■ORIGINAL ARTICLE

Clinical Utility of Positive Occupation-Based Practices Applying an Engagement Estimation System: A Single-Group Pre/Post-Comparison Study

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Abstract: Objectives: This study aims to examine the treatment effects of Positive Occupation-Based Practice (POBP) in individuals with mental illness using the Engagement Estimation System (EES) of the Assessment of Positive Occupation 15 (APO-15) in a single-group, pre/post-comparison design in a multicenter study.
Method: This study was a collaboration between day hospitals (two facilities) and psychiatric hospitals (three facilities). The sample consisted of a diverse group of participants, aged 20–80 years, diagnosed with psychiatric disorders and recruited with the consent of their treating physicians. This study examined the treatment effects of POBP with EES applied as an adjunct to day hospital or psychiatric occupational therapy in a single-group, pre/post-comparison design. Participants were asked to attend the standard program and the EES-applied POBP program at each facility. The intervention period was 5 months, starting from baseline, with an additional 1-month follow-up period after completion of the intervention. In this study, the Subjective Well-being Scale was used as the primary outcome measure. In addition, the Positive and Negative Affect Schedule and the APO-15 were used as secondary outcome measures.
Results: The study included 18 participants. Basic participant information included diagnosis (12 schizophrenia, 5 depression, 1 organic psychosis), gender (9 male, 9 female), age (57.61 [±13.25]), and living environment (12 community, 6 hospital). EES-applied POBP showed a statistically significant therapeutic effect on 7 of the 9 factors in the three outcome measures.
Conclusion: The EES-applied POBP may contribute to the effective enhancement of subjective well-being and positive emotions in individuals with mental illness.

Keywords: mental illness, intervention effect, occupational participation, subjective well-being, positive emotions

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Introduction

In recent years, a new evidence base has emerged for global trends focused on well-being [1–4]. This enables health services to be oriented toward promoting well-being as well as treating illness, making it a reality that health is more than the absence of illness. As a result, occupational therapists working in mental health services must be able to contribute to both the promotion of well-being and the treatment of clients' illnesses.

In psychiatric occupational therapy in Japan, one method of support that can contribute to the above issues is Positive Occupation-Based Practice (POBP) [5]. Positive occupations are defined as occupations that have the potential to contribute to the promotion of human health and well-being, based on previous research in positive psychology and occupational science [5]. For example, positive occupations, such as the ability to engage in positive relationships, may not only reduce

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Table 1 Can-Do Chart of EES

No.	Item-content	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
6	I feel supported by the people surrounding me	○	○	◎	◎	◎
8	I live my life the to the fullest	–	○	○	◎	◎
7	I can concentrate on my favorite activities	–	○	○	◎	◎
11	I feel fulfilled when we can help each other with the people around me	–	○	○	◎	◎
10	When I come across people who are in trouble, I want to help them immediately	–	○	○	○	◎
9	I live my life according to my values	–	–	○	◎	◎
3	I'm currently making efforts to achieve my goal	–	–	○	○	◎
2	I have a goal that I want to achieve	–	–	○	○	◎
15	I take an active role in making decisions that shape my life	–	–	○	○	◎
13	I can concentrate on my hobbies	–	–	○	○	◎
12	I'm making an effort to be able to concentrate	–	–	○	○	◎
5	I can make an effort to achieve my long-term goals rather than my momentary profits	–	–	○	○	◎
4	I can communicate well with people and work with them to achieve my goals	–	–	○	○	◎
1	I have the motivation to fulfill my hope	–	–	○	○	◎
14	I always try to see the bright side of things	–	–	○	○	○

Note. Factor items = positive relationships (4, 6, 10, 11, 14), achievement (1, 2, 3, 5), engagement (7, 12, 13), meaning (8, 9, 15), Rank 1 = very weak participation group, Rank 2 = weak participation group, Rank 3 = moderate participation group, Rank 4 = strong participation group, Rank 5 = very strong participation group.
The table above is presented in descending order from the positive occupation in which the 4159 clients self-identify as participating on the APO-15 scale items. On the right side of the scale items, participation status in positive occupations is expressed probabilistically according to each rank: – = unable to participate, ○ = able to participate, and ◎ = well able to participate.
To illustrate the status of each rank, for example, a Rank 1 client perceives that the client can participate in item 6, "I feel supported by the people surrounding me." Rank 5 clients that they perceive themselves to be able to participate well in positive occupations, with the exception of item 14, "I always try to see the bright side of things."

feelings of isolation and loneliness but also contribute to a sense of companionship and self-worth [6]. POBP is a support method that teaches clients about the positive occupations listed above and helps them make them a habit in their lives through experiential learning [5]. The effectiveness of POBP has been demonstrated in several studies. For example, a non-randomized controlled trial evaluated the effectiveness of POBP in individuals with mental illness who used psychiatric day hospital, inpatient psychiatric occupational therapy, and employment transition support [7, 8]. The results showed that the POBP group showed increased positive emotions and social participation compared to the control group following the standard program implemented at each facility. In addition, POBP has been evaluated for its intervention effects not only in individuals with mental illness but also in elderly salon users [9]. The results reported that POBP contributes to the promotion of well-being in elderly salon users. Therefore, the effectiveness of POBP is a potential contribution to promoting the well-being of individuals with mental illness, and elderly salon users.

The POBP uses the Assessment of Positive Occupation 15 (APO-15) scale to assess the client. The APO-15 is a scale that can assess a client's state of participation in positive occupations [10, 11]. The scale structure of the APO-15 consists of 15 items with four factors (positive relationship, achievement, engagement, and meaning) and has good psychometric properties [10, 11]. In addition, the APO-15 developed the Engagement Estimation System (EES), which can assess positive occupational participation status with a five-point rank score by using the Latent Rank Theory (LRT) [12]. The rationale for applying LRT to the APO-15 is that cutoff points have been suggested to be 1) subject to misclassification and 2) inflexible in actual operation, making it difficult to tailor interventions to individual conditions [13]. In other words, the LRT has the potential to contribute to the aforementioned problems, and because it can clearly indicate the subject's condition through the rank estimation, it has the characteristics that make it easy to explain meaningful differences to evaluators and subjects and to consider interventions that are appropriate for individual conditions [14]. The EES evaluation criteria range from "Rank 1: Very weak participant group" to "Rank 5: Very strong participant group," with Rank 5 being considered the best condition [12]. In addition, EES has implemented a "Can-Do Chart" to effectively promote participation in positive occupations based on response data from 4159 clients [12] (Table 1). Previous research has suggested that the use of the EES in psychiatric occupational therapy and POBP may be effective in improving well-being and social participation [15, 16]. In other words, the use of the EES in psychiatric occupational therapy and POBP assessments may be useful for occupational therapists' clinical

reasoning and may effectively promote clients' positive occupational participation. However, these have been limited to case reports, and their therapeutic effects have not yet been fully investigated. Based on the above, the purpose of this study was to evaluate the therapeutic effects of EES-applied POBP in a multicenter study using a single-group pre/post-comparison design. By addressing the following research questions, we hope to contribute to the validation of the therapeutic efficacy of the EES-applied POBP:

1. Does the EES-applied POBP promote the well-being of individuals with mental illness?

Methods

Ethics statement

This study was approved by the Ethics Committee of the Zikei Hospital 171(3–4). Furthermore, we received approval from the facility directors of all institutions that participated in this study. Participants in this study provided written and verbal informed consent. Participation in this study was entirely voluntary, and participants were free to leave at any time without explanation. The study lasted from April 2022 to November 2022. This study was carried out in accordance with the Declaration of Helsinki. It is also registered in the UMIN Clinical Trials Registry (UMIN000047015).

Research design (Fig. 1)

This study used a single-group pre/post-comparison design. Participants were asked to participate in an EES-applied POBP that was incorporated into a standard day hospital/occupational therapy program. The above POBPs were conducted by occupational therapists trained in intervention methods. The intervention lasted 5 months from the start of the study, with a 1-month follow-up to assess the therapeutic effects.

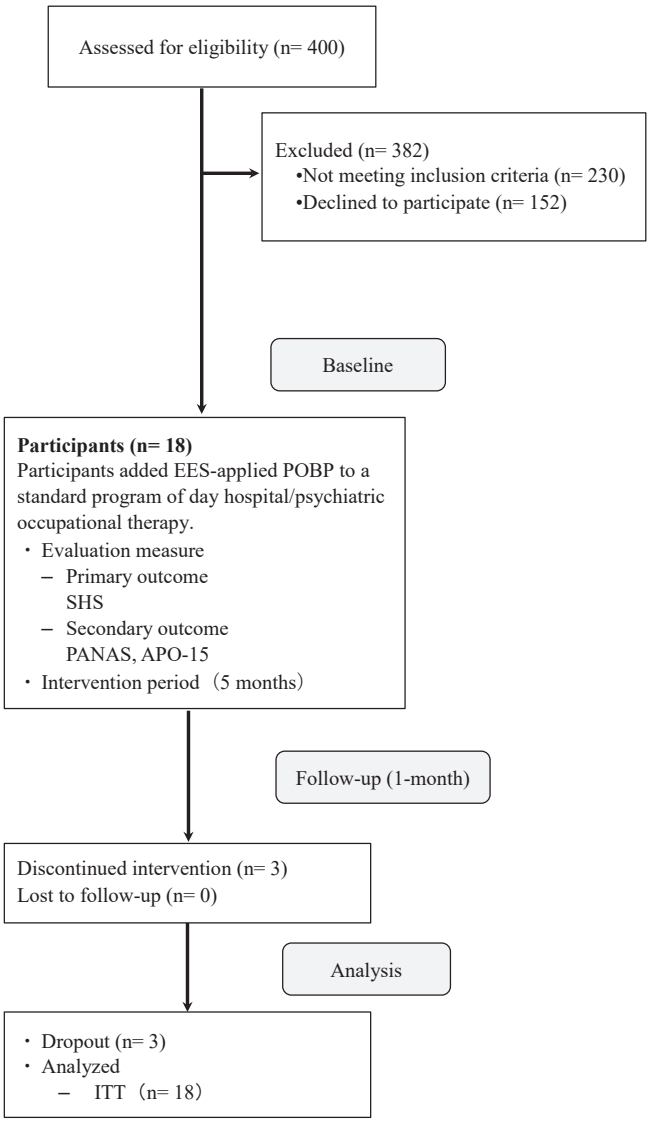

Fig. 1. Research outline.
Note. ITT = Intention to treat
The implementation environment of this study was the day hospital (2 facilities) and psychiatric occupational therapy (3 facility), and 18 participants who met the selection criteria conducted it.

Participants

This study was conducted in day hospitals (two facilities) and psychiatric hospitals (three facilities) located in Okayama, Ishikawa, and Niigata prefectures in Japan. The selection criteria for participants were as follows: (1) those who had been diagnosed by a physician with a psychiatric illness such as schizophrenia and had been treated for at least 1 year, (2) those between the ages of 20 and 80, (3) those whose estimated results on the EES were rank scores 1 to 4, (4) those whose condition was relatively stable as according to the physician and who were considered eligible to participate in the study, and (5) those who understood the content of the study and agreed to participate. On the other hand, the exclusion criteria were as follows: (1) those whose medical condition was unstable and whose attending physicians believed that it would be difficult for them to participate in this study until the end, (2) those whose age was less than 20 years or more than 81 years, (3) those whose estimated results by EES were rank scores 5, and (4) those who did not agree to participate in this study. The age range for participants in this study was set between 20 and 80 years because they were adults as defined by law, we wanted to include a broad age sample, and we considered the age range of occupational therapy users at each cooperating facility. Participants were recruited by displaying posters about this study in the lobbies and other conspicuous locations of each fa-

cility, and participants were encouraged to participate on a voluntary basis. Participants who expressed interest in the study were individually presented with a guide describing the content of the study, and informed consent was obtained. Participants were recruited over a period of approximately 1-month.

To establish a sound scientific basis for an intervention program, multiple phases of clinical trials are typically required, culminating in a randomized controlled trial that evaluates the effectiveness of the intervention. Consequently, during the initial phases, preliminary investigations into the safety and efficacy of intervention protocols are commonly conducted through single-group, pre/post-comparative studies involving a limited sample size of 20 or fewer participants [17]. Therefore, the rationale for the number of participants in this study was set at approximately 20 as a preliminary study of the EES-applied POBP.

Data collection

Data were collected three times: at baseline, after the intervention, and at follow-up. In addition, data were collected by staff who were not directly involved in this study and who asked participants to respond individually. Moreover, gender, age, diagnosis, medication, living environment [living alone, living with family, hospitalized], time since onset, length of hospitalization, and the number of hospitalizations were collected from participants.

Measures

The primary outcome measure of this study was the Japanese version of the Subjective Happiness Scale (SHS) [18], with the Japanese version of the Positive and Negative Affect Schedule (PANAS) [19] and the APO-15 as secondary outcome measures. All outcome measures used in this study had good validity and high reliability (Cronbach's coefficient > 0.80). In addition, negative affect was measured in this study because human emotions are complex and varied, and measuring only positive affect does not provide a sufficient understanding of an individual's experience and psychological state [20]. In other words, negative affect is a natural part of human experience and can play an important role in well-being, but when it is too strong, it can lead to excessive stress states and health problems. Therefore, our hypothesis throughout this study was that the EES-applied POBP would decrease negative affect as participants' positive affect increased.

SHS

The SHS is a scale that assesses one's subjective well-being. SHS is a self-administered scale with a single-factor structure of "subjective well-being" (4 items) scored on a 4-point Likert scale. In judging the results, the higher the mean scores of the four items, the higher the subjective well-being [18].

PANAS

The PANAS scale assesses positive and negative affect. The PANAS is a self-administered scale with a two-factor structure of "positive affect" (10 items) and "negative affect" (10 items) scored on a 6-point Likert scale. In judging the results, the higher the score for the relevant affective factor, the stronger it is [19].

APO-15

The APO-15 is a self-administered scale that assesses participation in positive occupations that promote well-being. The APO-15 is a 15-item survey of positive occupational participation that is based on four factors: "positive relationship" (5 items), "achievement" (4 items), "engagement" (3 items), and "meaning" (3 items). The APO-15 scores 15 items on a 4-point Likert scale (1 = disagree to 4 = agree). In judging the results, high total scores are associated with higher levels of well-being through positive occupational participation [10, 11]. In addition, the APO-15 can assess client strength; client strength as assessed by the APO-15 is determined by dividing the score of each factor by the number of related items and identifying the top two factors with the highest average score [5].

Intervention

Standard Program

The standard day hospital program included a comprehensive range of activities, including employment programs, psychosocial programs, volunteer planning, arts and crafts, and recreation. In contrast, the psychiatric occupational therapy hospital discharge support program was designed as an alternative to the aforementioned employment program and was delivered according to the needs of the participants. The employment programs within the standard program aimed to equip participants with skills necessary for successful employment [21]. Educational support was provided with a focus on promoting self-awareness and cultivating business etiquette. Participants engaged in activities aimed at enhancing their understanding of personal strengths, interests, and goals, as well as developing effective communication and interpersonal skills. The psychosocial programs addressed the diverse needs of participants through a range of interventions [22, 23]. These programs included stress management techniques, symptom management strategies, medication education, and social skills training. Stress management sessions provided individuals

Table 2 Treatment structure of EES-applied POBP

Purpose	POBP promotes well-being by making it a daily habit for individuals with mental illness to participate in positive occupations.
Therapists	➢ Occupational therapists had a 3–4 week preparation period to learn the program. During this preparation period, they reviewed the learning materials and were guided in practice sessions by the program developer. ➢ To ensure the quality of the intervention, occupational therapists were able to contact researchers through a mailing list to share information and ask questions.
Form	➢ Sessions: individual or group (approximately five people), once a week (approximately 1 hour) ➢ Homework: the client will be assigned homework so that positive occupations learned in this program can be practiced in daily life.
Key elements of the POBP	➢ Assessment and selection of learning materials – Assessment using the APO-15 to determine the client's strengths and rank value for positive occupational participation using EES. The selection of learning materials includes consideration of content that falls within the range of positive occupations one level above the client's current EES rank score. This selection is based on identifying content that builds on the client's strengths and is most likely to result in successful participation in positive occupations. ➢ Intervention for positive occupations – POBP's educational approach uses learning materials that summarize positive occupations that may promote human well-being. – Clients discuss with other participants and the occupational therapist the positive occupations they have learned from the materials and how they would like to incorporate aspects into their daily lives. – All learning materials include homework assignments related to the occupation. Clients are expected to experience the homework before the next session. Occupational therapists will also assist clients with their homework on an individual basis outside of the session. – For clients who have difficulty completing their homework, occupational therapy provides learning opportunities and practice as needed, as well as assistance with completing the homework. – At the beginning of the next session, the participant will reflect on the homework experience and consider further innovations to make it a habit in his or her own daily life. – Monitor the client's progress and consider new positive occupation learning materials to further enhance well-being as the client changes. ➢ Skills required of therapists – Throughout the POBP process, the therapist must have the following skills; orient, negotiate, inspire, reasonable, support, clarify, empathize, guide, feedback, assemble, advise, collaborate, etc.
Learning materials	The learning materials are organized according to the four factors of the APO-15. ➢ Positive relationship (13 types) Content of learning materials: "Kindness," "Gratitude," etc. ➢ Achievement (8 types) Content of learning materials: "working toward a goal," "self-control," etc. ➢ Engagement (6 types) Content of learning materials: "exercise," "remember joy and happiness," etc. ➢ Meaning (6 types) Content of learning materials: "Not stuck in the past," "having one's own standards of value," etc.

with coping skills to alleviate daily life challenges and mental health symptoms. Symptom management empowered participants with tools to mitigate the impact of psychiatric symptoms on daily functioning. Medication education provided comprehensive information on proper use, side effects, and adherence strategies. Social skills training aimed to help participants develop good relationships, communicate effectively, and promote social participation. The hospital discharge support program catered to participants needing assistance in transitioning from the hospital to community-based activities [24]. It was personalized to address their specific needs and preferences. The program focused on the goals and interests of the participants and focused on activities outside the hospital to prepare them for life in the community. It aimed to facilitate a successful transition by providing practical support, guidance, and resources to ensure a seamless integration into the community. Each of the above programs was supported both collectively and individually, depending on its content.

