountered, coping strategies, and forms of assistance or resources that were required when they went out with their children with gross motor dysfunction. The first author of this paper, who carried out the interviews, was not associated with the collaborative institutions or the study participants.

Each interview was audio-recorded with the participants' consent and transcribed verbatim. The entire transcript was cut into minimal meaning units, and the units were deductively divided into the domains of obstacles, coping strategies, and required assistance and resources. Then, inductive analysis [15] was taken to discern similarities among the meaning units. Similar meaning units were grouped together and categories were developed by naming these groups. These categories created the tentative accessibility checklist items. After the analysis for both IADLs and leisure activities were finished, the tentative accessibility checklist items were examined whether they were specific for IADLs, leisure activities, or were a common feature to both. Both of the authors were involved in the entire analysis process.

Step 2. Develop first-round Delphi questionnaire consisting of the tentative items

The tentative accessibility checklist items from both the obstacles and coping strategies domains were sorted by three processes: planning and preparing for the outing, transit, and performance of the aimed activities at the destination. Next, the prototype first-round Delphi questionnaire was developed. A five-rank Likert Scale was applied to examine how appropriate the tentative items were as an out-of-home activity accessibility checklist for the parents of children with gross motor dysfunction using a range from one (definitely inappropriate) to five (definitely appropriate). The participants residing in the central region of Japan were involved in the revision process for the first-round Delphi questionnaire prototype between July and August 2016. They were asked to answer the first-round Delphi

questionnaire prototype and to give their opinions regarding the ambiguity of the questionnaire items, any issues regarding answering the questionnaire items, the layout of the questionnaire, and any further comments or suggestions. Based on their responses, the first-round Delphi questionnaire was revised and finalized.

Delphi questionnaire survey

A different set of participants living in western Japan participated in the Delphi questionnaire survey to assess the accessibility checklist items. The survey was iterated three times (Hsu et al., 2007) and was given once every three months between September 2016 and May 2017. The authors sent each round of the questionnaire to the collaborating institutions, where the staff provided the questionnaires to the participants. After the participants filled out the questionnaire, they were collected and sent back to the authors. In the first-round survey, the participants answered the first-round Delphi questionnaire developed through the qualitative study. During the second and third-round surveys, the participants who participated in the previous surveys reassessed the same questionnaire items but also took into account the score distribution from the previous questionnaire that was shown by a band chart. Some items of the questionnaire in the previous rounds were reassessed, modified, or newly added based on the opinions from the open-ended comment box in the previous surveys. The questionnaire also asked the participants for information regarding themselves and their child (sex, age, diagnosis, etc.). The tentative accessibility checklist items were narrowed down to those that provided concise information associated with the performance of out-of-home activities of parents of children with gross motor dysfunction. A consensus was defined as ≥ 80% agreement as determined by the results from the third-round survey [16, 17].

Results

Qualitative study to formulate first-round Delphi questionnaire

Step 1. Generate tentative out-of-home activity accessibility checklist items

Fifteen participants involved in the semi-structured interview, and the data of 14 participants were analysed. One participant data was excluded because she could not answer all of the questions. The average length of the interviews was 31 ± 9 (range, 13–45) minutes. All the participants were female (mothers) and were 42 ± 5 (range, 31–48) years old. Their children were 6 ± 5 (range, 2–16) years old of which 11 had cerebral palsy (including periventricular leukomalacia, PVL), two had spina bifida, and one had chromosomal abnormalities. A total of 124 tentative checklist items were generated by the qualitative procedure from step 1. Of the tentative items, 80, 34, and 10 were classified in the obstacles, strategies, and required assistance and resources domains, respectively.

Step 2. Develop first-round Delphi questionnaire consisting of the tentative items

Three participants participated in a revision process. Based on their feedback, the tentative checklist items were reconsidered, modified, or integrated. As a result, the total number of tentative items was reduced to 115. Of these, 72, 34, and nine were classified into the obstacles, strategies, and required assistance and resources domains, respectively. The revised list of items formed the first-round Delphi questionnaire.

Delphi questionnaire survey

Forty-three of 56 participants (77%) completed three rounds of the iterative survey (Table 1). Twenty-four and six new items were added to the second-round and third-round questionnaire, respectively. As a result, a total of 145 tentative items were examined in the third-round questionnaire survey. In the third-round questionnaire survey, the average age of the participants was 41 ± 5 (range, 31–50) years, and the age of their children was 8 ± 5 (range, 2–18) years. Of these children, 21 (48%) had cerebral palsy (including PVL, infantile encephalitis, etc.), 10 (23%) had anomalies of the central nervous system (including spina bifida, hydrocephalus, etc.), eight (18%) had chromosomal abnormalities, one (2%) had developmental motor retardation, and five (11%) had no described conditions. Thirty-seven of 44 (84%) children required assistance to move around outdoors to some degree. Since 39 of the 145 (27%) items had a consensus of 80% or greater, they were adopted into the accessibility checklist (Table 2).

Discussion

This study developed an out-of-home activity accessibility checklist items for the parents of children with gross motor dysfunction. The checklist consisted of 39 items to obtain information regarding the process of out-of-home activities in terms of obstacles, coping strategies, and required resources.

Similar to previous studies [3, 4, 18, 19], most of the study participants were mothers even though the inclusion criterion was primary caregivers. In the qualitative study process, 57% of children required assistance to move outside to some degree and, of these, 71% had

Table 1 Demographic characteristics of subjects and their children with gross motor dysfunction

Round	1	2	3
Subjects			
Gender			
Female	51	45	39
Male	1	1	1
Not described	3	3	3
Age (years)	40 ± 5	41 ± 5	41 ± 5
Children[a]			
Gender			
Female	32	29	25
Male	23	20	18
Not described	1	1	1
Age (years)	7 ± 5	8 ± 5	8 ± 5
Diagnosis			
Cerebral palsy[c]	31	31	21
Nervous system deformity[d]	10	5	10
Chromosome abnormality	9	9	8
Others	2	0	1
Not described	5	6	5
Assistance with outdoor mobility			
Requires assistance	47	41	37
Independent	7	7	5
Not described	2	2	2
Use of facilities			
Developmental support centres[e]	20	15	10
Special classrooms	6	6	4
Special schools	24	24	24

Note. [a] The number of subjects and their children are not the same due to the inclusion of one parent of twins with movement disorders.
[b] Multiple answers were allowed under the diagnosis category.
[c] Cerebral palsy included periventricular leukomalacia, infantile encephalitis, etc.
[d] Nervous system deformity included spina bifida, hydrocephalus, etc.
[e] Developmental support centres are facilities that provide medical treatment and education for pre-school children with disabilities.

cerebral palsy. In the third-round Delphi questionnaire survey, 83% of children required assistance to move outside to some degree and, of these, 48% had cerebral palsy. The Japanese Ministry of Health, Labour and Welfare (2008) reported that 83% of children with gross motor dysfunction required assistance to move outside to some degree, and, of these, 48% had cerebral palsy. Therefore, the third-round Delphi questionnaire survey participants represented the children with gross motor dysfunction in Japan well. However, there was a discrepancy in distribution of disorders and severity between the qualitative study process and questionnaire survey participants, and this may lead to a large increase in number of tentative checklist items in the second-round questionnaire survey.

This study focused on the accessibility for parents of children with gross motor dysfunction when they perform out-of-home activities in terms of IADLs and leisure activities. However, the parents take care of their children whenever they go out with their children even though they perform leisure activities. In particular, parents collected extensive information regarding places they could visit for leisure activities, such as family trips or dining (#28–32), prior to their outing. The results from this study also indicated that some gave up these activities when they felt inconvenienced by their children based on the destination information and experiences from the past (#2, 3). In addition, the parents had more care burdens during prolonged outings for leisure activities since they involved feeding (#21), bathing (#25–27) as well as washroom assistance (#17–19). Previous studies also showed that prior unfavourable experiences due to unsuitable environments and attitudes and behaviours of the general public negatively affected family leisure activities [3, 4].

In the obstacles domain, there were two types of checklist items: individual level items relating to children (e.g. #1, 2) and families (e.g. #15, 20), and society level items relating to environment (e.g. #5–12) and social attitude (e.g. #3, 4, 13). The majority of items (23 items) were society level items. Several studies have also reported that unsuitable environments and attitudes and behaviours of the general public limited the participation of children with disabilities and their families [3, 4, 6, 8, 21]. Furthermore, all the items established in the required assistance and resources domain required society level improvement (#35–39). These results indicate that many obstacles were due to physical and social environments and that society level improvement is required to overcome these challenges. Recently, the number of occupational therapists involved in community development is increasing [22]. Since occupational therapists are unique professionals with diverse knowledge regarding medical disabilities and environment evaluation [23], occupational therapists may help in encouraging families of children with gross motor dysfunction to participate in out-of-home activities through their involvement in community environment coordination, educational activities to enhance the understanding of disabilities to the public as well as their direct intervention with children.

Limitations to our study may include the lack of certain background information of participants such as severity of their child gross motor dysfunction, major mode of transport, marital status, employment status, socioeconomic status, and educational background. This information may have affected the outcome of our study. In addition, there is no existing nationwide statistical data with this type of caregiver information to compare

Table 2 Consensus ratio and characteristics of the determined checklist items (n = 43).

Questionnaire item	Consensus ratio (%)	Category classification	
		Purpose[a]	Factor[b]
Obstacles domain			
1. Planning and preparing for outings			
#1 Restriction in the type of destination due to weather	95	C	I
#2 Hesitation or resignation of outing due to lack of human resources for child care	81	L	I
#3 Few or no appropriate places for children with disabilities to play safely (e.g., environment/other children)	93	L	S
2. Transit			
#4 Lack of parking for those with disabilities (e.g., insufficient number/misuse by general public)	83	C	S
#5 Lack of space to move wheelchairs in parking lot	88	C	S
#6 No roofs over parking lot	95	C	S
#7 No elevators at station	86	C	S
#8 Roundabout route to elevator	86	C	S
#9 Complicated layout of large stations	84	C	S
#10 Large number of stairs at subway stations	84	C	S
#11 Long distance between entrance gate to boarding area at stations	81	C	S
#12 Large gap between train and platform	88	C	S
#13 Worries in moving around crowded stations by wheelchair (e.g., attitude of general public)	81	C	S
#14 Uneven footpaths	81	C	S
#15 Difficulty in using umbrellas while pushing wheelchair	91	C	I
3. Performance of aimed activities at destination			
#16 Long wait times for crowded elevators (e.g., insufficient number/ thoughtlessness of general public)	81	C	S
#17 Lack of equipped restrooms for people with disabilities (e.g., insufficient number/misuse by general public)	86	C	S
#18 Lack of space to move wheelchairs in restroom	88	C	S
#19 No appropriate change tables for people with disabilities	95	C	S
#20 Difficulty in handling both shopping cart and wheelchair at grocery stores	91	P	I
#21 No appropriate chairs for children with disabilities at restaurants	84	L	S
#22 Rough walkways at tourist sites	93	L	S
#23 Few equipped attractions for people with disabilities at amusement parks	86	L	S
#24 Narrow entrance gates for wheelchairs	84	L	S
#25 Slippery floors at pools/public baths	88	L	S
#26 Limited space to take care of child at pools/public baths	91	L	S
#27 Difficulty in taking adolescents of the opposite sex to pools/public baths (e.g., environment/social stigma)	88	L	S/I
Coping strategies domain			
1. Planning and preparing for outings			
#28 Plan to re-visit familiar facilities	81	L	
#29 Reserve a private room or other appropriate environment for dining out	86	L	
#30 Check facility for barrier-free access (e.g., ramps and elevators)	84	L	
#31 Check availability of washrooms for those with disabilities	81	L	
#32 Check discount information for people with disabilities (i.e., if the facility has a discounted entrance fee, it may be equipped for people with disabilities)	86	L	
3. Performance-aimed activities at certain places			
#33 Use of a shoulder bag or backpack to take care of their children	86	C	
#34 Bring children's extra clothes	88	C	
Required assistance and resources domain			
#35 Improve restroom environment (e.g., include change tables for people with disabilities)	98	C	
#36 Equip rooms for rest/meals etc. for people with disabilities	81	C	
#37 Improve footpaths, and reduce the number of barriers, stairs, and potholes	95	C	
#38 Implement footpaths with roofs	93	C	
#39 Increase parking area for people with disabilities	93	C	

Note. [a] Classification by purpose of out-of-home activities. C: common items for both IADL and leisure activities. P: particular items for IADLs such as grocery shopping, dropping off and picking up children from school, etc. L: particular items for leisure activities such as family trips, etc. [b] Classification by level of obstacles: S, society level; I, individual level.

with the participants in this study. Furthermore, although the purpose of this study was to clarify the accessibility checklist items for both parents, most of the study participants were mothers. Therefore, several checklist items reflecting the opinion of fathers should be added in future studies.

Conclusion

To our knowledge, this study is the first to clarify the accessibility of out-of-home activities from the perspective of parents since many prior studies were conducted through the perspective children. Most of the obstacles encountered by parents during outings with their children with gross motor dysfunction came from society level issues such as lack in barrier-free infrastructures. Prior to going out for leisure activities, parents would have to collect extensive information regarding their destination in order to mitigate issues during their outing. Based on these results, parents require society level improvements, and the checklist may provide local communities with valuable information to construct more accessible environments and inclusive communities. Further studies are necessary to develop a more practical use for this accessibility checklist.