EES-applied POBP (Table 2)

The assessment of participation in positive occupations using the EES involves a series of five procedures: (1) Clients are asked to respond to the APO-15. (2) The specified Excel file (https://www.dropbox.com/sh/tq2ejel2cwv5nx5/AABIweu2e-GFgLWn_XGg0nQea?dl=0) is downloaded and enter the results of the APO-15 responses. (3) The Excel file is imported into the statistical software, Exametrika (https://www.dropbox.com/sh/tq2ejel2cwv5nx5/AABIweu2e-GFgLWn_XGg0nQea?dl=0~shojima/). (4) The estimation results are computed.

The setup method for the estimation is the Self-Organizing Map (SOM) "step model" [13, 25], the number of latent ranks is set to 5, and no prior distribution, monotonically increasing constraint, or distribution specification is set. (5) The scoring for the estimated results are as follows: Rank 1 (very weak participation group), Rank 2 (weak participation group), Rank 3 (moderate participation group), Rank 4 (strong participation group), and Rank 5 (very strong participation group), which is considered to be in good standing toward Rank 5. In addition, the rank score is related to the client's subjective well-being, which increases as one approaches Rank 5 [12]. SOM is a method for analyzing various high-dimensional data by grouping them based on the similarity between them [25]. In other words, EES can perform an analysis of the participation state in positive occupations expressed in terms of latent ranks by following the above procedure.

The protocol for the EES-applied POBP includes the following steps: (1) The APO-15 is used to assess the client's strengths, and the EES uses rank scores to assess their participation in positive occupations. (2) Based on the client's strengths and the results of the EES, learning materials are considered with reference to the Can-Do Chart. Specifically, we will consider learning materials for positive occupations, indicated by rank scores one rank higher than the EES estimated result when looking at the "Can-Do Chart," so that clients can use their strengths and participate more actively in these occupations. (3) During the interview, discuss the results of the assessment with the client and make suggestions. In addition, collaborate to select learning materials for positive occupations that can be incorporated into the client's daily life and may enhance their well-being. (4) Supplement the positive occupation knowledge gained through POBP with homework assignments to help clients integrate them as habitual practices in their lives. (5) Monitor the client's progress and consider new positive occupation learning materials to further enhance well-being as clients change. The learning materials (33 types) used in the POBP are structured according to the four factors of the APO-15 and include various aspects such as exercise, personal goals, flow, and relationships [5]. In addition, the learning materials are organized into a common structure consisting of (a) reaffirmation of purpose and meaning, (b) benefits of positive occupations, (c) specific exercises based on the aforementioned benefits, (d) points to consider, and (e) homework assignments designed to enhance client understanding [5]. POBP sessions are conducted weekly for one hour each, with either individual or group support. Please see the appendix for the POBP learning materials (Supplemental Material).

Data analysis

Descriptive statistics were used in this study to examine basic information about participants at baseline. In addition, intention-to-treat was also used for statistical processing to obtain more realistic analysis results [26]. According to previous studies, POBP may be sensitive to individual differences [27]. Therefore, the therapeutic effects of POBP were determined using a generalized linear mixed model (GLMM) [28]. GLMM is appropriate for Bayesian estimation [29]. We chose Bayesian methods because, even with small sample sizes, they work well with simple tests of pre/post-intervention differences. When no prior information is available, Bayesian evaluation can also be used to optimize interventions before full-scale testing, such as randomized controlled trials [28]. Therefore, we took a Bayesian approach and examined a regression model that accounts for repeated measures by including a group for fixed effects, time (baseline, intervention, and follow-up) for random effects, and intercept terms for each individual and environmental difference in a Markov Chain Monte Carlo (MCMC) fitting of the GLMM. MCMC is a method for generating a sample with a distribution characteristic that matches the posterior distribution by the Markov chain using the Bayesian method and using it to calculate an estimated value of the objective variable. Random effects affecting the fixed effect were set to the identification number of the subject and facility environment. Bayesian estimation was established by assuming that each value of the objective variable had a normal distribution, generating 4 chains of length 10,000, a warm-up of 5,000, and approximating the posterior and predictive distributions with 40,000 random numbers generated by the MCMC method. Moreover, SHS (mean score), PANAS (positive and negative affect), and the APO-15 (total score, rank score, positive relationships, achievement, engagement, meaning) were the objective variables used. The adoption criteria of the therapeutic effect were as follows: (1) the fixed-effect value does not cross 0 in the 95% credible interval (95%CI) and (2) Rhat is 1.1 for the convergence judgment of the data analysis [30]. We also used the statistical software HAD 16 (http://norimune.net/had) and brms package 2.12.0 in R 3.6.2 (https://www.r-project.org).

Results

There were 18 participants in this study. However, by the end of the study, there were 15 participants, and 3 of them dropped out due to discharge, transfer, or hospitalization during the study period. In addition, the participants in this study did not change their medication regimen during the study period.

Table 3 Demographics data (n = 18)

Characteristics		Mean (SD)	n (%)
Gender	Male		9 (50.00)
	Female		9 (50.00)
Age	Overall	57.61 years (13.25)	
	Male	56.88 years (10.30)	
	Female	58.33 years (16.31)	
Diagnosis	Schizophrenia		12 (66.67)
	Depression		5 (27.78)
	Organic psychosis		1 (5.55)
Complications	No complications		11 (61.11)
	Have a complication		7 (38.89)
Living environment	Live alone		5 (27.78)
	Live with family		7 (38.88)
	In-patient		6 (33.34)
Medical history		19.14 years (15.38)	
Hospitalize number of times		5.72 time (12.33)	
Hospitalization period		0.97 years (3.13)	

Note. SD = Standard deviation
Baseline data for participants were equally distributed between males and females and did not differ by age. Participants had mild mental retardation, developmental disabilities, and diabetes mellitus as comorbidities.

Descriptive Statistics (Table 3)

The basic information on the participants included their diagnosis (12 schizophrenia, 5 depression, 1 organic psychosis), gender (9 male, 9 female), and age (57.61 years [±13.25]). Other information about the participants included living environment (5 living alone, 7 living with family, 6 hospitalized), time since onset (19.14 years [±15.38]), length of hospitalization (0.97 years [±3.13]), and the number of hospitalizations (5.72 [±12.33]).

Therapeutic Effects (Table 4, 5)

According to the results of this study, the EES-applied POBP showed a therapeutic effect on 7 of the total 9 factors of the outcome measures (Table 4). For the primary outcome, the SHS "mean score" was shown to be higher by an estimated 0.86 points (95%CI [0.25, 1.45]) pre/post-intervention. Next, the secondary outcome, PANAS "positive affect" was shown to be 6.33 points higher (95% CI [1.44, 11.11]) pre/post-intervention. In addition, pre/post-intervention estimates for the APO-15 were as follows: "total score" estimated 8.34 points (95%CI [3.36, 13.20]), "rank score" estimated 0.73 points (95%CI [0.00, 1.44]), "positive relationships" estimated 3.21 points (95%CI [1.46, 4.95]), "achievement" estimated 2.48 points (95%CI [0.80, 4.14]), and "engagement" estimated 1.66 points (95%CI [0.32, 2.95]). Rhat was 1.00 for all of the models mentioned above. Random effects on fixed effects influenced the variance of all objective variables. In addition, 12 of the 18 participants in this study had a diagnosis of schizophrenia. Nevertheless, the intervention effects observed in the EES-applied POBP were consistently positive across the sample, regardless of the participant's specific diagnosis (Table 5).

Discussion and implications

The purpose of this study was to examine the intervention effects of EES-applied POBP in a multicenter, single-group, pre/post-comparison design in individuals with mental illness. The results showed that EES-applied POBP had therapeutic effects on 7 (SHS: mean score, PANAS: positive affect, APO-15: total score, rank score, positive relationships, achievement, engagement) of the total 9 factors of the outcome measures.

Therapeutic effects of the EES-applied POBP

In this study, we found that POBP participants who applied the EES had (1) increased subjective well-being (SHS), (2) increased positive affect (PANAS), and (3) increased positive occupational participation (APO-15). First, we explain why effects were observed for the primary outcome of subjective well-being (SHS), and the secondary outcome of positive affect (PANAS). Previous research has consistently shown that individ-

Table 4 Analysis Results

Scale	Objective variable	Estimate	Est.Error	95% CI [l, u]	Rhat	Bulk_ESS	Tail_ESS
SHS	Mean scores	.86	.31	[.25, 1.45]	1.00	20544	14379
PANAS	Positive affect	6.33	2.43	[1.44, 11.11]	1.00	15208	10698
	Negative affect	.07	3.25	[–6.39, 6.51]	1.00	18821	14507
APO-15	Total scores	8.34	2.51	[3.36, 13.20]	1.00	18293	15639
	Rank scores	.73	.37	[.00, 1.44]	1.00	19451	14747
	Positive relationship	3.21	.88	[1.46, 4.95]	1.00	18240	13896
	Achievement	2.48	.84	[.80, 4.14]	1.00	19452	13987
	Engagement	1.66	.67	[.32, 2.95]	1.00	13155	10958
	Meaning	.96	.56	[–.14, 2.06]	1.00	18535	14338

Note. Estimate = Point estimate, Est.Error = Standard error, CI = Credible interval. For each parameter, Bulk_ESS and Tail_ESS are effective sample size measures, and Rhat is the potential scale reduction factor on split chains (at convergence, Rhat = 1). The results of this study showed effects for 7 of the 9 factors in the outcome measures. Specifically, the primary outcome measure, an effect was found for the SHS "mean score". The secondary outcome measures showed effects on PANAS "positive affect" and APO-15 "total score", "rank score", "positive relationships", "achievement", and "engagement".

Table 5 Pre/post-intervention point estimates by diagnosis

Scale	Objective variable	Schizophrenia		Other	
		Baseline (SD)	Follow-up (SD)	Baseline (SD)	Follow-up (SD)
SHS	Mean scores	3.45 (1.22)	4.25 (1.03)	3.25 (1.35)	4.33 (1.39)
PANAS	Positive affect	29.41 (7.65)	35.08 (9.86)	24.00 (5.65)	28.50 (10.95)
	Negative affect	30.83 (11.17)	31.50 (13.35)	34.33 (11.94)	32.50 (10.48)
APO-15	Total scores	37.50 (7.28)	42.16 (10.81)	31.00 (11.78)	39.50 (10.13)
	Rank scores	1.83 (.83)	2.25 (1.65)	1.50 (.83)	2.16 (1.60)
	Positive relationship	12.33 (2.93)	14.25 (4.00)	11.00 (4.33)	14.33 (3.55)
	Achievement	9.50 (2.71)	11.41 (2.87)	8.00 (3.34)	9.83 (3.18)
	Engagement	7.66 (2.18)	8.66 (2.93)	5.83 (2.56)	7.66 (2.50)
	Meaning	8.00 (2.04)	7.83 (2.65)	6.16 (2.31)	7.66 (2.65)

Note. SD = Standard deviation, Pre/post-intervention point estimates of means and standard deviations for each measure in schizophrenia (12) and other disorders (6). The results of this study showed that the effectiveness of the EES-appiled POBP did not differ by diagnosis.

uals with schizophrenia tend to report higher levels of negative affect and lower levels of positive affect compared to mentally healthy individuals [31]. Long-term disability has also been linked to moderate to large declines in subjective well-being, followed by little adaptation over time [32]. Despite this, POBP contributed to the above results by enabling clients to participate in positive occupations appropriate to their condition through the EES. Ikiugu et al. [33] distinguish between meaningful and psychologically rewarding occupations, with the latter reporting that individuals feel more positive when engaged in them. In other words, the occupations used in the POBP, like psychologically rewarding occupations, were those that elicited a sense of fulfillment during the participation. In addition, positive affect plays an important role in improving cognitive processes and behaviors, thereby promoting well-being [34]. Therefore, making the positive occupations used in the POBP a habit in the participants' lives may have contributed to positive affect and subjective well-being. On the other hand, contrary to our prediction, no effect was identified for negative affect (PANAS). The reason for this is that POBP is primarily focused on positive occupations, which limits it as an intervention targeting negative affect. Therefore, POBP is considered a less promising aspect as an intervention targeting the reduction of negative affect.

Next, we will explain why APO-15 showed various effects on clients' "positive occupational participation". This may be due to the instrumental role of the EES in identifying specific aspects of positive occupational participation that warrant attention in the context of POBP interventions. Previous research suggests that the health-promoting component of an occupation is determined more by how the occupation is perceived than by doing the occupation itself [35]. In other words, the

EES-applied POBP may have broadened the clients' understanding of their perceived occupations through experiential learning of positive occupations that were suitable for their condition. Furthermore, Stewart et al. (2016) [36] suggest that occupational engagement may have both positive and negative effects on health and well-being, and therefore, they caution that occupational therapists need to be reminded of the relationship between occupation and health and well-being. In other words, because POBP provides clients with scientifically based knowledge about occupations that promote human health and well-being, it may have provided clients with an opportunity to become aware of the positive aspects of their occupations.

Finally, 12 of the 18 participants in this study were clients with schizophrenia. Nevertheless, it is worth noting that the intervention effects of the EES-applied POBP were consistently observed regardless of participants' diagnoses, with the exception of the negative affect and meaning factors. Previous research has examined several individual factors that influence POBP interventions [27]. It found that individual differences affecting POBP transcended individual differences due to diagnosis, age, gender, living environment, and length of treatment, with the exception of the number of hospitalizations factor, suggesting that these factors may contribute to client well-being. In other words, our findings are consistent with previous studies and support the notion that EES-applied POBP can be widely implemented for individuals with mental illness. Moreover, the intervention effects of EES-applied POBP may have been influenced not only by experiential learning in positive occupations but also by temporal factors and therapist contributions. The effects of POBP are likely to be maximized through continuous experiential learning of positive occupations. Previous research has demonstrated that POBP is effective for two months or longer [7, 8]. In other words, over time, the effects of POBP are expected to facilitate new cognitive and behavioral patterns that result in positive changes for participants. In addition, therapist involvement may also play a critical role in the effectiveness of POBP. Restall et al. (2021) [37] argue that relational factors, along with a focus on occupation, are important in promoting clients' occupational participation. In other words, establishing a collaborative relationship with the therapist enables participants to effectively implement and sustain the POBP. Considering these factors, the EES-applied POBP appears to be a useful approach with the potential to improve the well-being of people with mental illness.

Clinical implications

According to the results of this study, the therapeutic effects of EES-applied POBP were beneficial to the clients' subjective well-being, positive affect, and participation in positive occupations. In other words, the results of this study support the belief that occupational therapists can improve the well-being of individuals with mental illness. Therefore, if promoting client well-being is a treatment goal, occupational therapists may consider EES-applied POBP as a treatment option.

Limitations

This study has several limitations. First, the participants were clients interested in POBP. Second, a single-group pre/post-comparison design was used. This means that the results of this study must be interpreted with caution in terms of utility, as they are not comparable to standard psychiatric occupational therapy or previous POBP interventions. Therefore, future research should examine the effectiveness of the EES-applied POBP in randomized controlled trials with control groups. In conducting this study, the use of randomization methods should be considered to minimize potential bias and to assign participants to the intervention and control groups without bias in order to increase the generalizability of the results.

Conclusion

This study aimed to examine the therapeutic effects of the EES-applied POBP intervention on individuals with mental illness in a single-group, pre/post-comparative design in a multicenter study. In conclusion, the EES-applied POBP intervention showed promising results in enhancing the well-being of individuals with mental illness. In other words, this suggests that occupational therapists can consider EES-applied POBP as a treatment option when the promotion of client well-being is a treatment goal.

Conflict of Interest

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■ORIGINAL ARTICLE

Factors Associated with Continued Employment Among Persons with Mental Disorders: A Retrospective Cohort Study

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Abstract: Background: This study aimed to identify factors correlating with the continued employment of people with mental disorders who were hired after the launch of the Employment Support Programme in Cooperation with the Public (ESPCP) employment service.
Methods: A survey was conducted with 60 participants who were hired within 12 months after the launch of the ESPCP to determine whether they had retained that job or had changed jobs during the 12-month period after being hired. Factors relating to continued employment were then examined using binary logistic regression.
Results: The participants were classified into two groups: the job-retention (n = 43) and job-turnover (n = 6) groups. Of the participants in the job-retention group, 79.07% used psychiatric day care after securing their jobs. Psychiatric day care was extracted as a predictive factor for continued employment in a logistic regression model, whose variables included psychiatric day care, outreach services, and agency-based counselling services (odds ratio = 1.02, 95% confidence interval = 1.00–1.04, p = 0.04). The job-turnover group included those who wanted to change jobs and those who quit owing to their condition worsening. Two of the four participants whose conditions worsened had adjusted their medication use based on their own judgment.
Conclusions: The use of psychiatric day care is associated with job retention of people with mental disorders post-ESPCP. Preventing turnover requires paying attention to job satisfaction, desire to change jobs, medication adherence, and follow-up when unable to attend the psychiatric day-care centre.

Keywords: work tenure, mental disorders, vocational rehabilitation, employment support, vocational outcomes

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Background

Research on supporting the employment of people with mental disorders (PWMDs) has been based on implementations of the Individual Placement and Support (IPS) model [1, 2]. According to several randomised controlled trials examining the effect of the IPS model, PWMDs who go through IPS have a mean employment period of one to seven months [2]. Factors that have been reported to correlate with the continued employment of PWMDs include work experience, cognitive function, social function, psychiatric symptoms, motivation to work, satisfaction with working conditions, natural support in the workplace, importance of job preference matching, and frequency of support services provided after employment [3–7].

Japan currently lacks an employment support system for PWMDs based on the IPS model, and since most rehabilitation professionals in charge of PWMDs belong to psychiatric hospitals, support for PWMDs who wish to work is often provided at psychiatric hospitals as post-discharge day care (psychiatric day care) or as community welfare services under the Comprehensive Support for Persons with Disabilities Act. However, insufficient cooperation between medical institutions providing day care and the Employment Support Office

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operating community-based welfare services has emerged as a barrier to the implementation of efficient employment support [8].

We therefore developed the Employment Support Programme in Cooperation with the Public (ESPCP) employment service at the psychiatric day-care centre of a mental hospital in Japan. The ESPCP is characterised by interventions that focus on the following three key points: the Work Readiness Programme (WRP), a job search component, and job retention support. Furthermore, all phases of the programme are managed by the staff from the psychiatric day care (treatment facilities), the Public Employment Security Office (Hello Work), and the Employment Support Office (welfare facilities), all of whom have diverse job responsibilities but work together as a team. However, the method of collaboration between these team members is quite distinct from other support methods employed in Japan thus far, in that the staff from the Public Employment Security Office is seconded to that of the psychiatric day care and participates in supporting the WRP, job search activities, and workplace retention. In addition, unlike the IPS programmes in many other countries, the ESPCP in Japan includes a work preparation programme. Compared with past reports of IPS studies and survey research conducted in Japan, we report that the employment rate under the ESPCP, at 74.6% or 83.3%, and the continued employment rate under the ESPCP, at 76.7% or 80.0%, are higher than those found in several other studies [9, 10]. However, it is unclear which factors in the ESPCP contribute to continued employment. The objective of the present study was to retrospectively examine the progress of PWMDs who had found employment with the help of the ESPCP and identify factors correlating with their continued employment after 12 months. In identifying such factors, we hoped to propose new intervention strategies for supporting the employment of PWMDs in Japan.

Methods

Study design and participants

This study used a retrospective cohort design and was conducted at a single facility, with the approval of the Institutional Review Board of Shinshu University School of Medicine (approval no. 5420) in compliance with the Declaration of Helsinki Guidelines for Research Involving Human Subjects. The study was conducted from April 2016 to March 2021 at the psychiatric day-care centre at Tikumaso Mental Hospital in Ueda City, Nagano Prefecture, Japan. The participants were 80 PWMDs who received psychiatric day care, went through the ESPCP, and followed the procedure to provide their informed consent. They were notified that they could opt out of the study if they wished to. The participants who landed a job within 12 months of the end of the ESPCP were surveyed about whether they had retained that job or had changed jobs during the further 12-month period after being hired. In the analysis, we compared the data of the job-retention group with the data of the job-turnover group to examine the factors correlating with continued employment.

Inclusion and exclusion criteria

The inclusion criteria were as follows: 18–65 years old, diagnosed with mental illness per the DSM-IV criteria, registered user of psychiatric day care, wishes to work, agrees to participate in the ESPCP and to use the employment support services provided by Hello Work, and found a job within 12 months after the ESPCP. Moreover, at least 12 months must have passed since they first secured a job after the ESPCP. The exclusion criteria were as follows: having a physical disability, not having secured a job within 12 months after the ESPCP, and less than 12 months having passed since they first secured a job.

Interventions

The ESPCP included the WRP, a job search component, and job retention support. The WRP was a group-based programme that ran for six hours per day, five days a week over a total of three months. It included psychoeducation, social skills training, meta-cognitive training, cognitive behavioural therapy, computer skills practice, aerobic exercises, and on-the-job training. For the job search component, a Hello Work employee shared job postings with the participants once a week and interacted with them to discuss and confirm what they wanted to do. Meanwhile, the support team leader accompanied them on trips to observe the workplace and on job interviews. In terms of job retention support, their workplace leader and the support team held ‘care conferences’, either over the phone or by visiting their workplace in person. Even if participants took extended leave or quit after being hired, meetings were held with them and the company. Those who completed the WRP were encouraged to use the psychiatric day-care centre while looking for a job and after being hired. Psychiatric day care after being hired included interaction among participants, discussions to solve problems related to being employed, learning life skills, and individual consultations with supporters.

Measures

The data collection and evaluation schedule was as follows: T1 indicates the Pre-WRP assessment; T2,

Post-WRP assessment (three months after T1); T3, Job acquisition; and T4, Follow-up assessment 12 months after job acquisition (12 months after T3).

We collected demographic data from participants, support persons' interviews, and medical record reviews at T1, including sex, age, diagnosis, education, marital status, living situation, distance from the residence to the day-care centre, disability pension, social security, employment lasting more than 30 days in the past six months, and hospitalisation in the past 12 months. Data on cognition, social functioning, symptom severity and functional disability, and intrinsic motivation were collected at T1 and T2.

We assessed cognitive function using the Brief Assessment of Cognition in Schizophrenia (BACS) [11]. The BACS assesses multiple aspects of cognitive functioning in schizophrenia and includes six measures: verbal memory, working memory, motor speed, verbal fluency, attention, and executive functioning. Each of the six measures is standardised as z-scores, whereby the mean scores of the healthy participants are set to zero, and the standard deviations are set to one. We calculated the composite score by averaging all the z-scores of the six BACS measures. The approximate degree of impairment by z-score is as follows: −0.5 = mild, −1.0 = moderate, −1.5 = severe.

We assessed social functioning with the Life Assessment Scale for the Mentally Ill (LASMI) [12]. The LASMI consists of 40 items in five categories: daily living, interpersonal relationships, work, endurance/stability, and self-recognition. Each item is rated on a scale from 0 to 4, with higher scores indicating more severe impairment.

We assessed symptom severity and functional disability with the Japanese version of the modified Global Assessment of Functioning (mGAF) scale [13]; the mGAF was developed to improve the reliability and validity of the original GAF. The mGAF, which has more detailed criteria and a more structured scoring system than the original scale, is an observer-rated numerical scale with scores ranging from 1 to 100. Higher scores indicate higher functioning.

We assessed intrinsic motivation with the sum of the following three items from the Quality of Life Scale: sense of purpose, motivation, and curiosity [14]. Scores range from 0 to 6, with higher scores indicating better functioning. These three items measure general characteristics, such as motivation, and utilise core constructs from self-determination theory; scales consisting of these three items have been used in studies with PWMDs [15].

Data on vocational outcomes and service provision were collected on an ongoing basis for 12 months from job acquisition (between T3 and T4). The vocational outcomes referred to whether the participants remained employed, the length of time to find the initial job, working hours per week, and work earnings per week, calculated for both the job-retention and job-turnover groups. Those in the job-turnover group were also surveyed regarding the number of days from securing the initial job until the day they quit. The progress recorded by their individual supporters was described for each case with the aim of clarifying the reasons that participants in the job-turnover group left their jobs. Data on participants' engagement in competitive employment were collected based on support service records and employment contracts. Employment was defined as working for at least one day per month and receiving payment equal to or greater than the minimum wage stipulated by Japanese law. We classified the service provision data into four coded groups based on the Process Data Service Inventory used in a prior Japanese study [16]: psychiatric day care (hospital group service), outreach (mainly the workplace), individual service (individual consultations at the hospital or Hello Work), and by phone. We calculated the amount of time the coded services were used from the hospitals' diagnostic records and the support organisation's service provision records. The supports regularly checked to ensure that the data in participants' service records had not leaked or were not incomplete.

Statistical analyses

Inter-group comparisons of the pre- and post-WRP assessment scores, vocational outcomes, and service provision data were performed using the Mann–Whitney U test. To explore the relationship between continued employment and service provision time, we used a binary logistic regression with whether the participant's employment continued for 12 months or more as the dependent variable and service provision time (psychiatric day care, outreach, and individual service) as the independent variable. Statistical significance was tested at the two-sided 5% level. Effect size was evaluated with Cohen's d as follows: .20 = small, .50 = medium, .80 = large. All statistical analyses were performed using EZR (open-source software) [17].

Results

Participant characteristics

Of the 80 registered participants, one was excluded from the analysis for having a physical disability. The remaining 79 participants completed the WRP at the psychiatric day-care centre, and 60 of them (75.9%) secured a job within 12 months of completing the WRP.

Table 1 Participant characteristics: Pre-WRP assessment

	Job-retention group (*n* = 43)	Job-turnover group (*n* = 6)
Sex, *n* (%)		
Female	19 (44.19)	2 (33.33)
Male	24 (55.81)	4 (66.67)
Age, *mean* (SD)	35.95 (10.64)	36.00 (9.61)
Main diagnosis group, *n* (%)		
Schizophrenia and other psychotic disorders	17 (39.53)	4 (66.67)
Depressive disorders	10 (23.26)	1 (16.67)
Bipolar disorders	2 (4.65)	0 (0)
Neurodevelopmental disorders	11 (25.58)	0 (0)
Other	3 (6.98)	1 (16.67)
Highest level of school completed, *n* (%)		
High school	26 (60.47)	3 (50.00)
Technical college	1 (2.33)	1 (16.67)
Junior college	6 (13.95)	1 (16.67)
University	10 (23.26)	1 (16.67)
Marital status, *n* (%)		
Unmarried	33 (76.74)	4 (66.67)
Married	5 (11.63)	0 (0)
Divorced	5 (11.63)	2 (33.33)
Living situation, *n* (%)		
Living with family	36 (83.72)	4 (66.67)
Living alone	5 (11.63)	2 (33.33)
Residential facility	2 (4.65)	0 (0)
Distance from the residence to the day-care center, *mean*, *km* (SD)	6.75 (6.38)	6.30 (3.46)
Social security, *n* (%)		
Received	42 (97.67)	5 (83.33)
Disability pension, *n* (%)		
Received	30 (69.77)	4 (66.67)
Worked more than 30 days in past six months, *n* (%)		
Worked	7 (16.28)	1 (16.67)
Hospitalization in past 12 months, *n* (%)		
Hospitalized	7 (16.28)	1 (16.67)

SD, Standard Deviation; WRP, Work-Readiness Program.

Nineteen were unable to secure competitive employment because of the use of disability welfare services or hospitalisation due to worsening medical conditions. Eleven participants were excluded because 12 months had not passed since they secured a job. Ultimately, the data of 49 participants were selected for analysis, with 43 participants (87.8%) in the job-retention group and six (12.2%) in the job-turnover group. Table 1 shows the characteristics of the participants as recorded in the pre-WRP assessment. The average age of the participants was 36.0 years (standard deviation [SD] = 10.7) in the job-retention group and 36.0 years (SD = 9.6) in the job-turnover group. Seventeen participants (39.5%) in the job-retention group and four participants (66.7%) in the job-turnover group were diagnosed as having 'schizophrenia and other psychotic disorders' per the DSM-5. In the job-retention group, this was followed by 'neurodevelopmental disorders' (*n* = 11, 25.6%) and 'depressive disorders' (*n* = 10, 23.4%). The average distance from the residence to the day-care centre was 6.7 km (SD = 6.4) for the job-retention group and 6.3 km (SD = 3.5) for the job-turnover group.

Cognition, social functioning, symptom severity and functional disability, and intrinsic motivation

Table 2 shows the results of comparisons between the pre- and post-WRP assessments of both groups. Working memory ($p = 0.03$) and executive function ($p = 0.02$) scores from the BACS were significantly higher in the job-turnover group than in the job-retention group in the post-WRP assessments. Interpersonal relations scores ($p = 0.04$) and work scores ($p = 0.04$) from the LASMI were significantly higher in the job-retention group than in the job-turnover group in the post-WRP assessments. We found no significant inter-group difference in the mGAF, an indicator of symptom severity and functional disability, or the Quality of Life Scale, which was used as an indicator of intrinsic motivation.

Table 2 Comparisons of the BACS, LASMI, mGAF, and QLS scores between the job-retention and job-turnover groups: Pre- and post-WRP assessments

		Job-retention group (n = 43)		Job-turnover group (n = 6)		p	d
		Median	(IQR)	Median	(IQR)		
BACS							
Verbal memory	Pre-WRP	−0.76	(−1.75 – 0.07)	−0.40	(−0.91 – 0.09)	0.39	0.37
	Post-WRP	−0.34	(−1.07 – 0.06)	−0.67	(−1.02 – −0.06)	0.78	0.14
Working memory	Pre-WRP	−0.69	(−1.32 – −0.21)	0.04	(−0.32 – 0.46)	0.03*	0.78
	Post-WRP	−0.24	(−1.05 – 0.04)	0.45	(0.09 – 0.74)	0.02*	0.88
Motor speed	Pre-WRP	−1.15	(−1.98 – −0.32)	−0.62	(−1.26 – 0.40)	0.15	0.57
	Post-WRP	−1.15	(−2.01 – −0.15)	−1.07	(−1.62 – −0.90)	0.87	0.07
Verbal fluency	Pre-WRP	−0.35	(−1.08 – −0.03)	−0.57	(−0.85 – 0.50)	0.65	0.02
	Post-WRP	−0.27	(−0.97 – 0.17)	−0.13	(−0.47 – 0.08)	0.53	0.27
Attention	Pre-WRP	−0.88	(−1.37 – 0.02)	−0.03	(−0.94 – 0.66)	0.35	0.72
	Post-WRP	−0.34	(−1.30 – 0.15)	−0.16	(−0.76 – 0.62)	0.23	0.46
Executive function	Pre-WRP	−0.32	(−0.94 – 0.57)	0.14	(−0.32 – 0.46)	0.44	0.53
	Post-WRP	0.14	(−0.32 – 0.59)	0.59	(0.58 – 0.93)	0.02*	0.64
Composite score	Pre-WRP	−0.79	(−1.13 – −0.19)	−0.13	(−0.69 – 0.24)	0.13	0.83
	Post-WRP	−0.44	(−0.87 – −0.01)	−0.07	(−0.43 – 0.35)	0.10	0.62
LASMI							
Daily living	Pre-WRP	5.00	(3.50 – 8.50)	6.50	(4.25 – 8.00)	0.84	0.07
	Post-WRP	5.00	(3.00 – 7.50)	5.50	(4.25 – 7.50)	0.75	0.00
Interpersonal relations	Pre-WRP	14.00	(12.50 – 17.00)	12.00	(10.25 – 13.00)	0.02*	0.99
	Post-WRP	14.00	(11.50 – 16.00)	11.50	(8.50 – 13.00)	0.04*	0.85
Work	Pre-WRP	17.00	(14.00 – 20.50)	13.50	(11.25 – 15.75)	0.03*	1.08
	Post-WRP	12.00	(10.00 – 18.00)	9.00	(8.00 – 11.50)	0.04*	1.12
Endurance and stability	Pre-WRP	5.00	(4.00 – 5.00)	3.00	(2.00 – 4.00)	0.03*	1.11
	Post-WRP	4.00	(3.00 – 5.00)	2.00	(2.00 – 2.75)	0.05	0.77
Self-recognition	Pre-WRP	5.00	(4.50 – 6.00)	5.00	(5.00 – 5.75)	0.81	0.17
	Post-WRP	4.00	(3.00 – 5.00)	3.00	(3.00 – 3.75)	0.36	0.37
mGAF							
mGAF-S	Pre-WRP	68.00	(64.00 – 74.00)	69.50	(67.25 – 73.25)	0.60	0.19
	Post-WRP	68.00	(64.00 – 74.00)	69.00	(64.75 – 73.25)	0.76	0.10
mGAF-F	Pre-WRP	68.00	(64.00 – 74.00)	68.00	(62.75 – 70.25)	0.38	0.57
	Post-WRP	68.00	(68.00 – 74.00)	66.00	(61.75 – 70.25)	0.12	0.85
QLS							
Sense of purpose	Pre-WRP	4.00	(4.00 – 4.00)	4.00	(4.00 – 4.00)	0.79	0.11
	Post-WRP	4.00	(4.00 – 4.00)	4.00	(4.00 – 4.00)	0.58	0.25
Motivation	Pre-WRP	4.00	(4.00 – 4.50)	4.50	(4.00 – 5.00)	0.21	0.57
	Post-WRP	4.00	(4.00 – 4.50)	4.50	(4.00 – 5.00)	0.22	0.54
Curiosity	Pre-WRP	4.00	(4.00 – 4.00)	4.00	(4.00 – 4.00)	0.95	0.02
	Post-WRP	4.00	(4.00 – 5.00)	4.00	(4.00 – 4.00)	0.63	0.21
Total	Pre-WRP	12.00	(12.00 – 13.00)	12.00	(12.00 – 12.75)	0.79	0.17
	Post-WRP	12.00	(12.00 – 13.00)	12.00	(12.00 – 12.75)	0.88	0.00

*$p < 0.05$

Effect size (Cohen's d): 0.20 (small), 0.50 (medium), 0.80 (large)

BACS, Brief Assessment of Cognition in Schizophrenia; LASMI, Life Assessment Scale for the Mentally Ill; mGAF-S, modified Global Assessment of Functioning psychological symptom subscale; mGAF-F, modified Global Assessment of Functioning social functioning subscale; QLS, Quality of Life Scale; IQR, Interquartile Range; WRP, Work-Readiness Programme.

Table 3 Summary of the job-turnover group (n = 6)

Case	Sex	Age	Main diagnosis group	Employment history	Length of time to leaving a job [days]	Process of leaving the job
A	Male	40s	Depressive disorders	yes	201	After three months of employment, A began to tell his supporters that he wanted to change jobs from his current cleaning job to office staff. A care meeting was held and it was decided that he would continue to work while also looking for a new job. Because the job was every weekday, A did not use psychiatric day care. A resigned when he was offered a position at a new office.
B	Female	20s	Other	yes	91	B requested a fixed-term job, saying she wanted to 'gradually get used to work', and found a job with a company that met her working conditions, and she performed her job well. Due to work schedules, B was unable to use psychiatric day care. When her contract expired, B requested to 'find another job' and resigned.
C	Female	20s	Schizophrenia and other psychotic disorders	no	91	C started working in an office, but an argument with her father led to over-medication and unauthorized absences from work. C also continued to request psychiatric day care, saying that she did not want to use the service because she did not feel comfortable with some of the other users. Later on, C requested to be hospitalized for rest, and she offered to resign from her job, saying that she did not want to cause problems for the company, and she resigned, followed by her hospitalization.
D	Male	40s	Schizophrenia and other psychotic disorders	yes	328	D occasionally missed work due to insomnia, but his supervisor at work was prejudiced against mental illness and sometimes said that he was just lazy. Often, a support person would go to the workplace and explain the illness and his medical condition. D began to feel 'shunned' by his co-workers and called his support worker to discuss his concerns. The support worker tried outreach and medication reconciliation, but his feelings of victimization toward a particular coworker did not improve, and he continued to miss work and quit his job.
E	Male	30s	Schizophrenia and other psychotic disorders	yes	159	Shortly after he started working, E started drinking every night after he got home from work. Drinking was a sign of stress for E, but he hid the fact that he was drinking. When he drank, he stopped taking his medication after dinner, and his illness worsened. The caregiver also encouraged the patient to use psychiatric day care, but E said, 'I'll go next time,' and eventually did not use it. However, his condition did not improve, and on day 125 he was admitted to a psychiatric hospital and discharged at his request.
F	Male	40s	Schizophrenia and other psychotic disorders	yes	154	About two months after starting work, F began to wipe the same areas over and over again to check the areas that had been cleaned because of anxiety. Psychiatric day care was not available because of family caregiving. Eventually auditory hallucinations appeared and F began to miss work, stating that he could not go to work because he heard voices telling him to stop working. The support worker suggested reducing the number of hours and days he worked, but the employer would not agree.