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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■ORIGINAL ARTICLE

Joint Tightening in Hemiplegic Handwriting

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Abstract: Objective: Handwriting, which consists of multiple joint movements in the upper extremity, is a suitable model to investigate motor control after hemiplegic stroke. We analyzed pen tip movement during handwriting in relation to the finger and wrist to reveal tightening and joint linkage that control writing movements done by a hemiplegic hand.

Methods: Thirteen right-handed individuals with right-sided mild hemiplegia after a stroke and 14 age-matched, right-handed controls were included. Movements of the pen tip, finger, and wrist were recorded using a three-dimensional movement analyzer. We investigated their writing performance by measuring writing time, variabilities of pen tip kinematics and trajectory. Movement linkage of the joints during writing was quantified by calculating the ratio of the trajectory size at the finger or wrist to that at the pen tip.

Results: The time needed for writing and the kinematic variability did not differ between the hemiplegic and control groups. The tight linkage of the pen tip with the finger and wrist joint movement was found in hemiplegic handwriting, which was similar to nondominant hand use in the controls. The linkage parameter of hemiplegic handwriting significantly correlated with writing time and kinematic variability of the pen tip movement.

Conclusion: Individuals with dominant-hand hemiplegia, in an attempt to produce consistently legible writing, may tighten the joint linkage of the finger and wrist to reduce the freedom of motion to control writing and simultaneously slow their writing speed, potentially resulting in increased kinematic variability of the pen tip movement.

Keywords: handwriting; stroke; hemiplegia; three dimensional movement analysis; manual function

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INTRODUCTION

Hemiplegia is characterized by weakness and impaired coordination, which disrupts smooth and separate individual joint movement sequences [1]. Damage to the motor pathway in the brain may result in the abnormal linkage of individual joint movements, which is ascribed to the unintended co-contraction of muscles in the extremities [2]. Clinical grading scales of hemiplegia, such as the Brunnstrom Recovery Scale [3] and the Fugl–Meyer Assessment [4], are structured to emphasize this abnormal movement linkage. Meanwhile, the performance of the hemiplegic extremities, especially that of the hand, is measured quantitatively by standardized manual function tests, such as the Box and Block Test (BBT) and the Nine-Hole Peg Test. Lin et al. [5] reported that both scores correlated well. However, correlations with hemiplegia grade, as measured by the Fugl–Meyer Assessment, were lower, which was likely due to the manual activities of daily living (ADLs). Handwriting may be categorized as a manual ADL [6]. In fact, Platz et al. [7] demonstrated that a dissociation between motor function scores (Fugl–Meyer Assessment and BBT scores) and ADLs were measured by the modified Barthel Index.

Handwriting is a multi-joint movement involving the thumb, fingers, wrist, and, occasionally, the elbow. Each joint moves in relation to the others, and joint tightening has been observed in uncoordinated handwriting movements. Tightening of the finger and wrist joint linkage may reveal similar movement trajectories of the finger and wrist during handwriting. Harada and colleagues [8] focused on the relationship between the movements of the pen tip and holding a pen. They compared movement trajectory sizes between right and left

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handwriting. The size of the wrist movement trajectory to the pen tip ratio was smaller for the dominant hand than for the nondominant hand in healthy individuals. This meant that the pen tip movement for nondominant side handwriting was firmly linked to the hand. Furthermore, the pen tip movement for the nondominant side handwriting was dependent on the movement of the proximal hand segment. This linked movement of the distal pen tip with the proximal hand was termed the proximodistal linkage of movement. Conversely, the pen tip for the dominant side handwriting moved independently of the finger and hand movements. This was termed proximodistal separation.

In this study, the speed, kinematics, and morphological consistency of writing were measured as basic parameters of handwriting performance. Ratios of trajectory sizes representing movement linkage or separation, as described above, were analyzed in relation to those performance parameters and the manual function scores in individuals with hemiplegia. We investigated differences in these parameters between the dominant and nondominant hands, between different letter sizes, and between individuals with dominant-hand hemiplegia and controls. We hypothesized that writing with the dominant hand in patients with dominant-hand hemiparesis would retain characteristics of writing with the dominant hand and that this would differ from writing done by the nondominant hand. We assumed that in individuals with dominant-hand hemiplegia, the parameters indicating hemiplegic handwriting performance would not simply correlate with task-specific manual motor function scores. Further, we believed that tightening the linkage of the finger and wrist joints would dominate as a compensatory mechanism in hemiplegic handwriting. This study may facilitate further understanding of writing with a hemiplegic hand, emphasizing the importance of joint linkage strategies that may compensate for hemiplegia.

METHODS

Participants

This was a nonrandomized case-control study. Thirteen right-handed individuals (six males and seven females, mean age = 69.1 yr, and standard deviations (SD) = 12.9 yr) with mild right-handed hemiplegia secondary to first onset of cerebral infarction (frontal cortex: four, corona radiate: one, pons: two, and unknown: four) or hemorrhage (putamen: one and thalamus: one) were recruited from the stroke unit or ambulatory rehabilitation clinic of Kyorin University Hospital. The time from stroke onset to study inclusion ranged from 7 to 40 days (median: 20 days). Fourteen right-handed healthy volunteers (10 males and 4 females, mean age = 71.7 yr, and SD = 11.0 yr) were enrolled as age-matched controls (P = 0.57). Only individuals who could write legible characters in a 2-cm square frame were included. Those with sensory deficits, apparent dementia, aphasia, or unilateral spatial hemineglect were excluded. Past medical histories, affecting central or peripheral nervous systems, such as stroke, cervical myeloradiculopathy, and peripheral neuropathy, were denied. Participants were recruited from senior societies in the local community. This study was approved by the Ethical Board of Faculty of Medicine, Kyorin University. Participants provided informed consent. To statistically analyze the differences, the number of control participants was not fewer than that of the stroke participants.

Clinical evaluation of manual functions

Handedness, the hand used for writing, drawing, and tooth brushing, was determined using the Edinburgh Inventory [9] interview. The Edinburgh score ranges from −100 (completely left-handed) to +100 points (completely right-handed). All individuals with hemiplegia were classified as having mild paresis of stages 4–6, according to the Brunnstrom Recovery Scale. Grip strength and the BBT [10] scores were obtained to show the manual function of both hands. The Smedley Hand Dynamometer® (MIS, Tokyo, Japan) was used for measuring grip strength. In consideration of individual differences in both grip strength and BBT scores, we used the index of the ratio of the right hand to the left hand for these two parameters.

Three-dimensional handwriting analysis

Sitting on a regular wooden dining chair with a wooden desk, participants wrote a Japanese Hiragana character. Handwriting movement was analyzed using a three-dimensional movement analyzer, Liberty® (Polhemus, VT 05446, USA), which consists of a magnetic field generator, a stylus pen with a position sensor in the tip, and two small-block sensors (Fig. 1). The block sensors were placed at the dorsal surface of the index metacarpal head (finger) and the distal end of the radius (wrist). Three-dimensional coordinates of the pen tip and two block sensors were recorded at a sampling frequency of 240 Hz each. Individuals were required to write the Japanese Hiragana character (Fig. 2D) in four differently sized squares (2.0, 5.0, 7.5, and 15.0 cm) in free typeface (their regular typeface) using their right and left hands. This is a basic Japanese character that corresponds to the letter a in the English alphabet. The individuals wrote 10 characters in each frame with each hand, for a total of 80 characters. They were told to write at a comfortable speed and were instructed “not to

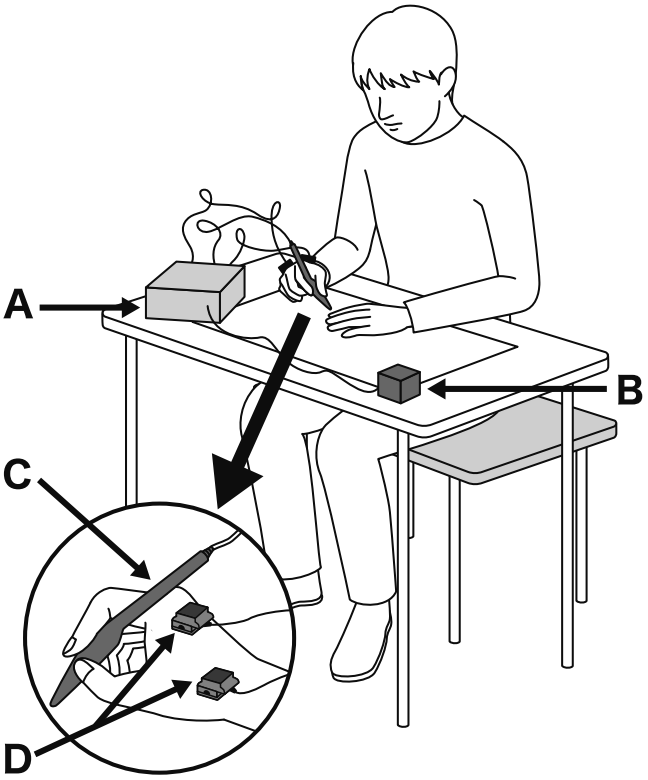

Fig. 1. Experimental system
A: An apparatus measuring three-dimensional coordinates of the sensors.
B: A transmitter yielding a constant magnetic field.
C: A ballpoint pen with a position sensor is installed in its tip.
D: Cube-shaped position sensors, 2.8 × 2.2 × 1.5 cm, fixed at the metacarpophalangeal joint surface of the index finger and at the distal end of the radius.

hurry and ignore legibility" and "not to intend to write too beautifully." Recorded coordinate data were analyzed with Matlab® software (Mathworks, Tokyo 107-0052, Japan). Since the analyzer samples data at equal time intervals, the data were converted into intervals of equal length by spline interpolation [8].

Parameters representing handwriting characteristics

The time needed to write a character was averaged for each character's size and each hand. Kinematic features of handwriting movement were illustrated as the instantaneous speed of the pen tip plotted against the track length from the initial point of writing and were expressed as a percentage of the total length (Fig. 2B). The average speed plots were obtained from 10 writing repetitions, and SDs were calculated for all plots. The SD was then divided by the mean for each plot to compute the grand mean of all SD/means, which was assumed to represent the kinematic variability of the pen tip movement [11]. Morphological variability of the writing trajectory was defined by the distance from the pen tip to the geometric center of its trajectory plotted against the trajectory length (Fig. 2C). The average distance plots were obtained from 10 writing repetitions, and SDs calculated for the plots were divided by the mean of each plot. The grand mean of all SD/means was assumed to represent the trajectory-shape variability of the pen tip [11].

The linkage of the pen tip to the finger and wrist movement was examined in terms of movement size. The average distance from the geometric center to the movement track represented the size of the movement. This proximodistal linkage was defined by the average distance for the finger and wrist track divided by that of the pen tip [8] (Fig. 2A). When this ratio was near 1 during writing, the holding of the pen was assumed to be tightly fixed to the pen.

Statistical analysis

We used a paired t-test to indicate differences between the right and left hands for grip strength and BBT to ensure that the manual function of the hemiplegic right hand was truly lower than that of the left hand. Three factors, that is, group of the individuals (hemiplegia vs. control), hand used (right vs. left), and frame size of writing (four sizes), were analyzed statistically for differences in writing time, kinematic and track–shape variability, and proximodistal linkage parameters, using a three-way analysis of variance (ANOVA) with repeated measures for two factors (hand side and writing-frame size). Estimated marginal means and 95% confidence intervals of the parameters were calculated. Post hoc Bonferroni comparisons were made to show differences when a significant interaction between any of the three factors was found by the three-way ANOVA. We analyzed the relationship between any pairs of these parameters for the hemiplegic hand using Pearson's correlation coefficient to find determinants of hemiplegic handwriting proficiency. The level of significance for all analyses was set at 5%. Finally, IBM SPSS Statistics for Windows, version 24.0 (IBM Corp, Armonk, New York) was used for the analysis.