Vocational outcomes

After the WRP, the job-retention group was employed for 96.0 days (SD = 56.2) and the job-turnover group for 117.0 days (SD = 58.3); the weekly work hours of the job-retention and job-turnover groups were 22.9 hours (SD = 6.8) and 28.3 hours (SD = 6.2), respectively. The weekly wages were $143.4 (SD = 46.8) for the job-retention group and $178.2 (SD = 36.9) for the job-turnover group. We found no significant difference between the groups in terms of the length of time taken to secure the initial job, working hours, or the wages earned. Among those in the job-turnover group, the median number of days from initial job acquisition to leaving that job was 122.5 (interquartile range = 70.3–171.0). Four of the six participants (66.7%) in the job-turnover group had been diagnosed with 'schizophrenia and other psychotic disorders' and stated mental illness as their reason for leaving. Two of them had adjusted their medication use based on their own judgment. Of the remaining two participants (33.3%), one had already secured their next job (case A) and one wanted to find a better job (case B). In addition, there were family disagreements (case C), prejudice against mental illness among workplace employees (case D), and discrepancies between the PWMD and employer expectations (case F; Table 3).

Table 4 Services per month provided by the employment support team during the 12-month study period, in minutes

	Job-retention group (n = 43)		Job-turnover group (n = 6)		p	d
	Median	(IQR)	Median	(IQR)		
Psychiatric day-care services	360.00	(120.00–930.00)	00.00	(0.00–90.00)	0.01**	0.70
Outreach services	10.00	(5.00–10.00)	23.50	(10.63–30.00)	0.05*	1.98
Agency-based counselling services	18.00	(10.00–20.00)	25.00	(20.00–33.75)	0.14	1.16
Telephone services	0.00	(0.00–2.25)	6.20	(1.50–14.35)	0.03*	1.37

*p < 0.05; **p < 0.01
Effect size (Cohen's d): 0.20 (small), 0.50 (medium), 0.80 (large)
IQR, Interquartile Range

Service provision data

Table 4 presents the service provision data for each group. By the time of the follow-up survey at 12 months after securing the initial job, the amount of time that the job-retention group used psychiatric day-care services per month was significantly longer than that of the job-turnover group. The amount of time that the job-turnover group used outreach and telephone services per month was significantly longer than that of the job-retention group. We found no significant difference between the groups regarding the amount of time they used agency-based counselling. Of the job-retention group, 79.1% used psychiatric day-care services in the 12 months after securing their job. Of the six job-turnover group members, two who were re-employed did not use psychiatric day-care services because of their work schedule (Table 3). The remaining four who left their jobs because of worsening medical conditions used psychiatric day-care services for an average of 75 minutes, significantly less than the average of 777 minutes noted in the job-retention group. The reasons given for their low use of psychiatric day care were interpersonal relationships (case C), lack of sense of meaning (cases D and F), and family care (case F).

Factors associated with staying in employment for at least 12 months after employment

Table 5 shows the results of the binary logistic regression. Among psychiatric day-care, outreach, and agency-based counselling services, the factor correlating with continued employment after 12 months or more after job acquisition was psychiatric day-care services (odds ratio = 1.02, 95% confidence interval = 1.00–1.04, p = 0.04).

Table 5 Binary logistic regression predicting 12-month job retention

	OR	95% CI		p
Psychiatric day-care services	1.02	1.00	1.04	0.04*
Outreach services	0.87	0.71	1.07	0.17
Agency-based counselling services	0.93	0.79	1.10	0.40

*p < 0.05
OR, odds ratio; CI, confidence interval

Discussion

This study retrospectively examined the progress of ESPCP participants to determine their rate of continued employment at 12 months after job acquisition and to ascertain factors correlating with their continued employment. The results showed that ESPCP participants who found a job within a year showed a high job retention rate (87.7%) 12 months after securing employment, and that 79.1% of the job-retention group used psychiatric day-care services. These results suggest the potential of psychiatric day-care services to contribute to the continued employment of PWMDs.

Compared with the job-retention group, the job-turnover group scored significantly higher on the working memory and executive function subscales of the BACS and significantly lower on the work subscale of the LASMI after completing the WRP. These results indicate that the job-turnover group was high-functioning and contradict the fact that they left their job. Indeed, the reasons for leaving work among the job-turnover group were based on the desire to change jobs (n = 2, 33.3%) or worsening psychiatric conditions (n = 4, 66.7%). Regarding the reasons for leaving the job, the percentages were similar to those found in previous studies, with one reporting 52% of participants quitting without having other job plans or being fired [3]. It is likely that the high-functioning patients wanted to change jobs and the condition of those who had adjusted their medication use had worsened. It was suggested that family relationships and relationships with employers were influential in the deterioration of mental health status. Studies have noted that the necessity of follow-up services for those diagnosed with schizophrenia differs depending on the severity of their cognitive impairment and negative symptoms [18–20]. Our results suggest that supporting continued employment requires paying attention to individuals' job satisfaction, desire to change jobs, medica-

tion adherence, familial relationships, and relationship with the employer.

After job acquisition, the job-retention group used psychiatric day-care services for a significantly longer amount of time than the job-turnover group. The binary logistic regression results also suggested that the use of psychiatric day-care services may be related to continued employment. In studies that faithfully implement the IPS model, outreach and individual services are more common than group services while one is employed [21]. The effect size of group services while one is employed may not be related to the duration of employment [22]. Our results partially differ from these previous reports.

One characteristic of the ESPCP is that before job-hunting begins, recipients participate in the WRP as part of psychiatric day-care services that are conducted mainly as a group programme [10]. The rate of finding employment within one year of completing the WRP is high (75.9%), which is likely related to the psychoeducation, social skills training, meta-cognitive training, and aerobic exercise programmes included in the WRP, as well as the improved work readiness resulting from conducting the sessions five times a week for three months. The habit-training effect of the WRP is an important element for reinforcing work readiness and for continued employment. Indeed, creating and following a regular schedule is known to be an effective way to maintain health and prevent further disorders [23–25].

Of the job-retention group, 79.1% used psychiatric day-care services in the 12 months after securing their job. The reason for the high utilisation of psychiatric day care by the job-retention group was not the distance from the residence to the day-care centre. Instead, we think that the job-retention group might have been more habitual of following the WRP's five times-a-week attendance schedule. Attending psychiatric day care five days a week may have contributed to this group's ability to maintain their mental and physical health and continue their employment. Participants who used psychiatric day-care services after job acquisition not only went to supporters for individual consultations but also exchanged information with other participants and participated in the day-care centre's normal group programme. This usage of psychiatric day-care services effectively facilitated job retention. The reasons for the low use of psychiatric day care by the job-retention group—interpersonal relationships, motivation to use psychiatric day care, and family situation—need attention when supporting their continued employment.

Study limitations

This study has a few limitations. First, there were limited survey items on the services provided during the follow-up period after job acquisition, which prevented us from analysing the kinds of support that were provided in detail (e.g. advice about working, medical support, daily living support, aptitude for a job). The kinds of support provided as part of psychiatric day-care services after job acquisition must be examined in detail. Second, this study was conducted at a single facility and the sample size of the job-turnover group was particularly small. The ESPCP has partially changed its programme since 2022, which made it difficult to increase the sample size for this study. Consequently, this study lacked sufficient statistical power. In addition, the job-turnover group varied in functional level; it included both high-functioning patients who wanted to change jobs and patients whose medical condition had deteriorated. The results of multiple testing require careful interpretation and might not be generalisable to other settings. Third—and this is related to the first limitation—the number of variables used in the analysis was limited; potential latent confounding factors could not be examined. In future research, we intend to identify more effective strategies for employment support that are suitable for the mental health landscape in Japan by using standardised inventory sheets to collect service data from multiple facilities and compare them with data from the IPS model.

Conclusion

We retrospectively examined factors correlating with the continued employment of ESPCP participants. Our results showed that the amount of time that participants used psychiatric day-care services after securing a job may be related to continued employment. Thus, the use of psychiatric day care is important for promoting job retention in the ESPCP. Supporting the continued employment of PWMDs also requires paying attention to their job satisfaction, desire to change jobs, medication adherence, familial relationships, and relationship with the employer. The provision of the ESPCP in psychiatric day care and the continued use of psychiatric day-care services by PWMDs after employment are effective strategies for ensuring their continued employment in Japan.

Conflict of interest

No potential conflict of interest was reported by the authors.

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■ORIGINAL ARTICLE

Effect of Motivational Autonomy on Rehabilitation in Convalescent Stroke Patients

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Abstract: Purpose: To determine the relationship between qualitative factors of motivation for rehabilitation and participants' performance of and satisfaction with self-determined goals, healthrelated quality of life, and functional independence in first-episode stroke patients in a convalescent ward.
Methods: Participants were first-stroke patients admitted to the A Hospital during November 2022–August 2023. Training Motivation Scale score was used as an explanatory variable to assess motivation quality. Canadian Occupational Performance Measure (COPM), MOS 36-Item Short-Form Health Survey (SF-36), and Functional Independence Measure (FIM) scores at baseline and discharge evaluations were used as objective variables for comparison.
Results: Significant differences were found on two factors related to the amount of change in the SF-36 role/social health component score: the controlled motivation score at baseline ($p < 0.01$) and the amount of change in the controlled motivation score ($p < 0.05$). Univariate logistic regression analysis showed a significant association between improvement above the minimum important change in COPM-P score and an increase in the controlled motivation score (odds ratio 6.67, 95% confidence interval 1.05–42.40, $p = 0.04$), but no increase in the non-motivation score (odds ratio 13, 95% confidence interval 1.27–133, $p = 0.03$). There was no relationship between motivation for rehabilitation and improvement in FIM score.
Conclusions: These findings suggest that focusing on controlled motivation as a qualitative aspect of motivation for rehabilitation promotes patients' motivation to reacquire roles and social life activities, positively affects their goal performance, and improves quality of life.

Keywords: motivation; stroke; quality of life; rehabilitation; goal setting

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1. Introduction

In recent years, interest has grown in goal setting in the field of rehabilitation. Previous studies have reported that goal setting reduces anxiety and increases participation in rehabilitation [1], improves health-related quality of life [2] (QOL), and improves grip strength and walking speed by setting a goal for the number of steps using a pedometer [3]. Therefore, it seems likely that goal setting improves both psychological/mental and physical characteristics of patients.

Motivation is an aspect of almost all behavior. In the field of psychology, motivation is defined as "a process that causes a certain behavior, sustains that behavior, and leads it in a certain direction" [4]. Psychological problems in post-stroke patients include post-stroke depression and apathy, which occurs in approximately 33% of patients and reduces goal-directed activities in cognitive, behavioral, emotional, and social domains [5].

Such psychological problems are likely to be major inhibitors of motivation. Intensive rehabilitation is required to provide support for convalescent patients and help them to return home [6]. However, psychological problems may reduce patients' motivation to participate in intensive rehabilitation, and very likely reduce the effectiveness of rehabilitation.

A systematic review of motivation for rehabilitation in stroke patients reported that the Multidimensional Health Locus of Control (MHCL) scales, the Vitality

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Index, observational ratings, and the Numerical Rating Scale (NRS) have been used as rating instruments, but none of them are specifically designed to assess motivation for rehabilitation [7]. Therefore, the effect of motivation on rehabilitation in stroke patients remains to be clarified. Additionally, some reports show that motivation may be a determinant of rehabilitation outcomes [8], that it is related to adherence to rehabilitation [9], and that it helps to improve QOL [10]. However, no previous studies have examined the quality of motivation.

The purpose of this study was to clarify whether qualitative factors of motivation for rehabilitation affect the subjective evaluation of participants' performance of and satisfaction with self-determined goals and health-related QOL, as well as functional independence (the main outcome of convalescent rehabilitation), and to determine whether these factors can be used as indicators for effective convalescent rehabilitation in stroke patients admitted to a convalescent ward.

Table 1 The Training Motivation Scale

1	I'm willing to do what I think is right.
2	I want to get good grades and brag about it.
3	I want to train hard so that I don't cause trouble for others.
4	I don't want to train because my body doesn't work the way I want it to.
5	I don't know what I'm training for.
6	I want to work hard until I am satisfied with my performance.
7	I want to train hard because I like the rehabilitation staff.
8	I feel encouraged to train with others.
9	I am willing to try to do things by myself even if they are difficult.
10	I want to think and work on my own, not just do what I'm ordered to do.
11	I think training is a waste of time.
12	I want to think of different ways to do difficult tasks.
13	I don't want to train because it is a burden on my body.

Autonomous motivation: 1, 6, 9, 10, 12
Controlled motivation: 2, 3, 7, 8
Non-motivation: 4, 5, 11, 13

2. Methods

2-1. Study design

A prospective observational study design with repeated data measurement at admission and discharge was used for stroke patients admitted to a convalescent ward. Because this was an observational study, the content of therapist interventions was not standardized but was decided by each therapist.

2-2. Participants

Inclusion criteria were (1) patients who were hospitalized in the convalescent ward of A Hospital from November 2022 to August 2023, (2) patients who had suffered a first stroke, and (3) patients who understood the purpose of this study and gave their consent for study participation. Exclusion criteria were (1) more than 6 months after the onset of stroke, (2) hospital stay of less than 30 days, (3) higher brain dysfunction such as severe consciousness disorder or attention disorder that would make it difficult to concentrate on the task, (4) aphasia, which would make it difficult to understand the questions, and (5) refusal to participate in the study.

2-3. Data collection

The baseline evaluation period was set within 2 weeks after admission to the hospital's convalescent ward. After baseline evaluation, a re-evaluation was conducted every month. Two evaluation scores were obtained, one at the time of the baseline evaluation and the other at the time of discharge. The occupational therapists in charge of each participant (who had 3–25 years of experience) conducted the evaluation. To ensure that the evaluation was accurate, the author held two study sessions for each occupational therapist before the evaluation was conducted (1st session: September 27, 2022, 2nd session: October 4, 2022).

2-4. Survey Items

1) Explanatory variables

(1) Training Motivation Scale

The concept of motivation is based on the self-determination theory of Ryan and Deci [11], which classifies motivation into intrinsic, extrinsic, and non-motivation from the perspective of motivational autonomy. Autonomy refers to a state in which people can make decisions using their initiative from the beginning to the end of an action without compulsion while maintaining self-discipline. The Training Motivation Scale was developed by Koike et al. [12] based on this self-determination theory. It consists of 13 items (5 on autonomous motivation, 4 on controlled motivation, and 4 on non-motivation) that are self-rated by respondents on a 5-point scale from 0 (hardly applicable) to 4 (very applicable). The validity and reliability of this scale have been confirmed in patients in the convalescent ward [12] (Table 1).

2) Objective variables.

(1) Canadian Occupational Performance Measure (COPM)

The COPM is a semi-structured interview method that assesses tasks that patients themselves identify as problems and evaluates patients' performance (COPM-P) of and satisfaction (COPM-S) with the identified tasks on a 10-point scale. It has been used as a primary

outcome in many randomized controlled trials, and a previous study of patients in a convalescent rehabilitation ward showed a clinically meaningful minimum important change (MIC) of 2.20 for the COPM-P and 2.06 for the COPM-S [13].

(2) MOS 36-Item Short-Form Health Survey (SF-36)

The SF-36 was used as a health-related QOL measurement tool for the target population. The SF-36 consists of eight health concepts; these are intercorrelated, leading to possible multicollinearity problems in the analysis [14]. To avoid this problem, three SF-36 component summary scores were used in this study. These comprised the physical component summary (3PCS), the mental component summary (3MCS), and the role/social component summary (3RCS).

3) Functional Independence Measure (FIM)

The FIM measures independence in daily living and is used in the rehabilitation field to evaluate patients' level of disability [15]. In the present study, the FIM motor items (FIM-M) were used as the outcome; the FIM cognitive items were excluded. This was because only participants with a reasonable level of cognitive function were included, so a ceiling effect was predicted.

2-5. Statistical analysis methods

Normally distributed data were analyzed using t-tests and non-normally distributed data were analyzed using Wilcoxon signed rank sum tests to compare baseline and final evaluation scores on each variable. As the number of items on each Training Motivation Scale subscale differs (five items on autonomous motivation, four on controlled motivation, and four on non-motivation), The mean value of subscale rather than the total score on each item was used in the statistical analysis.

To clarify the relationship between participants' achievement and satisfaction with their goals and their motivation to participate in rehabilitation, χ-square tests were conducted to assess increases or decreases in the mean of each score on the Training Motivation Scale and to examine whether the COPM-P and COPM-S scores showed improvement over the MIC values found in previous studies. Then, univariate logistic regression analysis was conducted to examine the relationship between the explanatory variables (increase/decrease in each Training Motivation Scale subscale score) and the objective variable (MIC value).

Next, to clarify the relationship between patients' motivation to participate in rehabilitation, FIM-M score, and health-related QOL, the correlation between the mean score on each Training Motivation Scale subscale at the baseline assessment and the FIM-M, 3PCS, 3MCS, and 3RCS scores at the baseline and final assessments, respectively, and the change in the Training Motivation Scale and FIM-M, 3PCS, 3MCS, and 3RCS scores at baseline and final assessment, were investigated. The normally distributed data were tested using Spearman's rank correlation coefficient.

Multiple regression analysis was then conducted using the forced entry method. The explanatory variables were the scores and changes on each of the Training Motivation Scale subscales at the time of the baseline assessment, and the objective variables were the changes in the FIM-M, 3PCS, 3MCS, and 3RCS scores. The statistical significance level was set at 5% for all variables. Statistical software R version 4.1.2 was used for the analysis. The sample size calculations were performed using G*Power3.1.9.7. Assuming that a multiple regression model with 2 explanatory variables for which we want to estimate the partial regression coefficients, and given an effect size of $f^2 = 0.5$ is obtained, when testing at a significance level of 5% and a power of 80%, the required sample size was calculated to be a total of 23 cases.

2-6. Research ethics

This study was conducted after receiving approval from the ethical review committee of Niigata Rehabilitation Hospital and Niigata University of Health and Welfare (date of receipt November 2, 2022) and was conducted following the principles of the Declaration of Helsinki. Participants provided their consent after being given a written explanation of the study. To protect personal data, non-personally identifiable numbers were used in the data analysis and publication of the study results. The data collected and the information obtained from participants were used for research purposes only and were kept confidential.

3. Results

3-1. Basic participant attributes

Of the 86 patients who met the inclusion criteria during the study period, 60 who also met the exclusion criteria were excluded. Thus, 26 patients participated in the study (Table 2).

The basic attributes of participants and the category data for the tasks selected in the COPM are shown in Table 2. The mean (± standard deviation) participant age was 60.8 ± 12.5 years, and there were 16 men and 10 women. Of participants, 17 had cerebral hemorrhage and 9 had cerebral infarction, and 12 had left paralysis and 14 right paralysis. The mean number of days after stroke onset was 25.1 ± 9.4 days, and participants had spent a mean of 93.8 ± 41.4 days in hospital. A total of 16

Table 2 Subjects characteristics and category data selected by COPM

		Subjects (N = 26)
Age (year)		60.8 ± 12.5
Gender	male	16
	female	10
Diagnosis	hemorrhage	17
	infarct	9
Paralyzed side	left	12
	right	14
Days after onset		25.1 ± 9.4
Days spent in hospital		93.8 ± 41.4
Pre-onset employment	yes	16
	no	10
Family members living together	yes	23
	no	3
MMSE		25.9 ± 3.5 (17, 30)
COPM category (N = 125)		
Self care (N = 65)	personal care	21
	functional movement	19
	social life activity	25
Productive activity (N = 37)	paid/unpaid work	13
	household affairs	24
	play/school	0
Leisure (N = 23)	quiet recreation	5
	active recreation	15
	socialeization	3

MMSE: Mini-Mental State Examination (minimaum, max)
COPM: Canadian Occupational Performance Measure

participants were employed and 10 were not employed before admission, and the mean Mini Mental State Examination (MMSE) score was 25.9 ± 3.5. COPM category data were obtained from 26 participants, and a total of 125 tasks were generated. Most tasks (65) were in the self-care domain (personal care: 21, functional mobility: 19, and social activities: 25), followed by productive activities with 37 (work: 13, housework: 24, and play/school: 0) and leisure activities with 23 (static recreation: 5, dynamic recreation: 15, and socializing: 3).

3-2. Comparison test results

(1) Difference between the mean of the baseline and discharge assessments (Table 3)

Significant differences were found in COPM-P, COPM-S, FIM-M, and 3PCS scores. There were no significant differences in mean scores on the Training Motivation Scale for autonomous, controlled, and unmotivated patients.

(2) Correlation analysis of Training Motivation Scale mean score and FIM-M, 3PCS, 3MCS, and 3RCS scores (Table 4)

A weak negative correlation ($r = -0.397$, $p = 0.04$) was found between the controlled motivation score at the baseline evaluation and the 3RCS score at the baseline evaluation. No significant correlation was found between changes in Training Motivation Scale score and changes on each variable, but weak correlations were found between the change in autonomous motivation score and 3RCS ($r = 0.32$) score, and between the change in controlled motivation score and 3RCS ($r = 0.286$) score, and non-motivation score and FIM-M score ($r = 0.32$).

(3) Multiple regression analysis of Training Motivation Scale mean score and FIM-M, 3PCS, 3MCS, and 3RCS scores (Table 5)

There were no significant differences between the FIM-M, 3PCS, and 3MCS scores. There were significant differences between the two factors related to the

Table 3 Baseline and discharge evaluation results for each variable for the subject

	Baseline (N = 26)	Discharge (N = 26)	p[1]	Amount of change	d
COPM-P	3.87 ± 2.7	6.57 ± 2.2	< 0.001*	2.7	0.96
COPM-S	2.90 ± 2.3	5.86 ± 2.6	< 0.001*	2.96	0.92
FIM-M	48.58 ± 17.7	77.42 ± 15.2	< 0.001*	28.84	1.32
3PCS	31.45 ± 14.9	38.43 ± 12.1	0.001*	6.98	0.5
3MCS	59.15 ± 13.1	58.79 ± 9.7	0.9	−0.36	0.03
3RCS	28.62 ± 23.4	31.89 ± 15.8	0.5	3.27	0.16
	Baseline (N = 26)	Discharge (N = 26)	p[1]	Amount of change	d
Autonomous motivation score	3.05 ± 0.5	3.13 ± 0.6	0.4	0.08	0.14
Controlled motivation score	2.59 ± 0.7	2.59 ± 0.7	1	0	0
Non-motivation score	0.35 ± 0.5	0.5 ± 0.7	0.3	0.15	0.22

Mean ±Standard deviation *$p < 0.05$ effect size d < 0.2 = small, < 0.5 = medium, < 0.8 = large
[1] Willcoxson signed rank sum test, T-test
COPM-P: Canadian Occupational Performance Measure Performance score
COPM-S: Canadian Occupational Performance Measure Satisfuction score
3PCS: Physical component summary. 3MCS: Mental component summary. 3RCS: Role/Social component summary

Table 4 Results of the correlation analysis between the mean of the training motivation scale score and 3-component summary score (N = 26)

	Autonomous motivation score at baseline	Controlled motivation score at baseline	Non-motivation score at baseline
FIM-M score at baseline	0.043 (.84)	−0.268 (.19)	−0.087 (.67)
discharge	0.015 (.94)	−0.216 (.29)	−0.105 (.61)
3PCS score at baseline	−0.025 (.91)	−0.078 (.71)	0.347 (.08)
discharge	−0.046 (.82)	−0.173 (.40)	0.212 (.30)
3MCS score at baseline	0.25 (.22)	0.153 (.45)	−0.149 (.47)
discharge	0.142 (.49)	0.07 (.71)	−0.039 (.85)
3RCS score at baseline	0.043 (.83)	−0.397 (.04*)	0.069 (.74)
discharge	0.287 (.16)	0.004 (.98)	0.249 (.22)

Spearman's signed rank sum test *$p < 0.05$
FIM-M: Functional IndepDischargeence Measure of motor items. 3PCS: Physical component summary.
3MCS: Mental component summary. 3RCS: Role/Social component summary.

Table 5 Multiple regression analysis of training motivation scale score means and FIM-M, 3PCS, 3MCS, 3RCS

outcome	factor	β	p
FIM change amount	Autonomous motivation score at baseline	−3.39	0.53
	The amount of change in the autonomous motivation score	0.59	0.92
	Controlled motivation score at baseline	4.15	0.32
	The amount of change in the controlled motivation score	0.43	0.94
	Non-motivation score at baseline	−1.83	0.73
	The amount of change in the non-motivation score	5.93	0.21
3PCS change amount	Autonomous motivation score at baseline	1.61	0.67
	The amount of change in the autonomous motivation score	6.38	0.13
	Controlled motivation score at baseline	−2.61	0.39
	The amount of change in the controlled motivation score	−3.21	0.47
	Non-motivation score at baseline	−6.19	0.11
	The amount of change in the non-motivation score	−1.57	0.63
3MCS change amount	Autonomous motivation score at baseline	−8.07	0.11
	The amount of change in the autonomous motivation score	−9.86	0.08
	Controlled motivation score at baseline	−5.2	0.2
	The amount of change in the controlled motivation score	−8.28	0.17
	Non-motivation score at baseline	4.51	0.4
	The amount of change in the non-motivation score	2.06	0.66
3RCS change amount	Autonomous motivation score at baseline	8.89	0.38
	The amount of change in the autonomous motivation score	3.54	0.75
	Controlled motivation score at baseline	21.07	< 0.01**
	The amount of change in the controlled motivation score	24.69	0.01*
	Non-motivation score at baseline	4.74	0.64
	The amount of change in the non-motivation score	2.55	0.78

β: standard regression coefficient *$p < 0.05$ **$p < 0.01$
FIM-M: Functional Independence Measure of motor items. 3PCS: Physical component summary.
3MCS: Mental component summary. 3RCS: Role/Social component summary.

amount of 3RCS change, namely, the controlled motivation score at the baseline evaluation ($p < 0.01$) and the amount of change in the controlled motivation score ($p < 0.05$).

(4) Relationship between the presence/absence of an increase/decrease in Training Motivation Scale score and the presence/absence of COPM-P and COPM-S MIC values

The results of the χ-square test showed a significant

Table 6 Relationship between Increase/Decrease in Training Motivation Scale Score and MCI Value of COPM

	Model1			Model2		
	odds ratio	95% confidence interval	p[1]	odds ratio	95% confidence interval	p[1]
Autonomous increase	1.33	0.28–6.28	0.72	3.5	0.69–17.9	0.13
Controlled increase	6.67	1.05–42.40	0.04*	2.33	0.44–12.4	0.32
No increase in non-motivation	13	1.27–133	0.03*	2.29	0.39–13.3	0.36

[1] Single-variable logistic regression analysis *$p < 0.05$
Model1: Improvement over the COPM-P MIC value or not. Model2: Improvement over the COPM-S MIC value or not.

association between improvement over the MIC value on the COPM-P and no increase in the average non-motivational score. A similar comparison showed no significant association between improvement above the MIC value on COPM-S and no improvement above the MIC value on COPM-P. Univariate logistic regression analysis showed a significant association between COPM-P with improvement above the MIC and an increase in the controlled motivation score (odds ratio 6.67, 95% confidence interval 1.05–42.40, $p = 0.044$) but no increase in the mean non-motivation score (odds ratio 13, 95% confidence interval 1.27–133, $p = 0.031$), with a significant association (Table 6).

4. Discussion

In this study, we examined the relationship between qualitative factors of motivation for rehabilitation and performance of and satisfaction with self-determined goals, health-related QOL, and functional independence in first-episode stroke patients admitted to a convalescent ward. The results showed that increased controlled motivation and no increase in non-motivation were significantly associated with improvement in COPM-P score beyond the MIC value. In addition, two items, controlled motivation score at baseline and the amount of score change were found to affect the amount of change in 3RCS scores and QOL (in terms of role/social aspects). There was no association between motivation for rehabilitation and FIM score.

This study focused on the qualitative factors of motivation. The findings suggest that an increase in controlled motivation positively affects improvement in COPM-P scores over the MIC and the amount of change in the role/social health aspect of QOL. The following section discusses possible explanatory factors for why the effect of controlled motivation was significant and its relationship to goal setting.

(1) COPM Category Selection and Role of Training Motivation Scale Question Items and Population

Autonomous motivation for rehabilitation, which can be expressed by the Training Motivation Scale used in this study, ranges from identification motivation as described by self-determination theory [11] (e.g., "1. I will accomplish what I think is right") to intrinsic motivation (e.g., "9. I am willing to try to do things by myself even if they are difficult") All the items are considered to measure aspects of motivation that have few external influences from others or the environment. In contrast, controlled motivation can be considered as motivation that is influenced by external factors such as relationships with others and evaluations, such as "3. I want to do my best in training so as not to bother others" and "7. I want to do my best in training because I like the rehabilitation staff."

The most common category of goal setting, as assessed by the COPM for participants in this study, was social life activities (N = 25), followed by household chores (N = 24). This may be because the average age of the population was 60.8 ± 12.5 years, 16 participants were employed, and 23 lived with family members; therefore, the study population comprised individuals who had multiple roles in society and the home. This may indicate that an important goal for participants was to reacquire roles in these relationships, as social activities and household chores are categories that concern relationships with others and with cohabitating family members. Therefore, it is likely that COPM-P scores were significantly improved by the increase in controlled motivation, which is influenced by external factors such as relationships with others and evaluations.

(2) How is the level of performance (how well one thinks one can do something) perceived?

In this study, the effect of increased controlled motivation was observed in the improvement of COPM-P score over the MIC value, but it is necessary to examine how participants perceived their level of performance. In the early stage of convalescence, 28%–97% of patients overestimate or underestimate their abilities owing to a lack of a sense of ownership of physical and cognitive functions [16], and they may not use the correct evaluation criteria for self-perception of their performance.

Previous studies have reported that emotional and social support from other patients promotes physical activity in stroke patients [17] and that support from rehabilitation professionals and patients affects the motivation of stroke patients [18]. It is possible that our participants were affected by other patients and rehabilitation professionals, which may have increased their expectations of success toward their goals. To clarify this factor, it would be necessary to include in the explanatory variables the effects of the frequency and content of interactions between participants and other patients, family members, and staff, as well as the effects of psychological variables. This is an issue to be addressed in future work.

(3) Relationship between controlled motivation and 3RCS score

Negative correlations were found between 3RCS scores and the level of controlled motivation at the baseline evaluation. This suggests that higher levels of controlled motivation at baseline were associated with a lower sense of role/social health. It has been reported that, as a psychological condition in the early stage of convalescence, the sudden loss of the ability to do things they used to be able to do affects patients' self-concept and may be associated with low self-esteem [19]. Additionally, this experience of illness-associated loss reduces QOL [20]. The present study was conducted to investigate the effects of participants' inability to do things they used to be able to do on their psychological condition. In this study, participants were highly motivated to engage in rehabilitation for the sake of someone else (e.g., society, family) in a controlled manner. Therefore, 3RCS score was significantly decreased owing to the strong effect of feelings of loss as participants were unable to fulfill their previous roles, a loss that would likely be felt in participants' relationships with others in terms of roles and sense of social health. Regarding the amount of change, a high and increasing level of controlled motivation at baseline may have been associated with a high level of motivation to engage in rehabilitation for the sake of someone else, resulting in a high self-evaluation of self-determined goals and a significant change in 3RCS score. To clarify this prediction, the relationship between COPM improvement and 3RCS score needs to be examined and will be the subject of a future study.

(4) Relationship between motivation for rehabilitation and FIM gains

Regarding the lack of association between motivation for rehabilitation and FIM gains, Yoshida et al. [21] examined the association between motivation and FIM gains in subacute stroke patients using the Motivation in Stroke Patients for Rehabilitation (MORE) scale. Although one report found no relationship between motivation and FIM, another showed a difference in FIM improvement between highly motivated patients and less motivated patients in improving physical function in the late subacute phase [22]. In this study, we focused on qualitative factors rather than motivational factors, and found results similar to those of Yoshida et al. Additional studies are needed to examine factors other than motivation, such as the amount of physical activity induced by motivation.

5. Limitations

There were several study limitations. The number of participants was small (N = 26); therefore, the results may not be highly reproducible because they may have been easily affected by participant individual differences. Regarding statistical analysis, because of the small sample size, we were unable to conduct multiple regression analyses that included the effects of multiple factors, and thus were unable to examine the effects of factors other than motivation. In addition, the impact of motivational quality may vary depending on the age of the population and the goal-setting category. We believe that future analyses stratified by age and role of the target population, by increasing the population size, will clarify whether it is more effective to promote autonomous or controlled motivation, depending on the individual factors of the target population. When setting goals using the COPM, we were not able to examine the reasons for selecting the tasks. Therefore, we unable to identify the psychological factors that lead to goal setting. We believe that clarifying what motivations led to the selection of goals for the subjects will clarify the relationship.

6. Conclusion

In this study, we examined the relationship between qualitative factors of motivation for rehabilitation and performance of and satisfaction with self-determined goals, health-related QOL, and FIM score in first-episode stroke patients admitted to a convalescent ward. The results showed that an increase in controlled motivation and the absence of an increase in non-motivation were significantly associated with improvement in COPM-P score beyond the MIC value. We also found that two items, the controlled motivation score and the amount of change at the baseline assessment, influenced the amount of change in 3RCS score, and the role/social dimension of QOL. The results suggest that focusing

on controlled motivation as a qualitative aspect of motivation for rehabilitation promotes patients' motivation to reacquire roles and social life activities, positively affects their performance of goals, and improves QOL.

Conflict of interest

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

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A Scoping Review of Prognosis Prediction Studies Focusing on Activity and Participation Among Patients with Stroke in Japan

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Abstract: Objective: A comprehensive overview of prognosis prediction studies on activity and participation among stroke survivors in Japan is currently lacking. This scoping review aimed to identify outcome measures, study characteristics, gaps, and issues in prognosis prediction studies focusing on activity and participation among patients with stroke in Japan. The study sought to provide guidance for future research.
Methods: The PubMed and Ichushi-web databases were searched. Two reviewers independently selected studies according to set inclusion and exclusion criteria. After study selection, author names, publication year, aims, study type, study design, study scale, setting, sample size, outcomes, main analysis methods, and main findings were extracted, categorized, and summarized.
Results: Eighty-three articles were finally included. The most frequently covered outcomes were activity of daily living (ADL) scores, such as the Functional Independence Measure (34 studies, 39.5%), followed by walking (26 studies, 30.2%). On the other hand, only few studies covered outcomes related to instrumental ADL and social activities, such as return to work and driving resumption. Although the number of studies has been increasing in recent years, 85.5% of the studies were conducted at single centers. Furthermore, only approximately 15% of the studies examined the validity of prediction models and indicators using a validation group.
Conclusions: In the future, prognosis prediction studies focusing on multiple aspects of activity and participation, such as instrumental ADL and social activities are required in Japan. Equally important is the generation of high-quality evidence, a goal achievable by promoting multicenter studies and validating existing predictive models and indicators.

Keywords: stroke, activity, participation, prognosis prediction, scoping review

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Introduction

Evidence-based prognosis prediction is crucial for efficient and effective rehabilitation after stroke. The Japanese Guidelines for the Management of Stroke (2022) recommend that rehabilitation programs should be planned based on prognosis predictions of patients' functional disability, activity of daily living (ADL), and limitations in social life [1]. Predicting outcomes after stroke rehabilitation can help clinicians and therapists set attainable goals, provide information to patients and relatives, and reach shared decisions [2].

Various prognosis prediction studies in patients with stroke have been reported worldwide. The topics covered range widely, including life prognosis [3], functional prognosis [4], discharge destination [5], ADL [6], and social activities [7]. In recent years, activity and participation have been considered primary outcomes of rehabilitation [8]. As a result, the number of prognosis prediction studies focusing on activity and participation among patients with stroke is expected to increase further in the future.