RESULTS

Functional evaluation of the hemiplegic hand

All participants were right-handed. The Edinburgh handedness scores were 70–100 (mean = 94.6 and SD = 8.4) and 55–100 (mean = 92.1 and SD = 12.2) for the hemiplegic and control groups, respectively. The mean and SD of the grip–strength ratio of the right to left hand were 0.80 (SD = 0.21) for the hemiplegic group and 1.07 (SD = 0.11) for the control group. The mean and SD of the BBT ratio of the right to left hand were 0.82 (SD =

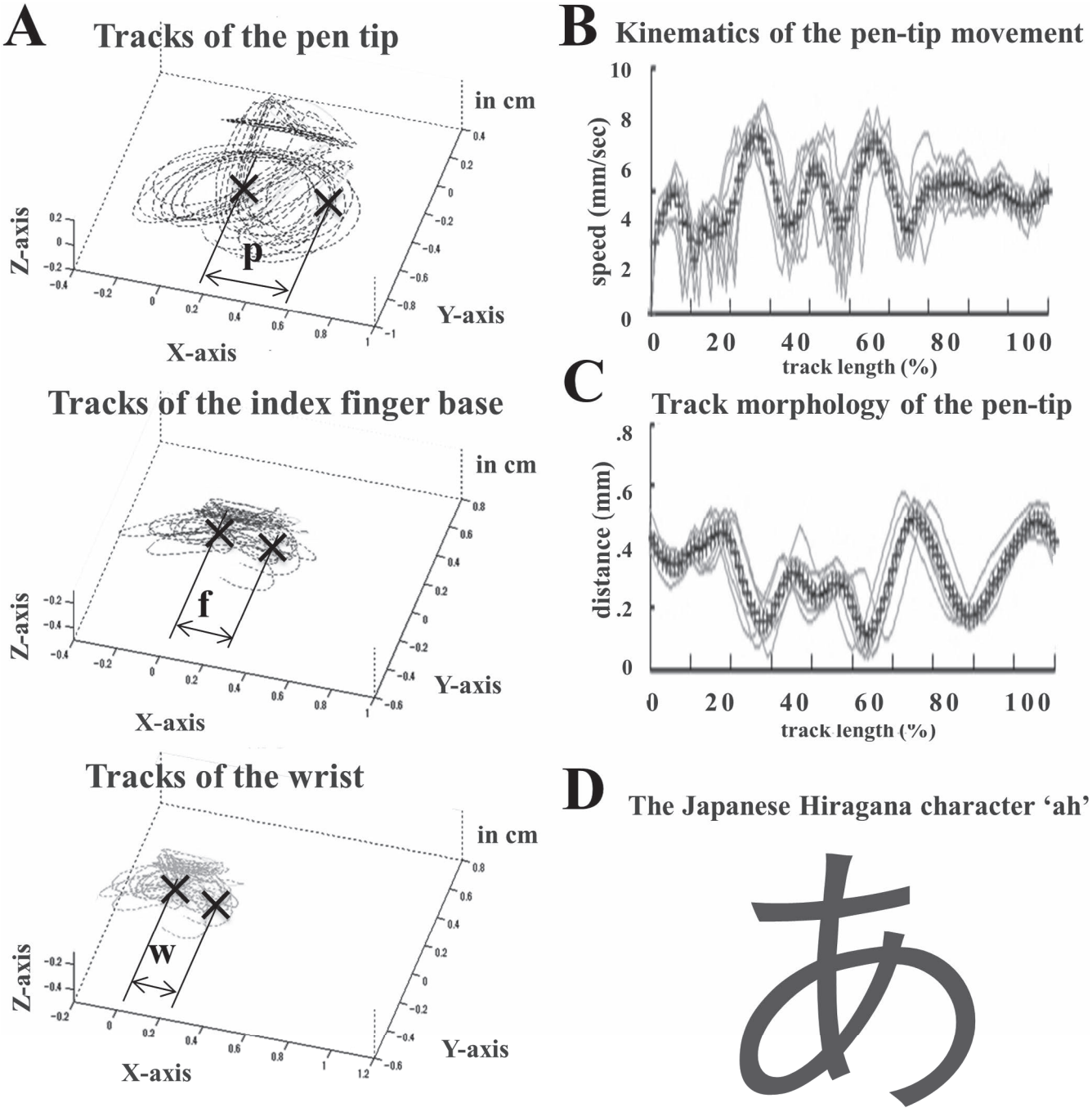

Fig. 2. Writing tracks and correlations of writing parameters

A: An example of the Japanese syllabic character handwritten by a control individual. Ten tracks of writing movements with the pen tip, metacarpal head of the index finger, and radial end of the wrist in a 2-cm square are layered. The tracks of the index finger base, pen tip, and wrist were of a similar shape. Average distances from the pen tip, finger, and wrist to the geometric center of their tracks are shown by *p*, *f*, and *w*, respectively.

B: Pen tip speed is plotted against length along the writing tracks expressed as a percentage. Ten trials are layered, and the average plots are illustrated as small crosses. These plots indicate the kinematic features of the pen tip movement. The kinematic variability was defined by the coefficient of variation in the difference in speed from the mean.

C: Distances of the pen tip from the geometric center of the track are plotted against the length along the writing tracks. Ten trials of writing are layered, and the average plots are illustrated as small crosses. These plots indicate the morphology of the pen tip track. This morphological variability was defined by the coefficient of variation of difference from the averaged distance.

D: The Japanese Hiragana character adopted for this study.

0.17) for the hemiplegic group and 1.05 (SD = 0.10) for the control group. Both the grip strength and BBT were significantly lower in the right hand than in the left hand in the hemiplegic group (paired t-test, $p < 0.001$).

Time needed to write a character (Table 1)

The time needed for writing did not differ between the hemiplegic and control groups (ANOVA, $F(1, 25) = 1.79$, $p = 0.193$). Writing time was significantly greater for the left than for the right hand ($F(1, 25) = 8.90$, $p = 0.006$) and for larger-sized letters ($F(3, 75) = 53.18$, $p < 0.001$). A significant interaction was found between the group and side of the hand used ($F(1, 25) = 6.96$, $p = 0.014$) between which a multiple comparison showed that it took more time in the hemiplegic group for right-handed writing in the 2-cm (Bonferroni test, $p = 0.045$) and 5-cm ($p = 0.048$) frames.

Handwriting variability (Table 1)

The kinematic variability (Fig. 2B), as defined by the coefficient variation of the pen tip speed, did not differ between the hemiplegic and control groups ($F(1, 25) = 2.28$, ANOVA, $p = 0.144$) or between right-handed and left-handed writing ($F(1, 25) = 2.20$, $p = 0.151$). However, it decreased significantly when the frame size for writing increased ($F(3, 75) = 150.31$, $p < 0.001$).

In addition, the track–shape variability (Fig. 2C) did not differ between the groups ($F(1, 25) = 4.18$, ANOVA, $p = 0.52$) or between right and left hand writing ($F(1, 25) = 0.98$, $p = 0.331$). It was significantly less for larger-sized writing ($F(3, 75) = 76.56$, $p < 0.001$). A significant interaction was found between the group and the hand side ($F(1, 25) = 4.65$, $p = 0.041$) and between the size and the hand side ($F(1, 25) = 3.21$, $p = 0.028$).

Multiple comparisons indicated that group differences in shape variability were significant for right-handed writing in the 2-cm (Bonferroni test, $p = 0.011$) and 7.5-cm ($p = 0.014$) frames and were insignificant for right-handed writing in the 5-cm frame ($p = 0.083$) and 15-cm frame ($p = 0.072$). There was a significant difference between the right and left hands only in the 2-cm frame in the control group ($p = 0.011$).

Between-size differences in track–shape variability were significant for the 2/7.5-cm (Bonferroni test, $p = 0.002$) and 2/15-cm ($p < 0.001$) size pairs in right-handed writing in the control group and for the 2/5-cm ($p < 0.001$), 2/7.5-cm ($p < 0.001$), 2/15-cm ($p < 0.001$), and 5/15-cm ($p = 0.016$) size pairs in left-handed writing in the control group. Differences were also significant for the 2/5-cm ($p < 0.001$), 2/7.5-cm ($p < 0.001$), 2/15-cm ($p < 0.001$), and 5/15-cm ($p = 0.02$) pairs in right-handed writing in the hemiplegic group. In left-handed writing in the hemiplegic group, differences were significant for the 2/5-cm ($p < 0.001$), 2/7.5-cm ($p < 0.001$), 2/15-cm ($p < 0.001$), 5/7.5-cm ($p = 0.03$), and 5/15-cm ($p < 0.001$) size pairs. In general, track–shape variability tended to increase in right-handed writing in the hemiplegic group as well as in smaller-sized writing in both the hemiplegic and control groups.

Proximodistal linkage of handwriting movements (Table 1)

The proximodistal linkage (Fig. 2A), which was defined as the ratio of movement track diameter of the finger to the pen tip (finger–pen ratio), was significant for the group (ANOVA, $F(1, 25) = 6.05$, $p = 0.021$), side of handwriting ($F(1, 25) = 14.80$, $p = 0.001$), and frame size ($F(3, 75) = 9.41$, $p = 0.001$). Those defined as the wrist–pen ratio were significant and/or marginally significant for the group ($F(1, 25) = 4.21$, $p = 0.051$), side of handwriting ($F(1, 25) = 17.4$, $p < 0.001$), and frame size ($F(3, 75) = 10.28$, $p = 0.001$). Interactions in the finger–pen ratio were found for the factors of the group and side of handwriting ($F(1, 25) = 6.89$, $p = 0.015$), side of handwriting and frame size ($F(3, 75) = 1.40$, $p = 0.001$), and for all three included factors ($F(3, 75) = 1.40$, $p = 0.006$). Interaction in the wrist–pen ratio was found for the side of handwriting and frame size ($F(3, 75) = 5.43$, $p = 0.002$) and for all three factors ($F(3, 75) = 5.80$, $p = 0.001$).

Multiple comparisons of the finger–pen ratio revealed significant group differences for all four frame sizes (Bonferroni test, 2-cm: $p = 0.004$, 5-cm: $p = 0.001$, 7.5-cm: $p = 0.009$, and 15-cm: $p = 0.009$) in right-handed writing. Right–left differences were also significant for all four sizes of right-handed writing in the control group (2-cm: $p < 0.001$, 5-cm: $p < 0.001$, 7.5-cm: $p = 0.007$, and 15-cm: $p = 0.015$). Size-related differences were significant for all right-handed writing size pairs in the control group (2/7.5-cm: $p = 0.003$, 2/15-cm: $p < 0.001$, 5/7.5-cm: $p = 0.002$, 5/15-cm: $p < 0.001$, and 7.5/15-cm: $p < 0.001$), apart from the 2/5-cm pair. It was significant only for the 7.5/15-cm pair of left-handed writing in the control group ($p = 0.001$). Size-related differences in the hemiplegic group were not found for any pair of sizes in either right-handed or left-handed writing.

Group differences in the wrist–pen ratio were found for the 2-cm (Bonferroni test, $p = 0.015$) and 5-cm (Bonferroni test, $p = 0.011$) frames of right-handed writing. Right–left differences were significant for all four sizes in the control group (2-cm: $p < 0.001$, 5-cm: $p < 0.001$, 7.5-cm: $p = 0.014$, and 15-cm: $p = 0.012$) and for the 7.5-cm frame in the hemiplegic group ($p = 0.02$). Between-size differences in right-handed writing were

Table 1 Estimated Marginal Means and 95% Confidence Intervals (CI)[a]

Parameters	Group					Side					Size						
	Estimated marginal mean (95% CI)		*df*	*F*	*P*	Estimated marginal mean (95% CI)		*df*	*F*	*P*	Estimated marginal mean (95% CI)				*df*	*F*	*P*
	Control	Hemiplegia				Rt	Lt				2cm	5cm	7.5cm	15cm			
Writing time (sec)	3.21 (2.35, 4.07)	4.02 (3.12, 4.91)	1	1.79	.19[b]	3.38 (2.75, 4.02)	3.85 (3.20, 4.50)	1	8.9	.006[b]	3.10 (2.55, 3.65)	3.45 (2.83, 4.08)	3.73 (3.06, 4.39)	4.18 (3.51, 4.86)	3	53.18	< .001
Kinematic variability (SD/mean)	0.25 (0.22, 0.29)	0.29 (0.26, 0.33)	1	2.28	.14	0.27 (0.24, 0.30)	0.28 (0.25, 0.31)	1	2.2	.15	0.35 (0.32, 0.39)	0.27 (0.25, 0.3)	0.25 (0.22, 0.28)	0.22 (0.20, 0.24)	3	150.31	< .001
Track shape variability (SD/mean)	0.17 (0.16, 0.19)	0.19 (0.18, 0.21)	1	4.18	.052[b]	0.18 (0.17, 0.19)	0.19 (0.18, 0.20)	1	.98	.33[b, c]	0.23 (0.21, 0.24)	0.18 (0.17, 0.20)	0.17 (0.16, 0.18)	0.15 (0.14, 0.16)	3	76.56	< .001[c]
Movement size ratio																	
Finger/pen-tip (ratio)	0.78 (0.75, 0.82)	0.84 (0.81, 0.88)	1	6.05	.021[b, d]	0.78 (0.75, 0.81)	0.84 (0.81, 0.87)	1	14.8	001[b, c, d]	0.79 (0.76, 0.83)	0.80 (0.77, 0.83)	0.81 (0.79, 0.84)	0.84 (0.82, 0.86)	3	9.41	.001[c, d]
Wrist/pen-tip (ratio)	0.73 (0.69, 0.77)	0.78 (0.74, 0.82)	1	4.21	.051[d]	0.72 (0.68, 0.76)	0.79 (0.76, 0.82)	1	17.4	< .001[c, d]	0.73 (0.70, 0.77)	0.74 (0.72, 0.77)	0.76 (0.73, 0.78)	0.78 (0.76, 0.8)	3	10.28	.001[c, d]

[a] Significance, determined with an analysis of variance, was set at a *P* value of <.05.

[b] Significant difference for interactions between side and group.

[c] Significant difference for interactions between side and writing size.

[d] Significant difference for interactions among side, group, and writing size.

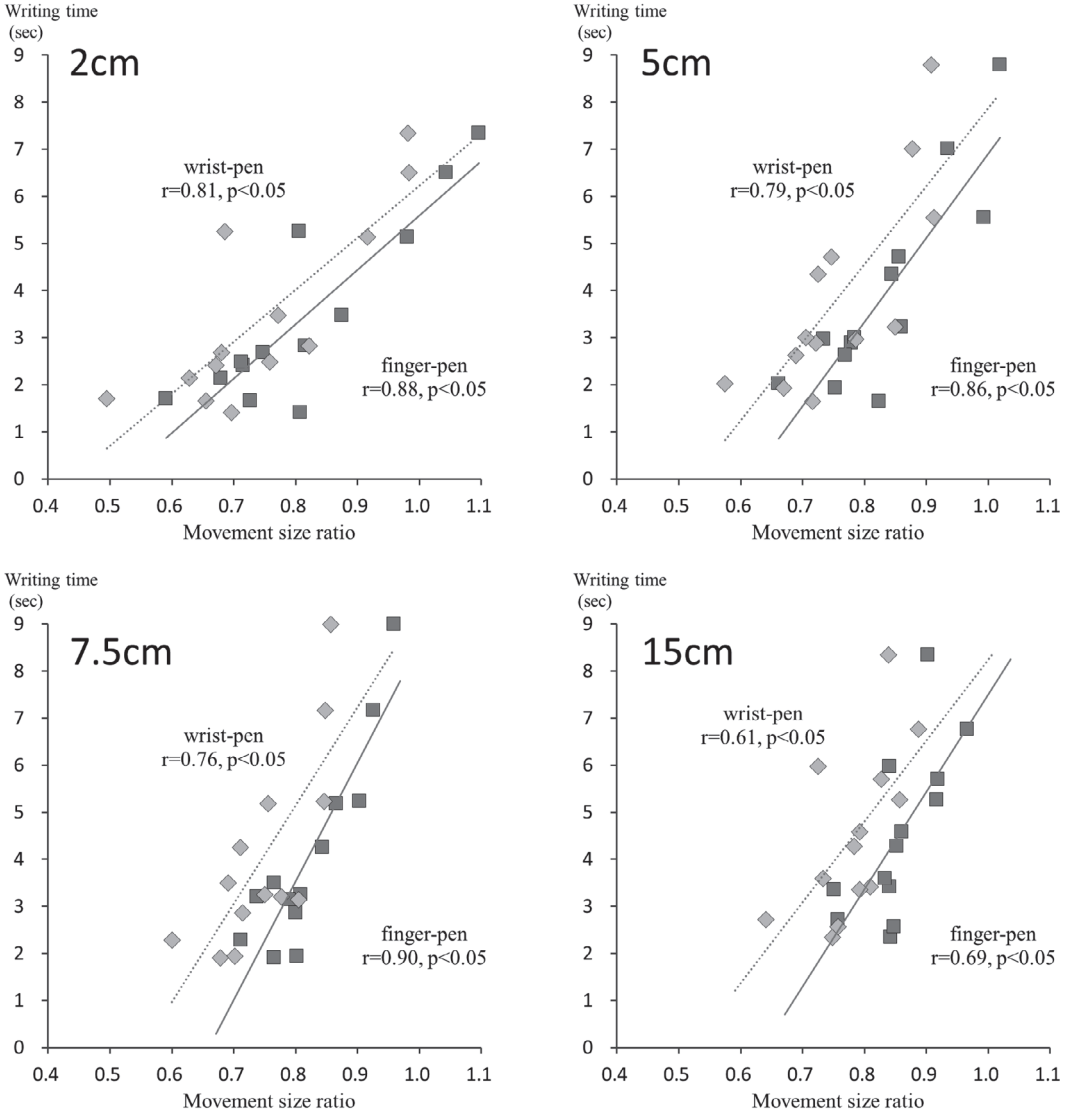

Fig. 3. Correlation between writing time and proximodistal linkage in handwriting
The writing time was significantly correlated with the movement–size linkage defined as finger–pen or wrist–pen for all frame sizes of writing by the hemiplegic hand. See text for the definitions of the movement–size ratios, finger–pen, and wrist–pen.

significant for all size pairs in the control group (2/7.5-cm: $p = 0.001$, 2/15-cm: $p = 0.001$, 5/7.5-cm: $p < 0.001$, 5/15-cm: $p < 0.001$, and 7.5/15 cm: $p = 0.002$) except for the 2/5-cm pair, similar to the finger–pen ratio, and was significant for the 7.5/15-cm pair in the hemiplegic group ($p = 0.03$). However, no size-related differences were found in left-handed writing, in either the control or hemiplegic groups.

In general, the proximodistal linkage was high, causing tightly linked movement of the pen tip with the finger and wrist in left-handed writing in the control group and both right-handed and left-handed writing in the hemiplegic group. In contrast, it was low for right-handed writing in the smaller frames in the control group, indicating a separation of the pen tip movement from the finger and wrist movement.

Characteristic determinants of writing by the hemiplegic hand

The ratio of hemiplegic right-handed grip strength to left-handed grip strength marginally correlated with the same BBT score ratio ($r = 0.553$, $p = 0.05$). The grip–strength ratio of the hemiplegic hand correlated with track–shape variability for right-handed writing in the 2-cm ($r = -0.712$, $p = 0.006$), 5-cm ($r = -0.727$, $p = 0.005$), and 7.5-cm size frame ($r = -0.642$, $p = 0.018$). However, the BBT ratio did not correlate with writing time, kinematic variability, or proximodistal linkage parameters.

As shown in Fig. 3, the Pearson's correlation coef-

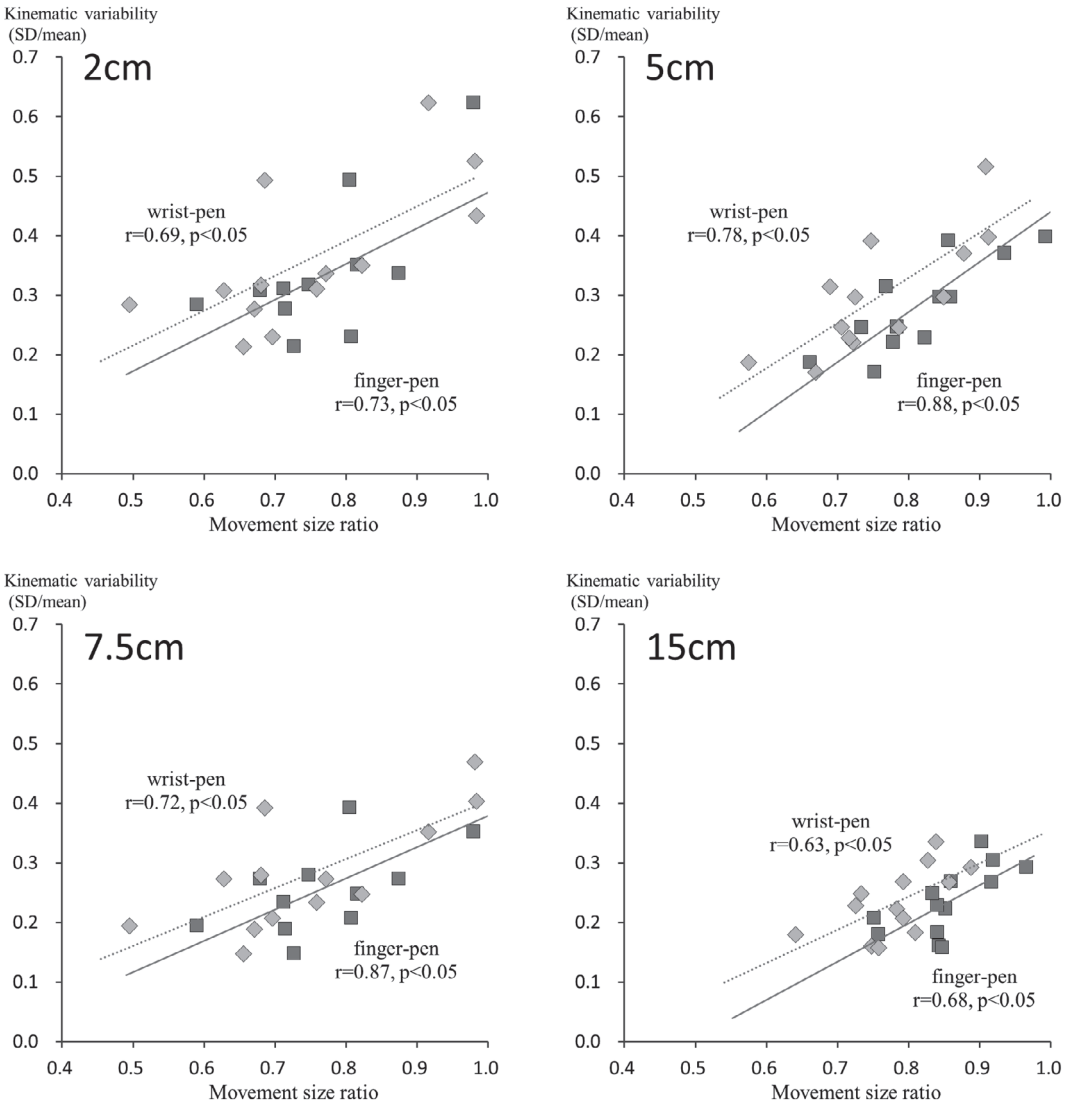

Fig. 4. Correlation between kinematic variability and proximodistal linkage in handwriting
The kinematic variability was significantly correlated with the movement–size linkage (both finger–pen and wrist–pen) for all frame sizes of writing by the hemiplegic hand.

ficients of both finger–pen and wrist–pen ratios showing proximodistal linkage for the hemiplegic right hand were significant for the writing time (r = 0.61–0.90, P = 0.03–< 0.001) and kinematic variability for all four sizes (r = 0.63–0.88, p = 0.06–< 0.001; Fig. 4).

Other correlations were significant between writing time and kinematic variability (r = 0.859 for the 2-cm frame, r = 0.914 for the 5-cm frame, r = 0.939 for the 7.5-cm frame, r = 0.897 for the 15-cm frame, and p <.001) and between kinematic variability and trajectory-shape variability (r = 0.563 for the 2-cm frame, p = 0.045; r = 0.688 for the 7.5-cm frame, p = 0.009; and r = 0.792 for the 15-cm frame, p = 0.001).

DISCUSSION

Handwriting and the manual function of the hemiplegic hand

Speed and accuracy, or writing time and consistency of writing trajectory, are assumed to be major indicators of movement performance, but they may represent a trade-off [12] as accuracy decreases with increasing speed. However, regarding writing, the movement of handwriting becomes automatic and consistent after years of practice [13]. Freeman [14] found that writing time is relatively constant regardless of writing size, that is, the isochrony property of adult handwriting, in contrast to the immature handwriting of children where writing time changes in proportion to the size of writing,

and is ascribed to a constant pen tip movement speed. Wright [15] investigated this property by the sofisticated methods. Viviani & Terzuolo [16] measured instantaneous pen tip speed during writing and plotted it against time. They found that this speed profile maintained a similar shape even with faster or larger writing. This kinematic property of pen tip movement, or handwriting rhythm, is called space–time invariance. In other words, smaller kinematic variability is evidence of more mature handwriting. Morphological invariance of writing [15, 17] is another writing characteristic that is individually acquired. To date, no reports focus on changes in these invariance properties caused by stroke hemiplegia.

Only grip strength showed a moderate correlation with morphological variability. In other words, only weakness affected the morphological consistency of writing. However, other parameters, such as writing time, kinematic variability, and proximodistal movement linkage, were irrelevant to either grip strength or BBT. There is no reason that BBT and/or grip strength would be correlated with handwriting parameters since BBT assesses the proximal rather than the distal movement of the upper extremity, and grip strength simply represents the strength of the distal musculature. This study only included individuals with hemiplegia who could write legible characters. Therefore, hemiplegia was mild and less varied in terms of severity. In principle, handwriting is categorized as an activity involving various factors, such as individual customs and aesthetic consciousness. Therefore, it was expected that the parameters in the present study would not be strongly related to the manual or proximal arm function as measured by grip strength or BBT, respectively.

We introduced parameters quantifying kinematic and morphological variability of writing, on the basis of the studies of Viviani and Terzuolo [16] and Castiello and Stelmach [17] respectively, both of which graded the clinical severity of ataxia [11]. In the present investigation, significant differences in both measures of variability were found for some of the frame sizes between the hemiplegic hand and the healthy dominant hand and between the dominant and nondominant hand in the control group. In addition, a larger variability in these parameters was ascribed to less controllability of the hemiplegic hand and the nondominant hand.

Increased proximodistal linkage in hemiplegic handwriting

Handwriting involves multiple joint systems that include the fingers and wrist. A single character or letter can be written using numerous joint movement patterns. However, each joint moves smoothly in a coordinated manner, resulting in writing with similar kinematics and morphology. Lacquaniti [18] demonstrated that the wrist and elbow became increasingly involved in dominant handwriting with increasing writing size. In contrast, the wrist and elbow, rather than the thumb and fingers, are mainly used in nondominant handwriting irrespective of writing size. Meulenbroek et al. [19] reported such linkage between pen tip movements and finger or wrist movements in circle-drawing. However, circle-drawing may differ from handwriting in its mechanisms of movement control. Circle-drawing is done principally through the visual feedback information of drawn lines, whereas handwriting is accomplished without correction based on feed-forward control acquired after the daily activity of writing during childhood.

The relationship in movement size between the pen tip and finger/wrist was the major focus of the present investigation and elucidated the proximodistal linkage of movements as first proposed by Harada et al. [8]. Contrary to their expectation, they could not indicate a significant increase in the proximodistal movement linkage of the hemiplegic handwriting. Only in hemiplegic cases with position sense impairment did the pen tip move in linkage with the finger and hand for dominant side handwriting. However, two issues may prevent us from drawing conclusions from their study. The first was the inclusion of the patients with position sense impairment, which might have obscured minor differences in handwriting between the patients with dominant-hand hemiplegia and the controls. Position sense impairment caused ataxia, which would cause a large variability of handwriting kinematics and morphology [11]. The other problem was the exclusion of small-sized writing. Harada et al. [8] did not include small-sized writing for statistical analysis, which would require a separation in the distal movements. Our study revealed that writing size was a major determinant of writing time, variability, and proximodistal linkage parameters.