However, many limitations and difficulties may arise when using prognosis prediction models that have been developed and validated in environments with

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different social security systems, healthcare systems, lifestyles, and cultures. The frequency and content of post-stroke rehabilitation vary according to each country's social security system. Utilizing prognosis prediction models from countries with different rehabilitation delivery systems may compromise the prediction accuracy for patients in one's own country. Furthermore, variables used in prognosis prediction models are frequently based on scales unique to a specific country and may be difficult to use in one's own country. Lifestyle and cultural differences between countries may also cause variations in the outcomes addressed in prognosis prediction studies. Considering the above factors, using prognosis prediction models developed and validated in similar settings is usually beneficial when predicting the prognosis of patients with stroke in one's own country. Therefore, clarifying the current state of the reported findings in prognosis prediction studies focusing on activity and participation among patients with stroke in each country is imperative. In the case of Japan, however, a comprehensive overview of prognosis prediction studies on activity and participation among stroke survivors is currently lacking.

This study aimed to determine the outcomes that have been covered in prognosis prediction studies focusing on activity and participation among patients with stroke in Japan. Additionally, through a scoping review, the study aimed to identify the characteristics and issues associated with these studies. This review holds potential to furnish clinicians and therapists with useful information for evidence-based prognosis prediction and goal-setting in rehabilitation. Furthermore, the study findings can provide guidance for shaping the trajectory of future research in prognosis prediction focusing on activity and participation among Japanese patients with stroke.

Methods

This review followed the process outlined by Arksey and O'Malley [9], which encompassing five stages: (1) identifying the research question; (2) searching for relevant studies; (3) selecting studies; (4) charting the data; and (5) collating, summarizing, and reporting the results. A scoping review methodology was chosen due to its effectiveness in identifying gaps in the current scope and findings. This approach provides valuable insights to steer future prognosis and prediction research focusing on the activity and participation of patients with stroke. We also used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses-Extension for Scoping Reviews (PRISMA-ScR) for reporting [10].

Table 1 The search strategy (PubMed)

("stroke"[MeSH Terms] OR "stroke"[All Fields] OR "strokes"[All Fields] OR "stroke s"[All Fields]) AND ("predict"[All Fields] OR "predictabilities"[All Fields] OR "predictability"[All Fields] OR "predictable"[All Fields] OR "predictably"[All Fields] OR "predicted"[All Fields] OR "predicting"[All Fields] OR "prediction"[All Fields] OR "predictions"[All Fields] OR "predictive"[All Fields] OR "predictively"[All Fields] OR "predictiveness"[All Fields] OR "predictives"[All Fields] OR "predictivities"[All Fields] OR "predictivity"[All Fields] OR "predicts"[All Fields] OR ("prognosis"[MeSH Terms] OR "prognosis"[All Fields] OR "prognoses"[All Fields])) AND ("rehabilitant"[All Fields] OR "rehabilitants"[All Fields] OR "rehabilitate"[All Fields] OR "rehabilitated"[All Fields] OR "rehabilitates"[All Fields] OR "rehabilitating"[All Fields] OR "rehabilitation"[MeSH Terms] OR "rehabilitation"[All Fields] OR "rehabilitations"[All Fields] OR "rehabilitative"[All Fields] OR "rehabilitation"[MeSH Subheading] OR "rehabilitation s"[All Fields] OR "rehabilitational"[All Fields] OR "rehabilitator"[All Fields] OR "rehabilitators"[All Fields]) AND ("japan"[MeSH Terms] OR "japan"[All Fields] OR "japan s"[All Fields] OR "japans"[All Fields] OR ("asians"[MeSH Terms] OR "asians"[All Fields] OR "japanese"[All Fields] OR "japaneses"[All Fields]))

1. Definitions of terms

The definitions of activity and participation in this study followed the International Classification of Functioning, Disability and Health (ICF) [11]. Activity was defined as the execution of a task or action by an individual, while participation was defined as a person's involvement in a life situation. The ICF includes the following in the categories of activities and participation: mobility, managing self-care tasks, managing domestic life, and engaging in major life areas, such as employment.

2. Identifying the research questions

The scoping review sought to answer the following questions:

1) What outcomes have been covered in prognosis prediction studies focusing on activity and participation among patients with stroke in Japan?
2) What are the characteristics of the included studies (e.g., study types, settings)?
3) What are the gaps and issues that exist in the included studies?

3. Searching for relevant studies

PubMed and Ichushi-web, a Japanese medical article database, were searched. All searches included the terms *stroke*, *prediction/prognosis, and rehabilitation*. In addition, PubMed also included the terms *Japan/Japanese*. As an example, Table 1 shows the search strategy utilized in PubMed. These search terms were determined by discussion among the reviewers. No hand search was conducted, and grey literature was excluded. Both data-

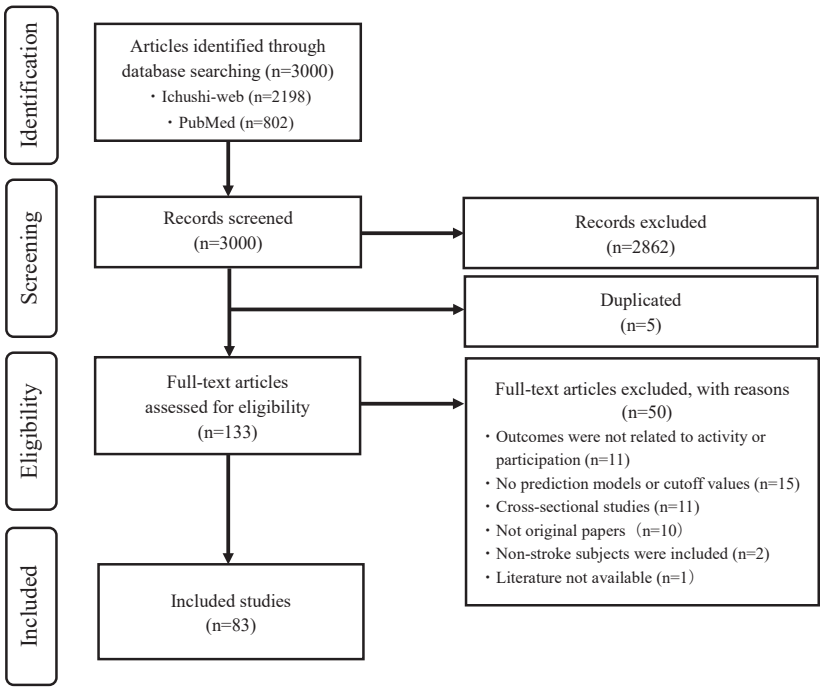

Fig. 1. Flowchart of study selection for the scoping review

base searches were conducted on 2 March 2022.

4. Selecting studies

To be included in this review, articles were required to meet the following criteria: (1) original articles, (2) participants being Japanese stroke survivors (including ischemic stroke, hemorrhagic stroke, or subarachnoid hemorrhage), (3) longitudinal studies, (4) description in the English or Japanese language, (5) incorporation of outcome measures related to activity and participation, (6) reporting of prediction models and cutoff values (not only predictors), and (7) publication date after 2000. The exclusion criteria were as follows: (1) conference proceedings, abstracts, brief communication, bulletins, and review articles; (2) included outcome measures unrelated to activity or participation; and (3) cross-sectional studies.

First, two reviewers separately screened study titles and abstracts and selected the relevant studies. Subsequently, the two reviewers assessed the full texts to determine the relevance of the studies. A third-party opinion was required to resolve disagreements when discrepancies occurred.

5. Charting the data

The data chart included the following data for each study: author names, publication year, aims, study type, study design, study scale, setting, time poststroke, sample size, outcomes, main analysis method, and main findings. The study type was categorized as development (creation of prediction equations or indicators using a derivation group), validation (validation of prediction equations or indicator performances using a validation group), or both. The study design was categorized as prospective or retrospective. The setting was categorized as acute, subacute, acute and subacute, and outpatient. The study scale was categorized as single or multicenter.

6. Collating, summarizing, and reporting the results

To integrate and summarize the outcomes covered in the included studies, they were categorized according to their topics. Data on extracted study characteristics were also categorized and summarized by publication year, study type, study design, setting, study scale, sample size, and main analysis method. The publication year was categorized as 2000–2004, 2005–2009, 2010–2014, 2015–2019, or 2020–2022. The sample size was categorized by study type: < 50, < 100, < 200, < 300, or ≥ 300 participants. The main analysis method was categorized separately for development and validation studies.

Results

1. Study selection

The study selection flow is shown in Fig. 1. The database search yielded 3,000 studies. After the screening of titles and abstracts and assessment of full-text articles, 83 studies were finally included in this review. The data chart of the included studies is shown in Table 2.

Table 2 The data chart of the included studies

Authors	Year	Aims	Study Type	Study design Study scale	Setting Time poststroke	Sample size	Outcomes	Main analysis method	Main findings
Kobayashi et al. [12]	2022	To develop prediction models for domestic chores resumption among mild stroke patients three months after discharge from specialized rehabilitation wards.	D	Prospective Multicenter	Subacute 120 (84–169) days	91	Domestic chores resumption	LRA	Six models were developed to predict individual domestic chores resumption. These models included predictors such as walking speed, cognitive function, self-efficacy, and number of family members living together.
Miyata et al. [13]	2021	To clarify the external validation of the prediction equation for m-FIM score at discharge developed by Tokunaga [71].	V	Retrospective Single	Subacute 26.0 ± 11.3 days	176	ADL score (m-FIM score)	Correlation analysis	The correlation coefficient between predicted and actual values of m-FIM score at discharge was 0.83. The residual was −1.2 ± 12.4.
Kobayashi et al. [14]	2021	To examine the external validation of the prediction models developed by Kobayashi [32] for resuming domestic chores after stroke.	V	Prospective Single	Subacute N/A	46	Domestic chores resumption	ROC	The prediction accuracy of six prediction models for resuming domestic chores such as preparing meals ranged from 75.0 to 82.2%, and the area under the ROC curve ranged from 0.71 to 0.86.
Tokunaga et al. [15]	2021	To predict the m-FIM gain by multiplying the effect of factors on standard m-FIM gain predicted by m-FIM score at admission.	D	Retrospective Single	Subacute 17.2 ± 8.1 days	230	ADL score (m-FIM gain)	Calculating the effect coefficients	A model was developed to predict m-FIM gain by multiplying the influence coefficients of three factors (age, days from onset to admission, and mRS before stroke onset) by the standard m-FIM gain. The median residual was 8.9.
Hiratsuka et al. [16]	2021	To develop a model to predict walking independence at 15 days after stroke onset.	D	Retrospective Single	Acute ≤ 3 days	612	Walking	DTA	The SFBBS score (≥ 13 or < 13) was selected at the first level, and the SFBBS (≥ 21 or < 21) and the SIAS distal item of lower extremity (≥ 3 or < 3) were selected at second level of decision tree.
Fujita et al. [17]	2021	To clarify the interaction among cognitive and physical functions associated with toileting independence.	D	Retrospective Single	Subacute 31.1 ± 12.3 days	125	Toileting	DTA	The SIAS verticality at admission (3 or ≤ 2 points) was identified as the best discriminator. HDS-R (≥ 19 or ≤ 18 points) and age (≥ 70 or ≤ 69 y) were selected at the second tree layer.
Imura et al. [18]	2021	To identify the factors affecting toileting independence in severe stroke patients using machine learning.	D	Retrospective Multicenter	Subacute N/A	1046	Toileting	DTA	The mRS score was the best discriminator. Among those with mRS score ≤ 4, the next discriminator was age (score ≤ 72, 73–80, or > 80). Among those with mRS score > 4, the next discriminator was also age (score ≤ 57, 58–72, 73–80, or > 80).
Uchida et al. [19]	2021	To develop a new prediction model by combining independence in eating and bladder management functions.	D	Retrospective Single	Acute 3 (2–3) days	250	ADL score (m-FIM score)	LRA	If either FIM eating or FIM bladder management was at least 5 points at admission, there was a 50% probability of reaching the m-FIM score of 41.3 points at discharge, and a 50% probability of 61.4 points if both items were at least 5 points.
Uwatoko et al. [20]	2020	To investigate the predictive value of the ABMSII score at admission for walking independence in acute stroke patients.	D	Retrospective Single	Acute N/A	67	Walking	ROC	The ABMSII score at admission of 26 or higher predicted walking independence on the 14th day from admission. Similarly, a score of 15 points or higher predicted walking independence on the 90th day from admission.

Table 2 *(continued)*

Authors	Year	Aims	Study Type	Study design Study scale	Setting Time poststroke	Sample size	Outcomes	Main analysis method	Main findings
Nakao et al. [21]	2020	To determine the predictors of life-space mobility 2 months after discharge from a rehabilitation unit.	D	Retrospective Single	Subacute 97 (66–134) days	1023	Life-space mobility	MRA	The prediction equation for LSA score 2 months after discharge was consisted of sex, age, c-FIM score at discharge, TUG score < 15 s, length of hospital stays and falls efficacy at discharge.
Yang et al. [22]	2020	To identify whether the ABMS II at admission would predict the functional status.	D	Retrospective Single	Subacute Within 2 months	94	Walking	ROC	An optimal cutoff of 18 points of ABMS II predicted achievement of independent or supervised walking at discharge.
Iwamoto et al. [23]	2020	To develop machine learning-based prediction for ADL dependence at discharge in stroke patients.	D	Retrospective Single	Subacute 31.3 ± 23.6 days	994	ADL score (mRS score)	DTA	FIM transfer (score ≤ 4.0 or > 4.0) was the best discriminator for ADL dependence. Among those with FIM transfer score > 4.0, the next predictor was FIM bathing (score ≤ 2.0 or > 2.0). Among those with FIM transfer score ≤ 4.0, the next predictor was FIM transfer toilet (score ≤ 3 or > 3).
Noriyama et al. [24]	2020	To examine the predictors of toileting independence at discharge.	D	Retrospective Single	Subacute 26.3 ± 9.1 days	88	Toileting	LRA	The prediction equation for toileting independence at discharge consisted of age, FIM toilet transfer, FIM problem solving, FIM walk/wheelchair, and days after stroke onset.
Okuma et al. [25]	2020	To investigate the relevance of the driving resumability judgment and the results of the driving simulator.	D	Retrospective Single	Outpatient N/A	50	Driving resumption	ROC	The cutoff values were calculated by the total number of false reactions, total stop-start, overall total, and total judgment scores. If three or more items exceeded the cutoff value, the judgment accuracy for non-resuming subjects was 78%.
Tokunaga et al. [26]	2020	To compare the accuracy of four methods of multiple regression analysis in predicting the m-FIM score at discharge.	D	N/A Single	Subacute 17.8 ± 9.7 days	1064	ADL score (m-FIM score)	MRA	The conversion model from m-FIM effectiveness to m-FIM at discharge and the model creating of two multiple regression equations had significantly smaller absolute values of residuals than the model by standard multiple regression analysis and the model with the reciprocal number of m-FIM at admission as one of the explanatory variables.
Tokunaga et al. [27]	2020	To investigate whether the prediction accuracy of FIM effectiveness can be improved by adding the mRS before onset and JCS at admission to multiple regression analysis.	D	N/A Multicenter	Subacute N/A	3412	ADL score (FIM effectiveness)	MRA	The prediction equation including stroke type, age, sex, days from onset to admission, and FIM at admission was developed, with the determinant coefficients adjusted for the degrees of freedom in 0.480. The coefficient of determination increased to 0.525 when the mRS before onset and the JCS at admission were added to the prediction equation.
Tokunaga et al. [28]	2020	To clarify the explanatory variables to predict improvement in the m-FIM at discharge in patients with severe stroke.	D	Retrospective Single	Subacute 17.2 ± 8.1 days	230	ADL score (m-FIM score)	MRA	The prediction equation consisting of age, c-FIM score at admission, m-FIM score at admission, days from onset to admission, mRS before onset, BRS of lower extremity, BMI, sitting stability, JSC, and hemispatial neglect was developed.

Table 2 *(continued)*

Authors	Year	Aims	Study Type	Study design Study scale	Setting Time poststroke	Sample size	Outcomes	Main analysis method	Main findings
Wada et al. [29]	2019	To compare the accuracy of formulae for predicting ADL outcome in post-stroke patients admitted to a rehabilitation ward.	D & V	N/A Single	Subacute D: 32.6 ± 12.1 days V: 32.5 ± 11.9 days	D: 751 V: 751	ADL score (m-FIM score)	D: MRA V: Correlation analysis	Three prediction equations were constructed: conventional multiple regression analysis, reciprocal multiple regression analysis, and calculation of m-FIM at discharge using m-FIM effectiveness, with intraclass correlation coefficients of 0.86, 0.90, and 0.89, respectively.
Fukuda et al. [30]	2019	To investigate the physical, cognitive, and social factors associated with the return to work of blue-collar workers after stroke.	D	Retrospective Single	Subacute 116.2 ± 48.1 days	71	Return to work	ROC	Functional upper limb represented by an increasing the STEF score was independently associated with return to work. The cutoff value of the STEF score between return to work and non-return to work was 82.
Fujita et al. [31]	2019	To clarify the impact of motor function interactions on self-care independence in individuals with stroke.	D	Retrospective Single	Subacute 57.8 ± 18.4 days	132	Self-care (feeding, grooming, toileting, and dressing)	DTA	The BBS score was selected as the most suitable variable for discriminating between the independent and dependent groups (score ≥ 41 or ≤ 40). In the second level, for the group with BBS ≤ 40, the STEF of the affected side was selected as the next classification variables (score ≥ 80 or ≤ 79).
Kobayashi et al. [32]	2019	To predict whether stroke survivors will resume domestic chores after discharge from a rehabilitation ward.	D	Retrospective Single	Subacute N/A	128	Domestic chores resumption	LRA	The prediction equations for individual domestic chores resumption were developed that included several factors such as sex, household composition, and walking speed.
Kondo et al. [33]	2019	To predict independence of chopsticks manipulation with the paralyzed dominant hand.	D	Retrospective Single	Acute 6.4 ± 1.4 days	51	Independence of chopsticks manipulation	ROC	The STEF was a predictor of independence in manipulating chopsticks with the paralyzed dominant hand, with a cutoff value of 50.
Hayashi et al. [34]	2019	To predict the period until attaining independent walking in stroke patients.	D & V	Retrospective Single	Subacute D: 21.3 ± 9.1 days V: 19.2 ± 6,2 days	D: 60 V: 19	The number of days until walking independence	D: MRA V: Correlation analysis	The prediction equation was [predicted days to walking independent = 163.509 − 6.052 × Ueda's 12-grade hemiplegic function test score for lower extremity −1.109 × m-FIM score].
Fujita et al. [35]	2019	To assess the accuracy of a prediction model for dressing independence created with a multilayer perceptron in a small sample at a single facility.	D	Retrospective Single	Subacute 36.6 ± 15.3 days	82	Dressing ability	MLP	A multilayer perceptron model was higher accuracy than a logistic regression model and a decision tree model for predicting dressing independence.
Saito et al. [36]	2018	To outline the association between the NIHSS in the acute stage and each of the m-FIM items several months later.	D & V	Retrospective Single	Acute D: 2 (1–2) days V: 2 (1–2) days	D: 53 V: 26	Individual ADL independence (*e.g., eating*)	D: LRA V: Calculating the accuracy rate	At least one NIHSS item was significantly associated with the functional independence of a single FIM motor item. Of the NIHSS items, the affected lower extremity item was the most widely associated with 11 of the FIM motor items, except for eating and shower transfer.
Umehara et al. [37]	2018	To identify the amount of physical therapy, occupational therapy, and speech therapy intervention to predict independence of ADL.	D	Retrospective Single	Subacute 22.9 ± 4.8 days	281	ADL score (mRS score)	ROC	In the early intervention group (hospitalization of 30 days or less), age, the amount of physical and occupational therapy intervention in the subacute phase, and m-FIM score at admission significantly affected the level of ADL independence at discharge. The cutoff point was 168 hours.