Factors affecting proximodistal movement linkage

In hemiplegic handwriting, both writing time and kinematic variability significantly increased, regardless of writing size, as the trajectory–size ratio of the finger or wrist to that of the pen tip approached 1 (Figs. 3 and 4). In other words, proximodistal linkage in hemiplegia correlated with longer handwriting time and larger kinematic variation. Writing time correlated positively with kinematic variability regardless of writing size, indicating that a trade-off rule was not necessarily applicable to the relationship between writing time and kinematic variability. In addition, kinematic variability correlated positively, in part, with morphological variability. However, the morphological variability did not correlate with writing time. This suggests stronger morphological

invariance than time and kinematic invariance in writing with the hemiplegic hand.

Proximodistal linkage is not always pathological, as has been seen in individuals with severe hemiplegia. Osu et al. [20] investigated the targeted reaching movement in healthy volunteers and demonstrated that the flexor and extensor muscles of the arm co-contracted so that freedom of motion could be lessened for easier control and higher performance of the intended movement. It is important to maintain the same shape of the writing, irrespective of hemiplegia, as characters should be written legibly. Individuals with dominant-hand hemiplegia may tighten joint linkage of the upper extremity and slow their writing speed, resulting in the disruption of kinematic invariance of the pen tip movement. This is most likely done in an attempt to yield consistent writing shapes.

Conclusion

Handwriting may be categorized as an ADL. Individuals with stroke hemiplegia of the dominant hand reacquire writing while adapting to hemiplegia. Legibility is seemingly more important than writing speed, as writing could result in nonsense without being legible. In this study, individuals with hemiplegia could write legibly by slowing their writing speed, which might cause greater kinematic and/or shape variability, and by tightening the finger and wrist joints as if they were moving as a solid block. This helped them control the hemiplegic hand by reducing the degree of freedom of motion. The results of this study may be helpful in understanding the fine manual movement of individuals with hemiplegia. A reduction in the degree of freedom of motion by tightening the joint linkage was important in accomplishing dexterous movement with the hemiplegic hand.

The conclusions of this study were obtained from a limited number of participants. With a larger sample size, we could have produced greater statistical data. The instructions given to the participants for the experiment were important as the writing performance by the hemiplegic hand might depend on the instructions. In this study, participants were instructed to write at their own speed, neither too quickly nor too slowly. If they had been asked to write as fast as possible, ignoring legibility, different results would have been obtained. Further studies are needed to address these issues.

Acknowledgments

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■CASE REPORT

Development of a Finger Extension Assistance Splint for a Hemiplegic Upper Limb After Stroke - A Case Report

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Abstract: Background: Paralysis of the upper limb after stroke affects daily life. Our objective was to examine the clinical effects of our newly developed finger extension splint, which was made by specially processing a shape memory alloy, in a chronic stroke patient.
Design: Comparison of the clinical effects of the splint use pre- and post-treatment.
Patient: A 70-year-old man who developed right thalamus hemorrhage 15 years previously presented with right hemiplegia.
Intervention: Training was performed 30 minutes/day for 10 weekdays for the fingers on the paralyzed side. Task-oriented training, such as block stacking, was performed.
Results: Upper limb function evaluation results (pre vs post-treatment): grip strength, 9.3 vs 12.1 kg; upper-extremity subtest of the Fugl-Meyer Assessment of Motor Function, 42 vs 54 points; Wolf Motor Function Test (functional ability scale), 47 vs 50 points; time, 389.2 vs 308.2 seconds, and the Box and Block Test: 11 vs 15 and 8 vs 15 with and without the splint, respectively.
Conclusion: When training was conducted using this splint, improvement of upper limb function was observed.

Keywords: stroke, arm function, splint

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1. Introduction

Stroke causes motor paralysis in the unilateral upper and lower limbs due to ischemic or hemorrhagic lesions in the brain. Increased muscle tension (spasticity) is difficult to treat and greatly affects activities of daily living (ADL).

Orthopedic therapy is used to apply continuous tension to muscles and joints, mainly to prevent the progression and deformation of joint contractures associated with spasticity. Although previous studies report that static splints may to be sufficiently effective in preventing joint contractures due to spasticity [1, 2, 3], attenuation of the effects of spasticity was reported with the use of dynamic splints, such as dorsal support functional braces [4], dynamic hand splints [5], and spider splints [6].

The degree of motor paralysis and spasticity varies between individuals, and it is important to use a splint that is appropriate for the patient's condition [7]. Previous studies have shown that each joint needs to be properly tensioned, but most dynamic splints pull the entire finger, including the interphalangeal (IP) and metacarpophalangeal (MP) joints. Thus, proper tension is not applied to each joint. We treated patients by prescribing that they wear spider splints, but we found that, in some patients, the MP joints were excessively extended due to the effect of the balance of muscle tension in the internal and external muscles. Therefore, as the first

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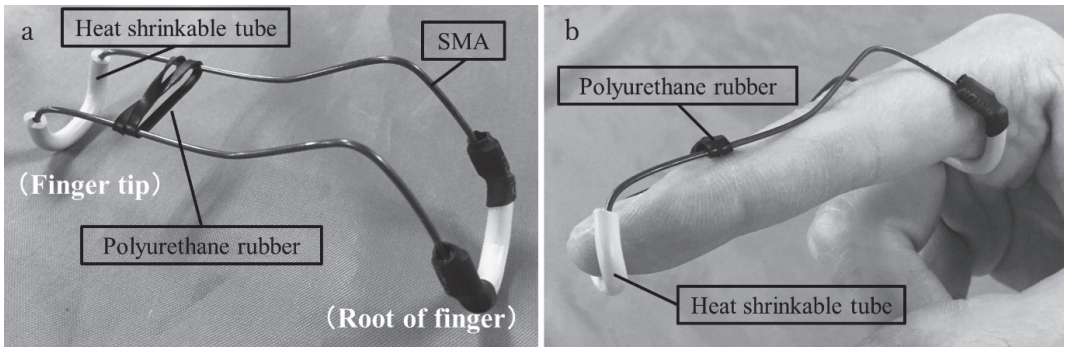

Fig. 1. Structure of the finger extension assistance splint. (a) Details of the structure of the finger extension splint. (b) Splint installation. SMA = Shape memory alloy.

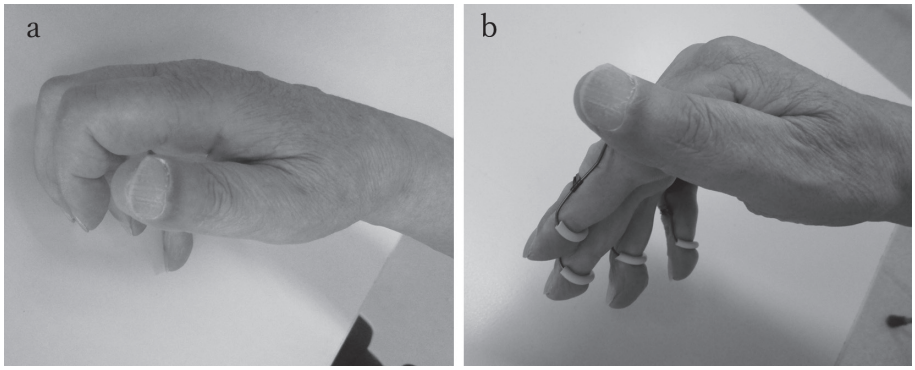

Fig. 2. Comparison of finger extension movement with and without the splint. State of finger extension without the splint (a) and with the splint (b).

step, we have developed a splint that responds to the degree of paralysis and spasticity in individual patients and provides tension to the IP joint independently. In this study, we used finger extension assistance splints for a chronic stroke patient and report clinical effects based on a comparative pre- and post-treatment study.

2. Methods

2.1. Structure of orthosis and method of fabrication

We developed a new splint that can support finger extension in hemiplegic patients with spasticity (Fig. 1). This device uses a shape memory alloy (SMA) wire with superelastic properties. When the finger is flexed, the SMA with a bent beam shape is deformed, and an assist force in the extension direction is generated in the distal IP and proximal IP joints. To reduce pain in the contact area, a heat-shrinkable tube with high cushioning properties is placed at the tip and base of the finger. The material at the base of the finger is a steel wire, which can handle various finger thicknesses. The length of the splint can be altered to fit the individual's fingers. Because the degree of spasticity varies between individuals, the assist power of this device can be adjusted by changing the diameter of the SMA.

2.2. Participant

A 70-year-old man, who developed right thalamus hemorrhage 15 years earlier, presented with right hemiplegia. Range of motion was reduced in his upper right hand and fingers due to spasticity and muscle shortening, although he could perform ADL independently.

2.3. Interventions and outcomes

The patient trained for 10 days of 2 weeks, 30 minutes/day. Task-oriented training was performed according to previous research [8, 9], with the finger extension splint attached to II-V fingers (Fig. 2). The patient performed a task of moving beanbags and wooden blocks as task-oriented training. The difficulty level of the task was gradually increased according to the success rate of the task, while providing feedback regarding the task execution time to the patient. Evaluation of upper limb function was performed pre- and post-intervention and included grip strength, upper-extremity subtest of the Fugl-Meyer Assessment of Motor Function (FMA-UE),

Fig. 3. The patient is wearing the splint and is able to move the blocks (Box and Block Test).

Wolf Motor Function Test (WMFT), Functional Ability Scale (FAS)/Time, and the Box and Block Test (BBT). BBT measurements were obtained twice, with and without the splint (Fig. 3). Evaluation of spasticity was with the Modified Ashworth Scale-elbow, finger (MAS-elbow, finger).

This research was conducted with the approval of the Nittazuka Medical Welfare Center Ethics Review Committee (ethics examination number: Shinrin 28–71). We explained the study to the subject in writing and verbally, and obtained consent. The authors declare no conflict of interest.

3. Results

Upper limb function evaluation results, pre- vs post-treatment, were: grip strength, 9.3 vs 12.1 kg; FMA-UE, 42 vs 54 points; WMFT FAS, 47 vs 50 points; time, 389.2 vs 308.2 seconds; Motor Activity Log-Amount of Use (MAL-AOU), 0.33 vs 0.41 points; Motor Activity Log-Quality of Movement (MAL-QOM), 0.30 vs 0.34 points and BBT, 11 vs 15 (when wearing a splint) and 8 vs 15 (when not wearing a splint) (Table 1). There was no change in MAS.

Table 1 Upper limb function evaluation results before and after training with the splint

Outcome	Pre-treatment	Post-treatment	Change value
Grip (kg)	9.3	12.1	**2.8**
FMA-UE	42	54	**12**
MAS-elbow	1	1	0
MAS-finger	3	3	0
WMFT-FAS	47	50	**3**
WMFT-times (second)	389.2	308.2	**81**
MAL-AOU	0.33	0.41	**0.08**
MAL-QOM	0.30	0.34	**0.04**
BBT: without splint	8	15	**7**
BBT: with splint	11	15	**4**

FMA-UE = Upper-extremity subtest of the Fugl-Meyer Assessment of Motor Function; MAS = Modified Ashworth Scale; WMFT = Wolf Motor Function Test; FAS = Functional Ability Scale; MAL = Motor Activity Log; AOU = Amount of Use; QOM = Quality of Movement; BBT = Box and Block Test
Outcomes with improvements post-treatment are indicated in bold.

4. Discussion

In this case, although flexion of the fingers was possible, voluntary extension movement was weak, and it was difficult to release an item once grasped. When training was conducted using this splint, improvement of upper limb function was observed. Before and after treatment, the amount of improvement for the patient was as follows: grip strength was 2.8 kg; the FMA-UE and WMFT-FAS were 12 and 3 points, respectively; the WMFT-time was 81 seconds, the MAL-AOU and MAL-QOM were 0.08 and 0.04, respectively; and the BBT was 7. In comparison, previous studies have reported a grip strength, according to the Minimum Clinically Important Difference (MCID), of 2.9 kg, an FMA-UE of 4.25–7.25, 1 point for WMFT-FAS, a WMFT-time of 19 seconds, 0.5 points for MAL-AOU and QOM, and a BBT of 5.5 [10, 11, 12, 13]. Thus, although the grip strength and the frequency of paralyzed hand use in daily life did not exceed the MCID, the changes in motor function evaluations such as FMA-UE, WMFT and BBT did exceed the MCID, which was clinically sufficient. When this splint is used in conjunction with task-oriented training, bending and stretching exercises of the fingers are repeated, and it is considered that motor learning effects are produced [5, 9, 14, 15]. These studies suggest that hand splints can be used for motor learning training and improving neural plasticity, such as motor cortex priming and reorganization in the brain. In addition, by performing task-oriented training under the above-mentioned environment, we believe that the treatment effect will not only extend to finger movements but also to the entire upper limb. The treatment effect in this case was not limited to the motor learning effect of finger extension; notably, improvements in grip strength and object handling ability were observed.

Dynamic splints increase muscle tissue stability, limit unnecessary movements that impair hand function, supplement weak muscles, and maintain the natural anatomical alignment of the hand [16]. Unlike the conventional splint, our splint allows fine adjustment of tension and size for each finger, provides tension parallel to the extension direction of the finger, and provides appropriate assistance along the normal structure of the

finger. In addition, our splint is smaller and lighter, and has the advantage of being less noticeable in everyday life situations. We believe that the development of splints with a structure like ours that follows the anatomy and anatomical functions of the finger is necessary.

5. Study limitations and future research

This study includes one case. We recommend further large-scale studies to investigate the state of muscle tone more objectively and quantitatively using physiological tests, such as evoked electromyography. In addition to this splint, we are developing a splint that provides separate tension to the MP joint. In the future, we will study the structure and methodology that provide proper tension to the distal interphalangeal and proximal interphalangeal joints, respectively.

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■ORIGINAL ARTICLE

Validation of the Developed Eating Activities Questionnaire in Working People with Disabilities: A Cross-Sectional Study

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Abstract: Objectives: There are only a few functional evaluations that non-medical personnel can perform and interpret without guidance. Here, we have created a questionnaire that focused on eating activities, which can be used to evaluate motor function easily because most people could relate to eating activities. This study aimed to verify the reliability and validity of the developed questionnaire by comparing it with clinical evaluations for upper extremity function.
Methods: This was a cross-sectional study. Patients who have cerebrovascular disease history with disabilities in the upper limb were included in the study. The questionnaire on eating activities was answered by the patients themselves. Upper extremity function was evaluated with the Fugl-Meyer Assessment (FMA). Work efficiency was evaluated with the General Aptitude Test Battery. Reliability of the questionnaire was assessed by test-retest reliability. Validity was evaluated using a correlation analysis.
Results: The study included 16 participants. The results indicated that all items had sufficient reliability. The correlation between the questionnaire score of the hand and the FMA score of the wrist, hand, and arm was statistically significant.
Conclusions: The developed questionnaire was reliable and significantly related to clinical evaluation of upper extremity functions. This questionnaire is of great value to patients with stroke to understand their functions.

Keywords: patient-based questionnaire, patient-based medicine, eating activities questionnaire, fugl-meyer assessment, upper extremity function, work efficiency

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Introduction

According to a WHO study, more than a billion people or about 15% of the world's population are estimated to live with some form of disability [1]. The number of people with disabilities is increasing. This is because people are aging, and chronic health conditions with disability are rising. Of patients with stroke, 70% have disabilities in the upper limbs and 40% in the chronic phase [2, 3]. Most people with brain injury want to live a normal everyday life after the injury, such as returning to work, earning their subsistence and participating in society [4]. Impairments after stroke often interfere with activities of daily living (ADLs). Patients may have difficulties caring for themselves such as in dressing, eating, and other daily tasks [5] Work disability is often associated with personal suffering and loss of income, diminished productivity, increased medical and societal costs, and can be addressed through vocational rehabilitation [6, 7]. This results in limited actions and has an impact on the level of activity and participation in different life areas [8].

To understand patient's disabilities, medical staff

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uses clinical evaluations, expertise, and International Classification of Functioning, Disability and Health (ICF) concept. Since the aspects of impairments, activities, and participation limitations together with contextual factors are incorporated into the same conceptual framework, the multidimensional model of the ICF can be used [9]. In actual rehabilitation scenes, the medical team follows the clinical pathway and mainly works on exercise such as muscular strength training, Range of motion (ROM) exercise, and walking. The ICF participation item (hobbies and work), which can be demand or hope, may be restricted because the medical team cannot tackle them after patients are discharged. After discharge, patients return to society, and their activities can be restricted because they do not sufficiently understand how much motor function they have. The crucial problem is that patients cannot understand their own functions.

The idea of Patient-Centered Medicine (PCM) is the key to solving this problem. PCM is a concept of capturing an individual, not a disease [10, 11]. In other words, medical staff should understand the characteristics of each patient treat and care so as to suit the person and improve the therapeutic effect. To increase the therapeutic effect, it is important for not only the medical staff but also patients themselves to understand the state of their own body. There are few functional evaluations (e.g., Patient-Based Questionnaire) that general people who are not medical personnel can monitor and understand by themselves [12–14]. Moreover, most Patient-Based Questionnaires ask about symptoms, pain, or feeling. There are no questionnaires for patients to understand their function by themselves. For this reason, we have developed a function evaluation tool that anyone can easily perform.

In order to be evaluated by everyone, we developed the assessment tool based on the ADLs. This includes walking, transferring, and dressing, but we especially focused on eating. We assumed that motor functions of the upper extremities could be evaluated, besides ADLs, as they rely on various tools (forks, spoons, chopsticks) and the hands for eating. Kinematic analysis is generally used in the clinical research to evaluate the effects of the intervention [15–17] or research motor function recovery after stroke [18–20]. Kinematic movements evaluated in the previous studies were limited to pointing or reaching, but in one case a drinking task was also evaluated to determine natural movement performance in daily living [21]. People can easily imagine these movements, but expertise and special tools are necessary for evaluations. In order to evaluate without expert knowledge and special tools, we developed an evaluation tool using a questionnaire, assigned scores for each function of the upper extremities, and created a conversion table so that the person with disabilities can visualize their own motor function. Anyone can evaluate their motor functions using the questionnaire if its contents and scores are related to the clinical evaluation. Additionally, from the viewpoint of vocational rehabilitation, there is a possibility of finding work by easily evaluating motor function in a patient-oriented manner.

Thus, this study aimed to verify the reliability and validity of the developed questionnaire by comparing it with the clinical evaluation of motor function. In addition, the upper limb function and work efficacy were also analyzed together.

Methods

Study design

This was a cross-sectional study.

Subjects

We targeted physically handicapped persons who mainly have upper limb dysfunction. In July 2018, at a place where many persons with physical disabilities work without utilizing cognitive function, the facility manager invited all staff with disabilities of the upper limbs and obtained measurements of those who provided consent. Measurements were carried out within the facility. The ethics committee of Kyoto University approved the study (No. R1612). Informed consent was obtained from all participants before enrollment. The eligibility criteria included (1) impairment in the upper limbs and (2) a history of cerebrovascular disease. The exclusion criteria included (1) inability to use the fingers and upper limbs on both sides, (2) severe neurological disease, (3) severe cardiovascular disease, and (4) significantly low cognitive function.

Measurement item

The following measurement items were evaluated: (1) basic information (age, sex, past medical history), (2) Eating Activities Questionnaire (the questionnaire on movements in eating), (3) Fugl-Meyer Assessment (FMA, clinical assessments of upper extremity function), and (4) General Aptitude Test Battery (GATB, work efficiency).

Basic information

Data on age, sex, past medical history, and strength of disabilities were self-reported by the participants (Appendix 1). Data on the dominant hand and paralyzed side were also reported.

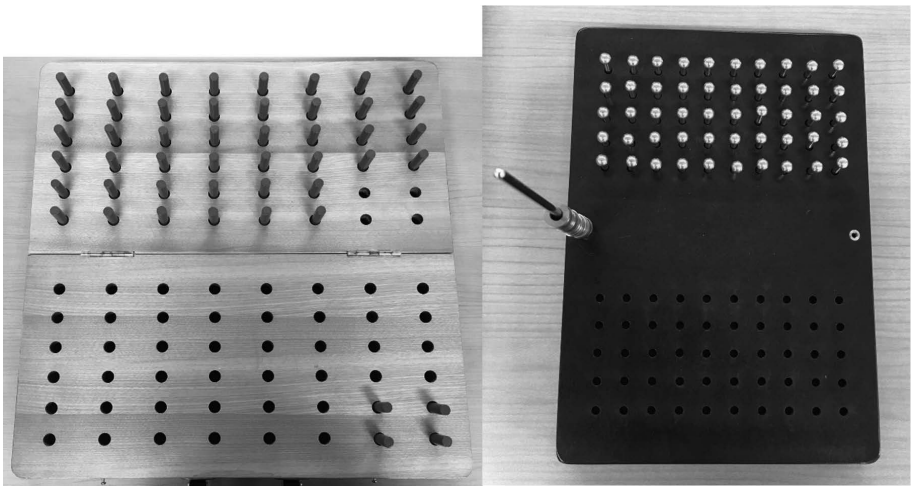

Fig. 1. A peg board and a finger dexterity board.
Rods are replaced from the upper row to the lower one.
Subjects assembled and/or dissembled the nails and washers.

Eating Activities Questionnaire

An orthopedic surgeon, a physical therapist, and a factory manager working with persons with disability created this questionnaire. We analyzed the necessary upper limb functions and observed their eating behavior related to the action. The upper limb functions required for each dietary movement were analyzed and weighted with points. The researchers filled out the questionnaire as they listened to the responses of the subjects.

Questions about various daily meal actions can be answered with can or cannot. The contents of the questionnaire are about drinking, eating with a fork or chopsticks, and so on (Appendix 1). In each question, we extracted the necessary upper limb functions and independently weighted point (a) (Appendix 2). Moreover, point (b) is 1 if the answer to each question was "Yes", and it was 0 if the answer was "No." By multiplying (a) and (b), the score is calculated. The maximum score is 80 points for the total items about the fingers, 37 points for the total items about the arm, and 17 points for the total items about the trunk. The minimum score is 0 for each part.

We asked the questionnaire again one week after the first measurement for test-retest reliability.

Clinical assessments of upper extremity functions

We evaluated the upper extremity functions by the Fugl-Meyer Assessment (FMA) [22]. The test on the upper limb consists of four parts (A, arm; B, wrist; C, hand; and D, coordination). The score is based on the ability to perform isolated movements within and out of synergy patterns. There are 33 items, and each item is graded from 0 to 2 points. The maximum score is 66 points. We measured not only the paralyzed side but also the healthy side to compare with that in the Eating Activities Questionnaire.

Work efficiency

Work efficiency was evaluated using the General Aptitude Test Battery (GATB) [23], which was developed in the USA and revised for the Japanese population by the Ministry of Health, Labor and Welfare. There are 12 paper tests and 4 apparatus tests, but we conducted only the apparatus tests in this time. It can evaluate two functions: (1) arm dexterity and (2) hand dexterity. Arm dexterity is evaluated by two tests with a peg board, and hand dexterity is evaluated by two tests with a finger dexterity board (Takei Scientific Instruments, Niigata, Japan) (Fig. 1).

(1)-1: The number of rods that were replaced from the upper row to the lower one with their paralyzed upper extremity in 15 s is counted. After performing the test three times, the best score is converted to the final score using a conversion table. The maximum score is 139, and the minimum score is -67.

(1)-2: The number of rods that were turned over with the paralyzed upper extremity in 30 s is counted. After performing the test two times, the best score is converted to the final score. The maximum score is 156, and the minimum score is -104.

(2)-1: Subjects combine nails and washers and pierce the pairs into a hole with their paralyzed arm. An observer counts the pairs they combined and pierced in 1 min 30 s. They can try the test only once, and the score is converted to the final one.

The maximum score is 156, and the minimum score is -30.

(2)-2: Subjects disassemble the combined nails and washers, insert the nails into the hole on the upper stage, and attach the washers to the stick with their paralyzed hand. An observer counts the pairs they disassembled in 1 min, and the result is converted to the final score. The maximum score is 91, and the minimum score is -34.

Sample size

The sample size in the correlation analysis was calculated using the G*Power 3 program (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). A sample size of test-retest reliability of 10, 7, and 5 for detecting the value of ICC of 0.7, 0.8, and 0.9, respectively, involved two observations. A sample size of 13 was necessary for the analysis, with a planning value of correlation of 0.61, alpha = 0.05, and power = 0.8 [24].

Statistical analysis

To confirm the reliability of the Eating Activities Questionnaire, the total scores of both arms, both hands, and trunk were compared between the first and second results of the questionnaire. We filled the questionnaire again 1 week after the first measurement for test-retest reliability, which was estimated by intraclass correlation coefficient (ICC) [25, 26]. ICC was calculated using the SPSS version 20.0 software (SPSS, Chicago, IL, USA).

The validity was investigated by correlation analysis [24]. Results on the paralyzed side were used for analysis in consideration of the ceiling effect. The Spearman's rank correlation coefficient was calculated with the questionnaire results, FMA, and GATB. The correlation analysis was performed using JMP Pro version 12.2 (SAS Institute, Cary, NC, USA), with a P-value < 0.05 considered as significant.

Results

The total number of subjects was 16. Of the 16 subjects, 10 (62.5%), who were available for measurement for the second time, retested the questionnaire after 7 days. Basic information (age and sex), questionnaire results, and FMA and GATB scores are shown in Table 1.

Table 1 Subjects' characteristics*

Variables	Subjects (n = 16)
Age (years)	48.75 ± 10.33
Men (%)	13 (81.3)
Dominant hand (right)	9 (56.2)
The Questionnaire (point)	
Arm	13.88 ± 15.39
Hand	28.56 ± 31.60
Trunk	12.5 ± 5.63
Fugl-Meyer Assessment (point)	
Arm	19.81 ± 12.55
Wrist	4.31 ± 4.21
Hand	6.44 ± 6.43
Work efficiency (point)	
Test 1	−60.25 ± 5.29
Test 2	−89.31 ± 11.64
Test 3	−13.44 ± 13.86
Test 4	−18.19 ± 12.32
Arm	−149.56 ± 16.00
Hand	−31.63 ± 25.70

* Values are mean ± SD or percentage.

Reliability

Test-retest reliability is shown in Table 2. The ICC value was 1.00 (95% confidence interval [CI], 1.00 to 1.00) for the right arm, 0.869 (95% CI, 0.526 to 0.969) for the left arm, 0.994 (95% CI, 0.974 to 0.999) for the right hand, 0.883 (95% CI, 0.570 to 0.972) for the left hand, and 1.00 (95% CI, 1.00 to 1.00) for the trunk. Overall, these results indicated that all items had sufficient reliability [27].

Validity

The correlations among the questionnaire, FMA, and GATB scores for the hand are shown in Fig. 2. A significant correlation was found between the questionnaire score of the hand and FMA score of the wrist (r = 0.746) and hand (r = 0.847). However, there was no correlation (r = 0.136) between the questionnaire score of the hand and the GATB score of hand dexterity and between the FMA score of the wrist (r = 0.372) or hand (r = 0.443) and the GATB score of hand dexterity.