Table 2 *(continued)*

Authors	Year	Aims	Study Type	Study design Study scale	Setting Time poststroke	Sample size	Outcomes	Main analysis method	Main findings
Yoshida et al. [38]	2018	To identify the physical factors at discharge that best predict outdoor activities after discharge from a rehabilitation ward and its cutoff values.	D	N/A Single	Subacute 115.4 ± 50.3 days	31	Outdoor activity	ROC	Six-minute walking distance at discharge had the highest ability to predict outdoor activities after discharge and its cutoff value was 358.5 m.
Inoue et al. [39]	2018	To examine the influence of cognitive function of stroke patients with cognitive decline on the performance of ADL at discharge.	D	N/A Single	Acute 8.36 ± 2.75 days	22	Individual ADL items (*cf. bladder management*)	SRA	Seven FIM items (bladder management, bowel management, comprehension, expression, social interaction, problem solving, and memory) at 3 weeks after admission could be predicted from the MoCA-J total score one week after admission.
Ishikawa et al. [40]	2018	To determine whether SARA can predict whether patients with ataxia can walk independently.	D	N/A Single	Subacute 31 ± 12 days	30	Walking	ROC	SARA was a significant predictor of walking independence at discharge, with a cutoff value of 18.5 points and an area under the curve of 0.97.
Sawajima et al. [41]	2018	To examine whether the degree of brain damage in patients with putaminal hemorrhage can predict the walking independence at discharge from the rehabilitation ward.	D	N/A Single	Acute 2.6 ± 1.4 days	115	Walking	ROC	The cutoff values for walking independence were < 60.4% damage to the middle part of the posterior crus of the internal capsule, and < 27.4 ml of hematoma volume. The cutoff value for walking inability was ≥ 16.8% damage to the anterior part of the posterior crus of the internal capsule.
Yoshimatsu et al. [42]	2018	To develop a chart for predicting walking independence at 3 months after admission.	D	Retrospective Single	Subacute 32.0 ± 12.7 days	251	Walking	DTA	The BBS (≥ 13 or < 13) was selected at the first level, getting up (independent or dependent) was selected at second level, and cognitive impairment (presence or absence) was selected at third level.
Tsukinari et al. [43]	2018	To examine the usefulness of wheelchair safety operation management skills evaluation as a predictor of walking ability.	D	Prospective Single	Subacute 27.8 ± 13.9 days	16	Walking	ROC	The wheelchair operation safety management skills evaluation was higher at accurately predicting walking independence level at discharge than the other cognitive function tests.
Nagai et al. [44]	2018	To develop a prediction equation for the medication self-management.	D	Retrospective Single	Acute N/A	146	Medication self-management	LRA	The prediction equation for medication self-management was developed, consisting of age, the MMSE score, and stroke type.
Funakoshi et al. [45]	2017	To predict the walking Independence of patients who experienced nontraumatic subarachnoid hemorrhage at one month after admission.	D	Retrospective Single	Acute 2 (2–3) days	155	Walking	DTA	The prediction model based on the findings at the time of onset was composed of c-FIM and the stress index. The prediction model based on the findings from the clinical course was composed of c-FIM and number of days to the achievement of a 50-meter walk with minimal assistance.
Fujita et al. [46]	2017	To examine the cognitive and physical functional standards required for grooming independence.	D	Retrospective Single	Subacute 95.1 ± 35.8 days	96	Grooming	ROC	The cutoff value of the BBS to discriminate between the independent and supervision-dependent group was 41/40. The cutoff values of the STEF to discriminate between the independent-supervision and dependent groups was 68/67, 9/8 points for the Vitality Index, and 23/22 points for c-FIM.

Table 2 *(continued)*

Authors	Year	Aims	Study Type	Study design Study scale	Setting Time poststroke	Sample size	Outcomes	Main analysis method	Main findings
Hirano et al. [47]	2017	To develop a prognostic scale in severely hemiplegic stroke patients and allowing for prediction of the ability to walk and to carry out ADL at discharge.	D	N/A Single	Subacute 30.6 ± 15.2 days	80	① Walking ② ADL score (BI score)	MRA	The prognostic scale is as follows: Y = 0.7 × MMSE − 3.1 × NIHSS + 0.3 × TCT + 33.5 × KES/BW-US + 56.7. A score of 56.8 or higher on the prognostic scale suggested that the patient would be able to walk and that assistance with ADL would be unnecessary at the time of hospital discharge.
Tokunaga et al. [48]	2017	To elucidate the predictive accuracy of a method of calculating m-FIM at discharge from m-FIM effectiveness.	D	N/A Single	Subacute 17.4 ± 8.9 days	505	ADL score (m-FIM score)	MRA	The correlation between measured and predicted m-FIM at discharge, calculated from m-FIM effectiveness, was 0.916.
Kinoshita et al. [49]	2017	To test the ABMSII can predict walking ability during rehabilitation.	D	N/A Single	Subacute N/A	374	Walking	ROC	The cutoff value of the ABMSII score to discriminate between walking independence and dependence was 16 points or higher, with a sensitivity of 93% and a specificity of 71%, and an area under the curve of .908.
Kimura et al. [50]	2017	To examine the predictive validity of m-FIM score using the modified Koyama's prediction method [91] based on a logarithmic model.	V	Prospective Single	Subacute 34.4 ± 12.3 days	111	ADL score (m-FIM score)	Correlation analysis	The predictive value was highly correlated with the actual m-FIM score at discharge (intraclass correlation coefficient = 0.89).
Fujihara et al. [51]	2017	To create a formula for predicting medication self-management introduction in stroke patients using FIM items and patient data.	D	Retrospective Single	Subacute 23.5 ± 9.4 days	104	Medication self-management	LRA	The prediction formula was [4.404 − 0.229 × number of drugs at admission + 0.470 × walk/wheelchair mobility FIM at admission + 0.416 × memory FIM at admission −0.112 × age].
Hiraoka et al. [52]	2017	To examine the factors related to walking independence in patients with thalamic hemorrhage who were admitted to a rehabilitation hospital.	D	N/A Single	Subacute 27.2 ± 10.3 days	128	Walking	DTA	The decision tree analysis revealed that the patient's age, NIHSS score, MMSE score, hematoma volume, and presence of ventricular bleeding were factors that could predict walking independence.
Tokunaga et al. [53]	2017	To investigate if adding FIM improvement in the one month after admission as an explanatory variable improves the predictive accuracy of FIM gain.	D	Retrospective Single	Subacute 18.3 ± 9.4 days	547	ADL score (m-FIM gain)	MRA	The prediction equation using only data at admission and that adding FIM improvement for one month from admission were developed, with the determinant coefficients adjusted for the degrees of freedom of 0.364 and 0.711, respectively.
Ono et al. [54]	2017	To examine the relationship between early-stage starting of ambulation and walking independence at discharge in nontraumatic subarachnoid hemorrhage patients.	D	Retrospective Single	Acute 3.7 ± 2.1 days	240	Walking	ROC	The cutoff value for the number of days from onset to start of ambulation that predicted walking independence at discharge was 17.5 days, with a sensitivity of 61.4% and a specificity of 77.7%, and an area under the curve of .747.
Yamauchi et al. [55]	2017	To predict walking independence 3 months after stroke onset based on background factors and functional impairment 7 days after onset.	D	Retrospective Single	Acute Within 7 days	559	Walking	DTA	Decision tree analysis resulted in the adoption of SIAS for first tier, TCT and BMI for second tier, and c-FIM and age for third tier.

Table 2 *(continued)*

Authors	Year	Aims	Study Type	Study design Study scale	Setting Time poststroke	Sample size	Outcomes	Main analysis method	Main findings
Umehara et al. [56]	2017	To investigate the factors, including the frequency of therapeutic intervention (PT, OT and ST) that influence the recovery of ADL.	D	Retrospective Single	Subacute N/A	657	ADL score (m-FIM gain)	ROC	The cutoff values for the total frequency of PT and OT required for m-FIM gains above the median in the severely, moderately, and mildly limitation groups were retrospectively 747, 495, and 277 units, respectively.
Tokunaga et al. [57]	2017	To determine whether stratification of contributing factors is effective in improving prediction accuracy in multiple regression analysis with m-FIM gain as the objective variable.	D	Retrospective Multicenter	Subacute 36.3 ± 15.2 days	2542	ADL score (m-FIM gain)	MRA	The correlation coefficient was higher with the stratification of gender (0.509), stroke type (0.512), number of hospital days (0.516), days from onset to admission (0.518), mRS before onset (0.520), age (0.541), c-FIM at admission (0.588) and m-FIM at admission (0.641), than with the use of one prediction formula (0.507), and it was 0.653 with stratification into four groups with the two factors of motor FIM and cognitive FIM at admission.
Mizunashi et al. [58]	2016	To identify predictors of walking independence in patients with thalamic hemorrhage admitted a rehabilitation ward.	D	Retrospective Single	Subacute 30.4 ± 13.1 days	56	Walking	LRA	A prediction equation for walking independence was constructed in which two items were employed: the SIAS lower extremity total score at admission and the FIM total score at admission.
Watanabe et al. [59]	2016	To determine the clinical usefulness of FR to predict toilet transfer and walking ability.	D	Prospective Single	Subacute 40.0 ± 12.6 days	21	① Toileting ② Walking	ROC	FR ≥ 5 cm at one month after the first evaluation was considered useful to predict independence in toilet transfer, and FR ≥ 15 cm was considered useful to predict walk independence.
Tokunaga et al. [60]	2016	To clarify whether the accuracy of predicting m-FIM gain can be improved by using median values of m-FIM gain stratified by m-FIM score at admission.	D	Retrospective Multicenter	Subacute 36.3 ± 15.2 days	2542	ADL score (m-FIM gain)	MRA	Adding median m-FIM gain to the explanatory variables increased the correlation coefficient of measured values and predicted values of motor FIM gain from 0.507 to 0.638.
Funakoshi et al. [61]	2016	To create a model to predict the walking independence at 2 and 4 weeks from the onset of stroke.	D	Retrospective Single	Acute Within 3 days	915	Walking	DTA	The 2-week model was consisted of variables such as the NIHSS, the mRS before admission, the m-FIM, age, sex, and presence of pushing. The 4-week model was consisted of variable such as the NIHSS, age, stroke type, and sex.
Sato et al. [62]	2016	To create a prediction model for ADL independence at discharge in stroke patients in the convalescence stage.	D & V	Retrospective Single	Subacute 32.4 ± 14.2 days	D: 65 V: 98	ADL score (m-FIM score)	D: MRA V: Comparison of residuals	The prediction equation was following: m-FIM at discharge = 0.539 × m-FIM at admission + 2.674 × VI − 0.717 × age + 0.318 × SIAS + 54.5.
Murayama et al. [63]	2016	To development of a decision tree to predict walking and toileting independence on day 15 of hospitalization.	D	Prospective Single	Acute N/A	291	① Walking ② Toileting	DTA	Seven factors were selected for walking independence, including the Ueda's 12-grade hemiplegic function test (lower extremity) and transfer ability. Eight factors were selected for toileting independence, including the Ueda's 12-grade hemiplegic function test (upper extremity) and age.

Table 2 *(continued)*

Authors	Year	Aims	Study Type	Study design Study scale	Setting Time poststroke	Sample size	Outcomes	Main analysis method	Main findings
Hirano et al. [64]	2016	To identify predictors of walking independence that would be available at admission to rehabilitation hospital.	D	Retrospective Single	Subacute N/A	72	Walking	DA	The discriminant was derived from the following equation: Y = 0.093 × (age) − 4.316 × (KES/BW-US) − 4.984. If this formula yielded values less than zero, 89.8% of patients were able to walk independently.
Makizako et al. [65]	2015	To determine the optimal BBS cut-off score for predicting walking independence within 3 months after admission.	D	Retrospective Single	Subacute 32.0 ± 12.7 days	251	Walking	LRA	The optimal cutoff scores for BBS at admission and 1 month after admission were at least 13 and 27 points, respectively, to predict walking independence within 3 months of admission.
Tokunaga et al. [66]	2015	To predict m-FIM item-specific scores at discharge based on m-FIM item-specific scores at admission and demographic data.	D	Retrospective Multicenter	Subacute N/A	1465	Individual ADL items (*cf. eating*)	MRA	Five models were developed to predict m-FIM item-specific scores at discharge, such as eating and stairs. The determination coefficients adjusted for the degrees of freedom for the five models ranged from 0.506 to 0.700.
Tokunaga et al. [67]	2015	To develop multiple prediction equations stratified patients based on age, m-FIM score at admission, and c-FIM score at admission.	D	Retrospective Multicenter	Subacute N/A	1465	ADL score (m-FIM score)	MRA	Eight prediction equations were developed, stratified by age, m-FIM score at admission, and c-FIM score at admission. The correlation coefficient between the measured and predicted values of this prediction model was 0.885.
Hirano et al. [68]	2015	To predict ADL at discharge based on background factors and physical function at admission in patients with severe stroke.	D	N/A Single	Subacute N/A	62	ADL score (BI score)	DA	The discriminant was derived from the following equation: Y = 0.058 × (age) + 0.037 × (time since stroke onset) − 3.931 × (KES/BW-US) − 3.755. A value greater than 0 in this equation indicated patients needed assistance with ADL at discharge.
Watanabe et al. [69]	2015	To determine the cutoff value for predicting the walking independence from the ability to sit up from the supine position at admission.	D	Retrospective Single	Subacute 43.1 ± 11.9 days	106	Walking	ROC	The cutoff point for predicting walking independence based on the score for sitting up at admission was 6, with sensitivity of 87.7% and specificity of 80.5%.
Tokunaga et al. [70]	2015	To predict m-FIM score at discharge in patients with stroke from convalescent rehabilitation wards using multiple regression analysis.	D	Retrospective Multicenter	Subacute N/A	2320	ADL score (m-FIM score)	MRA	The prediction equation was [m-FIM score at discharge = 46.104 + 0.583 × m-FIM at admission + 0.569 × c-FIM at admission – 2.174 × mRS before stroke −0.203 × age − 0.147 × Number of days from onset to admission].
Tokunaga et al. [71]	2015	To predict m-FIM gain and m-FIM score at discharge by multiplying the median values of m-FIM gain and m-FIM score at discharge by the influence coefficients for age, cognitive function, and transfer interval.	D	N/A Single	Subacute 21.2 ± 10.4 days	1118	ADL score (m-FIM gain and m-FIM score)	Calculating the influence coefficients	The correlation coefficient between the actual and predicted values was 0.681 in the prediction of m-FIM gain and 0.874 in the prediction of m-FIM at discharge.

Table 2 *(continued)*

Authors	Year	Aims	Study Type	Study design Study scale	Setting Time poststroke	Sample size	Outcomes	Main analysis method	Main findings
Tokunaga et al. [72]	2015	To compare the prediction accuracy of multiple regression models predicting discharge FIM score in stroke patients reported to date in Japan.	V	Retrospective Multicenter	Subacute 35.0 ± 13.4 days	1229	ADL score (FIM total score and m-FIM score)	Comparison of residuals	The residuals were small in the prediction equations of Jeong [76] (median −0.16), Sonoda [90], and Iwai [81] (median −2.09).
Tokunaga et al. [73]	2015	To develop an equation to predict FIM at discharge for stroke patients stratified by age and FIM at admission	D	Retrospective Multicenter	Subacute 34.1 ± 13.4 days	1465	ADL score (FIM total score)	MRA	Prediction equations stratified into 6 groups, 2 groups by age and 3 groups by FIM at admission, were developed. The correlation coefficient between predicted and actual values was 0.893.
Fujino et al. [74]	2014	To calculate cutoff values of the BBS at admission that predict self-care and ADL independence at discharge.	D	N/A Single	Subacute 32.9 ± 12.5 days	57	ADL score (m-FIM score)	ROC	The cutoff values of BBS at admission predicting self-care independence (m-FIM score ≥ 70) and ADL independence (m-FIM score ≥ 80) at discharge were ≥ 20 and ≥ 28, respectively.
Hirano et al. [75]	2014	To predict walking ability at discharge of severe hemiplegic patients based on their physical function at admission.	D	N/A Single	Subacute N/A	56	Walking	LRA	The prediction equation was Y = −0.177 × age + 0.099 × TCT + 9.337. A value < 0 in this equation indicates that the patient will require assistance to walk at discharge. The accuracy was 91.1%.
Jeong et al. [76]	2014	To develop equations to predict FIM at discharge from acute and subacute hospitals using data from at admission.	D & V	Retrospective Multicenter	Acute and Subacute Acute: 3.0 days Subacute: 33.9 days	Acute D: 2118 V: 1905 Subacute D: 941 V: 999	ADL score (FIM total score)	D: MRA V: Correlation analysis	The formula for acute patients was [85.04 − 0.53 × age + 12.06 × SAH − 7.90 × complication present − 0.70 × number of days from onset to admission + 1.24 × GCS − 1.08 × NIHSS − 4.15 × mRS before stroke + 0.30 × m-FIM + 1.03 × c-FIM]. The formula for subacute patients was [33.04 − 0.34 × age − 3.88 × complication present − 0.11 × number of days from onset to admission + 2.44 × GCS − 1.68× mRS before stroke + 0.53 × m-FIM +1.25 × c-FIM].
Matsugi et al. [77]	2014	To confirm the accuracy of revised models for predicting the FIM at discharge.	D & V	Retrospective Single	Subacute N/A	D: 153 V: 90	ADL score (FIM total score)	D: Calculating the equation of logarithmic curve V: Comparison of residuals	The calculated equations for discharge FIM were following: Score for CI patients = 50.58 × ln [admission FIM] − 123.28, score for ICH patients = 49.36 × ln [admission FIM] − 111.29, and score for CI and ICH patients = 48.44 × ln [admission FIM] − 111.45.
Isho et al. [78]	2013	To predict walking independence at discharge in acute stroke patients using NIHSS sub-items	D	Retrospective Single	Acute Within 3 days	119	Walking	LRA	The prediction equation was [14.542 − 0.159 × age − 1.211 × The leg motor items on the paralyzed side in the NIHSS], with an area under the curve of .922.
Sakamoto et al. [79]	2013	To reveal the accuracy and superiority of three prediction models for walking independence at 3 months after onset.	V	N/A Single	Acute Within 7 days	153	Walking	ROC	Prediction accuracy of the author's model was higher than other two models until 2 weeks after admission.
Ohki et al. [80]	2012	To predict walking ability at discharge in elderly stroke patients using the BBS.	D	N/A Single	Subacute N/A	157	Walking	ROC	The cutoff value of the BBS at admission to discriminate between walking independence and non-independence at discharge was ≥ 18.