The correlation among the questionnaire, FMA, and GATB for the arm is shown in Fig. 3. There was a significant correlation (r = 0.858) between the questionnaire score of arm and the FMA score of the arm. There was no correlation (r = 0.310) between the questionnaire score of arm and the GATB score of arm dexterity, but a weak correlation (r = 0.593) was found between the FMA score of arm and the GATB score of arm dexterity.

Discussion

In this study, the Eating Activities Questionnaire was examined along with the traditional clinical assessment (FMA) and work efficiency assessment (GATB). The test-retest reliability of the Eating Activities Questionnaire was confirmed, and upper limb functions per the questionnaire and FMA were significantly correlated. There was no significant correlation between the questionnaire and work efficiency.

To evaluate reliability, test-retest reliability is commonly used. As shown in Table 2, since the ICC between the questionnaires given twice was significantly higher [28], its reliability was certain [29]. People with disabilities could easily understand questions and sentences of the developed questionnaire, and there was always no influence on interpretation. The confidence interval was wide in the upper left limb, probably because of a large number of right-handed subjects in the study.

In this study, upper limb functions per the questionnaire and FMA were significantly correlated. The research team independently evaluated the eating movements and constructed an algorithm for estimating upper limb function, but as a correlation was found with the index that has been used in the past, it may be sufficient for functional evaluation. Previous studies have shown the association between kinematic movements such as drinking task and FMA [17]. The drinking task also includes reaching, grasping, and lifting the glass from the table. Although the kinematic movement in the drinking task may be a subjective and qualitative assessment, the elements included in the kinematic movement are consistent with those of clinical assessments (FMA, ARAT). The correlation between kinematic movements and clinical assessments is due to this consistency. In this study, since the contents of the questionnaire are kinematic actions such as a drinking and grasping something to eat with the hand, it is thought that the relationship between the questionnaire and FMA was strong. From these results, it is possible to grasp the upper limb function of the patient with stroke from the questionnaire on the eating activities.

There was no significant correlation between the questionnaire and work efficiency because work efficacy includes elements of technology and speed; it may not have been dependent on simple functions. From the point of motion control, the movement is closely related to the individual, task, and environment. It has been also reported that the exercise of muscles of upper limb changes depending on the height of the desk [30] and in this study, the motor functions of the person with disabilities might not be fully measured under uniform conditions. Because it includes elements such as smoothness and time, it is thought that its association with motor function evaluation was low. This is why the questionnaire was not directly related to work efficiency. On the contrary, people with disabilities can determine their motor function from this questionnaire. Therefore, it is different from the previous questionnaire that they can assess themselves regarding daily life and social activities by understanding what they can presently do and what they are not good at. It is also possible to obtain the necessary abilities and circumstances to be able to work.

There are several limitations in this study. First, although a significant correlation was seen, the number of samples was small. In order to use the FMA index, the disease was limited to cerebrovascular disease; but the eating activities questionnaire created could be used to evaluate upper limb function regardless of the disease. Thus, the number of samples should be increased in the future studies.

Second, because GATB involves only assembling or replacing, the content may not be insufficient as evaluation of work efficiency (e.g., typing). Third, there were few female subjects. Fourth, this was a cross-sectional study. Therefore, any cause-effect relationship among the questionnaire, FMA, and GATB remains unknown.

In the future, it is thought that the questionnaire will be the cutting edge for disabled persons' return to society, employment support, and support for hobby activities. When generally used as a function evaluation tool, it is important to apply the questionnaire in not only functional evaluation but also a wide range of diseases (muscular dystrophy, multiple sclerosis, etc.) and fields (manufacturing, processing industry, desk work, etc.). It may also be used as an evaluation of rehabilitation [31].

In this study, the reliability of the developed questionnaire was confirmed, and the validity of that on motor function and work efficiency was investigated. The questionnaire was found to be significantly related to the clinical assessment of upper extremity functions in patients with stroke. Since the Eating Activities Questionnaire is a self-writing type questionnaire and can convert scores, it is possible to self-monitor the motor functions. Using this questionnaire, people can evaluate themselves and understand their functions.

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Disclosures

Approval of the research protocol: This study was approved by Ethic Review Committee in this facility (approve No. R1612) regarding research protocol including the voluntary participation, do not harm, confidentiality, anonymity and only assess relevant components of this study. Informed consent: In this study, we explained about this research sufficiently in document and oral to those who would participate beforehand, then this

study targeted for only those who gained consent from the person's free will. Explained items were following: the title and outline of this research including the objective, measurement items and its duration, disadvantages arising from becoming subjects, freedom of refuse to become subjects at any time, be able to withdraw consent from as required even after subjects and their family agree, protection of privacy and no reward is paid. *Registry and the registration no. of the study/trial: N/A. Animal studies: N/A*.

Author Contribution

YT wrote this paper. TH, HA, YY, NW conducted data collection. YT, YN, AY, YS, IY, TA designed study. YT, YN, AY, YS analyzed data. All co-authors confirmed this research.

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■ORIGINAL ARTICLE

Practical Usefulness of Clothes Hangers Hung Over Chair Backrests to Dry Pullover Garments Among Healthy Individuals and Patients with Hemiplegia

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Abstract: Purpose: Hanging washed pullover garments to dry with one hand poses a challenge in daily life for patients who are forced to use their unilateral upper extremity. We hypothesized that a hanger hooked onto the backrest of a chair (backrest hanger) would facilitate easy hanging of pullover garments that need to be dried with one hand; in particular, one can place a pullover garment on the backrest hanger and then pull the hanger along with the garment upward to separate them from the backrest. The present study aimed to demonstrate the practical usefulness of a backrest hanger for patients with hemiplegia.
Methods: This study included 20 healthy volunteers and 16 patients with hemiplegia. Participants were requested to hang a sweatshirt to dry with one hand only (the non-dominant hand for healthy volunteers and the non-paralytic hand for patients with hemiplegia) using a backrest hanger, pinch hanger, and a bath towel rack. Patients with hemiplegia performed the task after being instructed regarding how the greatest number of healthy individuals used each tool. Participants were requested to rate their level of ease in hanging the sweatshirts, and the total time required to complete the task was measured.
Results: Both healthy volunteers and patients with hemiplegia reported the backrest hanger to be the easiest mode of hanging sweatshirts, and it required significantly shorter amount of time as compared to the other two tools.
Discussion: The findings indicate the high practical usefulness of the backrest hanger method.

Keywords: hanging, washed garments, hemiplegia, chair backrest

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1. Introduction

Pinch hangers, bath towel racks, and clothes hangers are often used for hanging washed pullovers to dry. Hanging clothes with one hand is not easy, irrespective of the tools used [1]. This particularly poses a challenge to patients with orthopedic diseases and hemiplegia, as they are forced to use the unilateral upper extremity owing to various reasons. Among the abovementioned tools, clothes hangers are best suited for hanging pullover garments considering the appearance of dried garments. However, hanging a washed pullover garment on a clothes hanger is a task that is usually considered to be extremely difficult to accomplish without the use of both hands because one hand inserts the hanger inside the garment, and the other adjusts the garment's position on the hanger. One method for hanging front-opening garments with one hand requires one to first hang the garment on a chair's backrest, insert the hanger into the garment by using the opening in front of the garment,

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Fig. 1. Tools used for hanging.
Backrest hanger (left), pinch hanger (center), and bath towel rack (right). The arrow on the backrest hanger denotes a hook to hang the clothes on the backrest.

and finally pull the hanger's hook upward along with the garment [2]. However, this method is inconvenient for hanging pullover garments. We hypothesized that a clothes hanger hooked onto the backrest of a chair (backrest hanger) would facilitate better hanging for pullover garments that need to be dried with one hand; in particular, one can place a pullover garment on a backrest hanger and then pull the hanger along with the garment upward in order to separate them from the backrest.

This study aimed to demonstrate the usefulness of a backrest hanger for one-handed clothes hanging by observing healthy volunteers and patients with hemiplegia who used only one hand to attempt to hang a pullover garment on a backrest hanger, a pinch hanger, and a bath towel rack; after this the results for each tool were compared.

2. Methods

Participants

The study included 20 healthy volunteers (11 women; *M*age = 21 ± 2 years; range = 18–31 years), and 16 patients with hemiplegia due to cerebral infarction or hemorrhage (10 women; *M*age = 64 ±13 years; range = 44–85 years). The median intelligence of both groups was scored using the Hasegawa Dementia Rating Scale-Revised [3]. The score for the healthy sample was 30/30 points (range = 29–30 points), while, for the hemiplegic patients, it was 26/30 points (range = 24–29 points). All patients were in the chronic phase and regularly visited the daycare facilities.

This study was conducted in accordance with the Declaration of Helsinki after approval from the Institutional Review Board of Tohoku Medical College (approval number, 411). All participants provided written consent after receiving a detailed explanation of the study.

Equipment

The participants performed tasks while sitting in a chair in order to prevent themselves from falling [4]. Participants were requested to hang a washed pullover garment with one hand using a backrest hanger, pinch hanger, and bath towel rack as shown in Fig. 1. The pullover garment used in this task was a sweatshirt (dry weight, about 430 g) that was washed and dewatered for 7 minutes (weight after dewatering, about 620 g). The sweatshirt was placed in a basket within the reach of the participant. A backrest hanger was prepared by hanging a clothes hanger over a chair backrest via a wire hook attached to the backrest, as indicated by the arrow in Fig. 1. A pinch hanger was used by hanging it on a laundry pole.

Participants hanging the pullover garment to dry were recorded at 30 frames per second using two digital video cameras (NV-GS300; Panasonic Inc, Osaka). The camera was set at lateral side from the side of the hand used for the task and another camera was set diagonally behind on the opposite side. Images from these two video cameras were recorded synchronously and analyzed with a digital motion picture waveforms real-time synchronous recording system (The Teraview, Gigatex CO., Ltd.) for analysis.

Procedure

Healthy participants were included in Experiment 1, while patients with hemiplegia were included in Experiment 2.

Experiment 1. Participants were requested to hang a sweatshirt to dry in any way using only their non-dominant hand and three tools mentioned above. Their

order was counterbalanced, and the experiment was conducted after the participants had practiced to satisfaction. After completing the task with all the three tools, the participants were asked to subjectively rate how easily the sweatshirt was hung to dry with respective tools. Furthermore, after the sweatshirt had dried, the participants were asked if they would wear it as is and go out.

Subsequently, we reviewed video images of all healthy participants and measured the total time required to hang a sweatshirt with each of the tools (hereinafter referred to as "hanging operation time"). In addition, we selected the method of hanging adopted by the largest number of participants for each tool, summarized the key points, and used them for the participants of Experiment 2. We instructed how to hang a sweatshirt to the patients depends on the results of Experiment 1, since those patients have never washed cloth after stroke.

The sweatshirts were hung to dry indoors synchronously with respective tools, as explained to patients with hemiplegia in Experiment 2, and lengths of time required for drying (hereinafter referred to as "drying time") were measured. When the bath towel rack was used, however, one side of the sweatshirt was dried, and then turned over for the other side to dry, as the sweatshirt was held in half.

Experiment 2. Patients with hemiplegia were requested to hang a sweatshirt to dry with their non-paralytic, using the three tools mentioned above. An examiner provided instructions regarding the hanging process for each tool, and patients performed the task after practicing to satisfaction. The three tools were again counterbalanced, and the participants were asked to subjectively rate their ease in hanging the sweatshirt to dry, and whether they would wear it as is and go out. Further, the time taken to hang the sweatshirt was measured for each of the tools.

Analysis

Overall, four aspects were analyzed:

Subjective assessment of ease of hanging. The participants rated the tasks as "very easy," "somewhat easy," "neither easy nor difficult," "somewhat difficult," or "very difficult". Total responses for each of the options were counted.

Finish and acceptability of sweatshirts to be worn outside. Drying was considered done when the weight of the sweatshirt became equal to its dry weight measured before washing. In addition, the participants were asked if they felt comfortable wearing those sweatshirts outside, and the yes/no responses were counted.

Hanging operation time. The duration required to complete the hanging task (from removing the sweatshirt from the basket to taking the hand off of the hung sweatshirt) was measured using video images. The total hanging operation time for all three tools was compared using the Friedman test both in the Experiment 1 and 2. If differences were observed, data with the 3 tools were subjected to 2-group comparisons by Wilcoxon's signed rank test, and the significance level was < 1.6% after Bonferroni correction. In Experiment 2, any patient who could not use a tool was excluded from comparison.

Furthermore, the hanging operation time for healthy participants and those with hemiplegia was compared for each tool. Mann-Whitney U test was used to test differences, and the significance level was < 5%.

Drying time. The duration from when a dewatered sweatshirt was hung until when the sweatshirt was considered dry was measured. A hung sweatshirt was considered dry when its weight became equal to its dry weight measured before washing

3. Results

Experiment 1 (Healthy Volunteers)

Subjective assessment of ease of hanging. The backrest hanger was rated as the easiest tool to use (Table 1).

Finish and acceptability of sweatshirts to be worn outside. The sweatshirts hung to dry with backrest hangers had nearly intact shape (Fig. 2, left). Those hung to dry with pinch hangers had marks and were stretched where clothespins were placed (Fig. 2 middle, circled). Those dried using bath towel racks had a mark of the bar where folded (Fig. 2 right, arrow). Sweatshirts dried using backrest hangers were deemed comfortable to wear and go out by the majority of participants (Table 1A).

Hanging operation time. The median (interquartile range) of hanging operation time were 18.1 (14.8–20.2) sec, 57.0 (38.4–79.7) sec, and 35.7 (26.6–39.5) sec, respectively (Table 1A). Shortest duration was required to complete the hanging task using the backrest hanger, followed by the bath towel rack, and then the pinch hanger ($p < .01$).

The most commonly used way of hanging. Figure 3 displays the most commonly used way of hanging backrest hangers (a), pinch hangers (b), and bath towel racks (c). The methods shown in the figure were used by 12, 20, and 7 participants, respectively. The most commonly used way of hanging sweatshirt using a backrest hanger was as follows: The arm is inserted into the neck hole of the sweatshirt to reach the hem and the sweatshirt is lifted up; then the hanging side of the hem is placed on the backrest to start covering the side ipsilateral to the arm being used; while retaining the arm in the sweatshirt, the arm is moved on the backrest

Table 1. The responses of healthy volunteers and patients with hemiplegia to different tools.

	Backrest hanger	Pinch hanger	Bath towel rack	P value*
A. Experiment 1 (healthy volunteers)				
Assessment of ease of hanging (number of subjects)				
Very easy	14	0	7	
Somewhat easy	6	0	7	
Neither easy nor difficult	0	1	6	
Somewhat difficult	0	2	0	
Very difficult	0	17	0	
Clothes were comfortable to wear and go out in?				
Yes	20	0	12	
No	0	20	8	
I do not know	0	0	0	
Hanging operation time (seconds)				
Overall subject population	18.1 (14.8–20.2)	57.0 (38.4–79.7)	35.7 (26.6–39.5)	< 0.01*
Subjects who hung the tool to dry according to the instructions provided to the patients with hemiplegia	16.9 (14.5–19.2)	57.0 (38.4–79.7)	32.4 (25.2–38.4)	
Drying time (hours)	8	8	12	
B. Experiment 2 (patients with hemiplegia)				
Assessment of ease of hanging (number of subjects)				
Very easy	13	0	0	
Somewhat easy	3	0	11	
Neither easy nor difficult	0	0	5	
Somewhat difficult	0	0	0	
Very difficult	0	16	0	
Clothes were comfortable to wear and go out in?				
Yes	2	0	0	
No	0	2	2	
I do not know	14	14	14	
Number of subjects who completed the hanging task	16	12	16	
Hanging operation time (seconds)	16.9 (15.1–28.6)	48.4 (34.0–62.3)	28.7 (19.5–54.3)	< 0.01*

The hanging operation time lengths for all healthy volunteers are shown in mean form (standard deviation). The hanging operation time lengths for healthy volunteers who hung a sweatshirt to dry according to the instructions provided to the patients with hemiplegia and the hanging operation time lengths for patients with hemiplegia are shown in median form (interquartile range).
* Wilcoxon's signed rank test ($p < .016$): Backrest hanger < Pinch hanger, Bath towel rack < Pinch hanger, Backrest hanger < Bath towel rack

Fig. 2. Appearance of dried sweatshirts.
Sweatshirts dried using a backrest hanger (left), pinch hanger (center), and bath towel rack (right). Circles in the center panel indicate hem areas of the pinch hanger-dried sweatshirt where clothespin marks and stretches were observed. The arrow in the right panel denotes the mark of a rod of the bath towel rack.

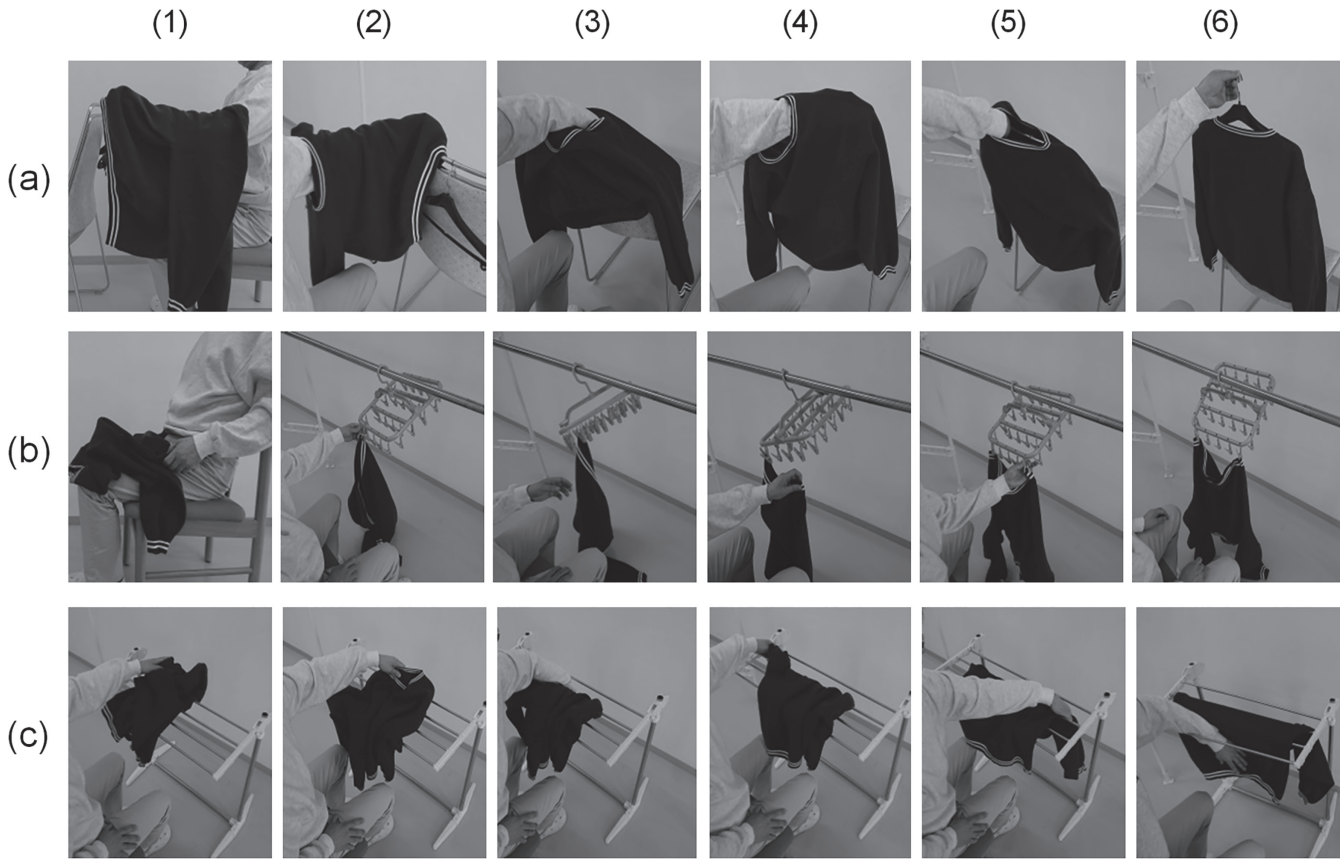

Fig. 3. Most commonly used methods of hanging with different tools
Methods of hanging with backrest hanger (a), pinch hanger (b), and bath towel rack (c). Photographs in column (1) in (a) and (b) were taken from the side of the hand being used. Photographs in columns (2)–(6) in (a) and (b) and those in columns (1)–(2) in (c) were taken from diagonally behind the opposite side of the hand being used.
(a) Method of hanging with a backrest hanger.
(b) Method of hanging with a pinch hanger. A sweatshirt is placed on the thigh; the left or right hem is held with the ring finger, little finger, and palm; the hem was pinched with a clothespin attached to the pinch hanger using the thumb and index finger. At this stage, the pinch hanger rotates and tilts as the clothespin is not at the center position of the pinch hanger. The other side of the hem is identified, held with the ring finger, little finger, and palm; the direction and height of the pinch hanger is adjusted using the thumb and index finger, and then the hem is pinched with another clothespin to complete the hanging task.
(c) Method of hanging with a bath towel rack. A sweatshirt is placed on a bath towel rack. The neck hole of the sweatshirt is held and inserted into the space between one rod and another. Arms of the sweatshirt are then inserted between the rods and pulled left and right to stretch. Finally, the hem is inserted between the rods to complete the hanging task.

first horizontally to the other side, then downward so that the sweatshirt covers the entire backrest, including the opposite surface; then the hanger is pulled up to detach it with the sweatshirt from the backrest; and this completes the hanging operation with a backrest hanger. Operations with other tools are shown in lower tiers in the figure. Patients with hemiplegia were instructed to use these ways of hanging in Experiment 2.

Drying time. The total drying time when using backrest hangers was comparable with that of pinch hangers, and 30% shorter than that of bath towel racks (Table 1A).

Experiment 2 (Patients with Hemiplegia)

Subjective assessment of ease of hanging. The backrest hanger was rated as the easiest tool to use.

Finish and acceptability of sweatshirts to be worn outside. Finished sweatshirts after drying were characterized similarly as in Experiment 1. Fourteen patients said, “I do not know because I do not usually wear sweatshirts.” The remaining two patients answered OK for the backrest hanger, but not OK for other tools.

Hanging operation time. Four patients could not complete the hanging task using a pinch hanger. The median (interquartile range) of hanging operation time were 16.9 (15.1–28.6) sec, 48.4 (34.0–62.3) sec, and 28.7 (19.5–54.3) sec, respectively (Table 1B). The

duration required to complete the hanging task using a backrest hanger was significantly shorter than that required using either of other two tools ($p < .01$). In addition, there were no significant differences in hanging operation time between patients with hemiplegia and healthy participants who used the same ways of hanging for respective tools.

4. Discussion

Results from these experiments demonstrated that, among the three tools, the backrest hanger was the easiest and quickest one to hang a sweatshirt to dry for healthy volunteers. They reported that they would be comfortable going out wearing the sweatshirts dried using backrest hangers. The backrest hanger was the easiest tool to hang a sweatshirt to dry also for patients with hemiplegia. When pinch hangers were used, four patients could not complete the hanging task, indicating that the pinch hanger may not always be suitable for patients with hemiplegia. Moreover, even in the comparison that excluded these patients, the backrest hanger had the shortest drying operation time among the three tools. These findings suggest that backrest hangers are more practically useful to hang pullover garments to dry than pinch hangers or bath towel racks for both healthy individuals and patients with hemiplegia.

When using a pinch hanger, the participants had to correct its position during the task (Fig. 3b). With respect to the bath towel rack, participants had to horizontally pull both sides of the sweatshirt hung on a rod several times to prevent wrinkle formation (Fig. 3c). The backrest hanger did not require any of these actions. Relatively simple series of actions were required to cover the backrest with a pullover garment, so the participants did not fail often. This is presumably why the backrest hanger was considered easy to use and required a shorter duration to complete the hanging task. For pinch hangers, several methods to solve difficulties in the hanging operation were reported, including a method of placing a pinch hanger on the table then starting the hanging operation [5], the use of a pinch hanger designed for one-hand users [6], and a method of attaching a curtain hook to each clothespin, putting such clothespins on a garment on the table, and hanging the garment over a pinch hanger through the curtain hooks [7]. However, irrespective of the methods used, the dried garment had marks and stretched where a clothespin was put, as shown in the center of Fig. 2. Consequently, we consider the use of a backrest hanger to be favorable than any of the previously reported methods.

As a pullover garment, we did not use a sweater or undershirt that is often worn by individuals in the age group of hemiplegic patients in this study. In addition, we did not directly ask with which method the finished garments were most preferable. As a result, we were uncertain about how the patients with hemiplegia felt regarding the finish with different tools. Nevertheless, sweaters and undershirts hung to dry using respective tools are expected to have similar characteristics to those seen in this study. The use of backrest hangers is likely to be most preferred as it does not leave any pinch mark, stretch, or folding line.

No significant differences were observed between heathy participants and patients with hemiplegia in terms of the time required to complete the hanging task for all the tools. In other words, patients with hemiplegia could complete the task in the same amount of time as the healthy participants albeit the backrest hanger method being new to them.

Limitations and Future Directions

In this study, participants with hemiplegia were limited to chronic-phase patients capable of attending a daycare service facility. In addition, patients with severe higher brain dysfunction were not included. Therefore, it remains unclear whether the backrest hanger method has a similar level of usefulness in acute-phase patients or patients with severe higher brain dysfunction. For example, the method may be difficult for patients with amnesia because they have to remember how to use the backrest and hanger they have never used before. It is conceivable that the method is similarly effective in patients who are forced to use the unilateral upper limb due to orthopedic diseases; however, this has not been demonstrated. In the future, the practical usefulness of this method should be tested in other patient populations, such as acute-phase patients, patients with higher brain dysfunction, and patients with orthopedic diseases. In the present study, we studied one part of the whole process of washing clothes. Thus, in the future study, it should be important to focus on the whole process of washing clothes as daily activity.

5. Summary and Conclusions

We requested healthy volunteers and patients with hemiplegia to hang a sweatshirt to dry by using only one hand to operate three tools: a backrest hanger, a pinch hanger, and a bath towel rack. Next, the participants were requested to rate their level of ease in hanging the sweatshirts, and the time they took to complete the task was measured. Both healthy volunteers and patients with hemiplegia reported that the backrest hanger was the easiest tool to use for hanging sweatshirts, and it required a significantly shorter amount of time compared

to the other two tools. The study findings thus indicated the high practical usefulness of the backrest hanger method.

Conflict of Interest

There are no conflicts of interest to declare.

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