Table 2 *(continued)*

Authors	Year	Aims	Study Type	Study design Study scale	Setting Time poststroke	Sample size	Outcomes	Main analysis method	Main findings
Iwai et al. [81]	2012	To evaluate whether or not the Nichijo-seikatsu-kino-hyokahyo could be used as an index for predicting ADL independence level.	D	Retrospective Multicenter	Subacute 33.3 ± 19.4 days	482	ADL score (FIM total score)	MRA	The prediction formula was [96.634 − 0.267 × age + 0.232 × m-FIM at admission + 0.97 × c-FIM at admission − 2.627 × Nichijo-seikatsu-kino-hyokahyo]. The model including the Nichijo-seikatsu-kino-hyokahyo increased the coefficient of determination by about 0.04, but did not change the predictive value.
Araki et al. [82]	2010	To examine the relation between rehabilitation outcome and cerebral blood flow values	D	N/A Single	Subacute 39 ± 10 days	101	ADL score (FIM total score)	MRA	Rehabilitation outcome evaluated with the FIM total scores could be led by the formulae with the factors of age, gender, NIHSS, right/left hemispheric lesions and right mean cerebral blood flow values.
Kaneda et al. [83]	2010	To predict ADL at 2- and 4-weeks using data at the beginning of rehabilitation in patients with acute stroke.	D	Retrospective Single	Acute 3.5 ± 2.8 days	57	ADL score (BI score)	MRA	The prediction equations were following; BI score after 2 weeks = − 26.986 + 1.133 × HDS-R + 13.758 × BRS for upper extremity, and BI score after 4 weeks = 25.722 + 0.917 × HDS-R + 14.241 × BRS for upper extremity.
Hamada et al. [84]	2010	To examine significant factors affecting ADL at discharge in stroke patients.	D	Retrospective Single	Acute 6.4 days	50	ADL score (BI score)	MRA	The prediction equation was [BI score at discharge = 0.81 × BI at rehabilitation starting − 0.61 × age + 5.6 × BRS for lower extremity at rehabilitation starting + 44.8].
Shiiba et al. [85]	2010	To develop a prediction equation for transfer independence one month after admission to a rehabilitation ward.	D	Retrospective Single	Subacute 21.0 ± 15.1 days	112	Bed transfer	DA	The prediction equation was [z = 0.129 × m-FIM + 0.023 × JSS-H − 5.146], predicting transfer independence when z ≥ 0 and non-independence when z < 0.
Yamashita et al. [86]	2009	To develop a prediction equation for walking independence at 3 months after admission to a rehabilitation ward.	D	Retrospective Single	Subacute 39.7 ± 14.8 days	95	Walking	LRA	A prediction equation was [Score = − 1.685 × length from onset to admission − 1.480 × presence of flaccid paralysis − 1.379 × presence of cognitive impairment − 2.106 × presence of a gap of 10% or greater on the line bisection test + 1.017 × FIM walking score at admission].
Ohsumi et al. [87]	2009	To predict basic movement ability in the 3 weeks after onset based on initial information such as age, location of lesion, and diameter of infarcted lesion.	D	N/A Single	Acute N/A	75	Basic movement ability	DTA	The diameter of the infarct lesion (≥ 7 cm or < 7 cm) was selected as the first level. For those with an infarct lesion diameter of ≥ 7 cm, age (≥ 60 or < 60) was selected as the next predictor. For those with infarct lesions < 7 cm in diameter, the next predictor was age (≥ 80/55 to 80/< 55).
Ito et al. [88]	2007	To investigate factors predicting dressing ability of stroke patients in a rehabilitation ward.	D	Retrospective Single	Subacute N/A	305	Dressing	MRA	The prediction equations for dressing upper and lower body at discharge were developed including the factors such as dressing upper body at admission, social interaction at admission, transfer (tub/shower) at admission, grooming at admission, bowel management at admission, and age.
Suzuki et al. [89]	2006	To identify predictors of the recovery of independent dressing ability after stroke.	D	Prospective Single	Acute 23.0 ± 7.2 days	51	Dressing	ROC	Only the FIM score for dressing upper body on the first day of dressing training was a significant independent predictor of dressing ability at the end of 15 days training, with a cutoff of 3 points.

Table 2 *(continued)*

Authors	Year	Aims	Study Type	Study design Study scale	Setting Time poststroke	Sample size	Outcomes	Main analysis method	Main findings
Sonoda et al. [90]	2005	To predict the m-FIM at discharge using the m-FIM at admission or its reciprocal number.	D & V	Retrospective Single	Subacute D: 81.3 days V: 80.8 days	D: 87 V: 44	ADL score (m-FIM score)	D: MRA V: Correlation analysis	Ordinary regression: m-FIM at discharge = 45.8 + 0.60 × m-FIM at admission + 0.28 × c-FIM at admission − 0.18 × age − 0.07 × days since onset to admission. Reciprocal regression: m-FIM at discharge = 97.3 − 909/m-FIM at admission + 0.26 × c-FIM at admission − 0.2 × age − 0.047 × days since onset to admission. The correlation coefficients between the predicted and actual values were 0.88 (ordinary regression) and 0.93 (reciprocal regression) in the validation group.
Koyama et al. [91]	2005	To examine the validity and applicability of logarithmic modeling for predicting functional recovery of stroke patients with hemiplegia.	D	N/A Single	Subacute Median 50 days	18	ADL score (FIM total score)	Calculating the equation of logarithmic curve	For each patient, the predicted FIM scores derived from the logarithmic formula matched the actual change in FIM scores. Regression analysis showed a close fit between logarithmic modeling and actual FIM scores ($R^2 = 0.945$).
Inouye et al. [92]	2001	To determine predictors of function at discharge for stroke outcome and examine their accuracy of prediction.	D	N/A Single	Subacute 74 ± 42 days	464	ADL score (FIM total score)	MRA	The prediction model for patients aged 60–69 was following: [expected discharge FIM total score = 111.88 + 0.08 × the type of stroke (1 for CI and 0 for otherwise) − 0.11 × age + 0.81 × admission FIM total score − 0.12 × onset to rehabilitation admission interval].
Inouye et al. [93]	2001	To develop a simple, easy-to-use ADL prediction model that has strong predictive power.	D	N/A Single	Subacute 74 ± 42 days	464	ADL score (FIM total score)	MRA	The prediction equation was following: FIM total score at discharge = 106.88x − 95.35, where x = log (FIM total score at admission). A multiple correlation coefficient was 0.84.
Saeki et al. [94]	2001	To examine the validity and precision of the Stroke Vocational Index, a checklist for evaluating the potential return to work after stroke.	V	N/A Single	Acute N/A	51	Return to work	Calculating the accuracy rate	The Stroke Vocational Index had a consistency of 75%, sensitivity of 59%, specificity of 82%, positive predictive value of 63%, and negative predictive value of 80%.

Abbreviations: D, Development; V, Validation; N/A, Not Available; LRA, Logistic regression analysis; FIM, Functional Independence Measure; m-FIM, motor items of FIM; ADL, Activities of Daily Living; ROC, Receiver operating characteristic curve; mRS, modified Rankin Scale; DTA, Decision tree analysis; SFBBS, Short Form Berg Balance Scale; SIAS, Stroke Impairment Assessment Set; HDS-R, Revised Hasegawa's Dementia Scale; ABMSII, Ability for Basic Movement Scale; MRA, Multiple regression analysis; LSA, Life-Space Assessment; c-FIM, cognitive items of FIM; TUG, Timed Up & Go test; JCS, Japan Coma Scale; BMI, Body Mass Index; STEF, Simple Test for Evaluating hand Function; BBS, Berg Balance Scale; MLP, Multilayer perceptron; NIHSS, National Institutes of Health Stroke Scale; SRA, Single regression analysis, MoCA-J, Japanese version of the Montreal Cognitive Assessment; SARA, Scale for the Assessment and Rating of Ataxia; MMSE, Mini Mental State Examination; TCT, Trunk Control Test; KES/BW-US, Knee Extension Strength/Body Weight Ratio on the Unaffected Side; PT, Physical Therapy; OT, Occupational Therapy; ST, Speech Therapy; FR, Functional Reach; VI, Vitality Index; DA, Discrimination analysis; SAH, Subarachnoid Hemorrhage; GCS, Glasgow Coma Scale; CI, Cerebral Infarction; ICH, Intracerebral Hemorrhage; BRS, Brunnstrom Recovery Stage; BI, Barthel Index; JSS-H, Japan Stroke Scale Higher Cortical Function

Table 3 Outcomes covered in prognosis prediction studies focusing on activity and participation among patients with stroke in Japan

Outcomes	Total n = 86*	D	V	D & V
ADL score (e.g., motor FIM score, FIM gain, BI score)	34 (39.5)	26	3	5
Walking	26 (30.2)	24	1	1
Toileting	5 (5.8)	5	0	0
Dressing	3 (3.5)	3	0	0
Several ADL items	3 (3.5)	2	0	1
Domestic chores resumption	3 (3.5)	2	1	0
Return to work	2 (2.3)	1	1	0
Life space mobility	2 (2.3)	2	0	0
Medication self-management	2 (2.3)	2	0	0
Driving resumption	1 (1.2)	1	0	0
Self-care	1 (1.2)	1	0	0
Grooming	1 (1.2)	1	0	0
Bed transfer	1 (1.2)	1	0	0
Basic movement ability	1 (1.2)	1	0	0
Chopsticks manipulation	1 (1.2)	1	0	0

Abbreviations: D, Development study; V, Validation study; D & V, Development and validation study; ADL, activity of daily living; FIM, Functional Independence Measure; BI, Barthel Index

* Studies dealing with several outcome within an article were counted as duplicates [47] [59] [63].

2. Outcomes covered in the included studies

A summary of the outcomes covered in the prognosis prediction studies of activity and participation among patients with stroke in Japan is shown in Table 3. The most frequently covered outcome was ADL scores, including the Functional Independence Measure (FIM) and the Barthel Index (BI), which accounted for 34 studies (39.5%). This was followed by 26 (30.2%) and 5 (5.8%) studies related to walking and toileting, respectively. On the other hand, only a few studies covered outcomes related to Instrumental Activities of Daily Living (IADL) and social activities, with 2 (2.3%) on return to work and 1 (1.2%) on driving resumption.

3. Characteristics of the included studies

Table 4 summarizes each characteristic of the included studies, including the publication year, study type, and study scale. Briefly, the number of studies appears to have increased since about 2015. In terms of study type, 70 (84.4%) were development studies, accounting for the largest number; 6 (7.2%) were validation studies; and 7 (8.4%) studies encompassed both development and validation aspects. In terms of study scale, 71 (85.5 %) and 12 (14.5%) were single-center and multicenter studies, respectively.

Table 4 Characteristics of prognosis prediction studies focusing on activity and participation among patients with stroke in Japan

		Count (%)
Publication year (n = 83)		
2000–2004		3 (3.6)
2005–2009		6 (7.2)
2010–2014		12 (14.5)
2015–2019		45 (54.2)
2020–2022		17 (20.5)
Study type (n = 83)		
Development		70 (84.4)
Validation		6 (7.2)
Both		7 (8.4)
Study design (n = 83)		
Prospective		7 (8.4)
Retrospective		53 (63.9)
Not available		23 (27.7)
Study scale (n = 83)		
Single center		71 (85.5)
Multicenter		12 (14.5)
Setting (n = 83)		
Acute		19 (22.9)
Subacute		62 (74.7)
Acute and subacute		1 (1.2)
Outpatient		1 (1.2)
Sample size	Development (n = 77)	Validation (n = 13)
< 50	6 (7.8)	4 (30.9)
< 100	24 (31.2)	3 (23.1)
< 200	14 (18.2)	3 (23.1)
< 300	8 (10.4)	0 (0)
≥ 300	25 (32.4)	3 (23.1)
Analysis method for development studies (n = 77)		
Multiple regression analysis		25 (32.4)
Logistic regression analysis		12 (15.6)
Decision tree analysis		12 (15.6)
Receiver operating characteristic analysis		19 (24.7)
Others		9 (11.7)
Analysis method for validation studies (n = 13)		
Correlation analysis		6 (46.1)
Comparison of residuals		3 (23.1)
Receiver operating characteristic analysis		2 (15.4)
Calculating the accuracy rate		2 (15.4)

Discussion

This study conducted a scoping review of prognosis prediction studies focusing on activity and participation among patients with stroke in Japan, and 83 articles were selected for analysis. The most frequently covered outcome was related to ADL scores. The characteristics of the included studies were as follows: although the number of studies has increased in recent years, most of them were conducted in single centers, and few studies validated the prediction models and indicators.

As mentioned above, the most frequently covered

outcome in the included studies was related to ADL scores, including FIM and BI (34 studies [39.5%]), followed by walking (26 studies [30.2%]). The findings suggest a significant interest in predicting the prognosis of outcomes such as recovery of ADL and walking ability. ADL and walking performance have been reported to affect post-discharge life, including the discharge destination and care burden [5, 95–97]. Additionally, these outcomes have long been considered major rehabilitation goals. This background may explain numerous studies focusing on these outcomes.

On the other hand, few studies reported predictive models or indicators for outcomes related to IADL and social activities, such as return to work and driving resumption. In other countries, several models and indicators have been reported to predict the frequency of social activities, including work and leisure, and the resumption of driving after stroke [7, 98–100]. However, the reason behind the scarcity of such studies in Japan remains unclear. One potential explanation could be the prevailing overemphasis in Japan on using ADL improvement as the primary outcome measure for assessing the effectiveness of stroke rehabilitation [101]. A more in-depth consideration of the multifaceted nature of activity and participation in patients with stroke is warranted. Furthermore, the development and validation of predictive models and indicators should encompass not only ADL but also IADL and social activities among patients with stroke. This holistic approach will facilitate evidence-based prognosis prediction from multiple perspectives in clinical practice.

One trend observed among the studies included in this review is the increase in the number of publications in recent years, with a particularly large increase since 2015. This may reflect a growing awareness of the need to set rehabilitation goals and programs for patients with stroke based on scientific evidence. Conversely, moving forward, not only increasing the number of publications but also ensuring the quality of the studies becomes imperative. In this context, the transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD) guidelines were published in 2015. These guidelines aim to increase transparency in the reporting of prediction indicators [102]. The TRIPOD guidelines include 22 checklists, which cover aspects such as study design, methods for measuring outcomes and predictors, and sample size calculation. In the future, using such guidelines will be important to ensure the scientific validity of the evidence from prognosis prediction studies.

Most of the studies included in this review (85.5%) were conducted in a single-center setting. Domen noted that prognosis prediction studies in patients with stroke in Japan are mainly single-center studies, with fewer multicenter studies than those in the U.S. and Europe [103]. Twenty years after this report, the number of multicenter prognosis prediction studies focusing on activity and participation among patients with stroke remains small (14.5%). Prediction models and indicators developed at a single institution have been shown to have diminished predictive accuracy when used at other institutions. Therefore, we believe that one of the challenges for the future is to promote multicenter studies to increase the generalizability of prediction models and indicators.

In terms of study type, 84.4% were development studies, and only a few were validation studies of prediction models or indicators. The Japanese Guidelines for the Management of Stroke (2022) also note that few prediction studies have examined predictive accuracy using a validation group, and caution should be exercised in using prediction models that have not been validated [1]. In the future, the imperative lies not only in the development of prediction models and indicators, but also in their validation and demonstration of clinical utility.

A limitation of this study is that only two databases, PubMed and Ichushi-web, were used. The Joanna Briggs Institute (JBI) guidelines for scoping reviews recommend a “search of at least two appropriate online databases relevant to the topic” [104]. However, using only two databases for a scoping review that requires an exhaustive literature search is a major limitation of this study. In the future, it will be necessary to conduct an exhaustive search using more databases. In addition, the risk of bias in each study was not assessed. This decision was made due to the aim of this review: to provide an overview of the prognosis prediction studies focusing on activity and participation among stroke survivors in Japan. In the future, increasing the comprehensiveness of the studies and conducting systematic reviews that include a quality assessment of the studies will be necessary.

Conclusions

We conducted a scoping review of prognosis prediction studies focusing on activity and participation among patients with stroke. Many of the studies covered outcomes related to ADL scores and walking. Conversely, only a few studies focused on outcomes related to IADL and social activities, such as return to work and driving resumption. This review revealed an increase in the number of studies in recent years. However, most of these were single center studies, with only a few studies having verified the validity of the prediction models or

indicators. In the future, conducting prognosis prediction studies focusing on IADL and social activities becomes imperative. Moreover, prioritizing the promotion of multicenter studies and the validation of existing prediction models and indicators in Japan is essential.

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Conflict of Interest

There are no conflicts of interest to declare.

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■ORIGINAL ARTICLE

Effects of Voluntary Upper-Extremity Functional Training in Patients with Chronic Stroke

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Abstract: Background: There is a paucity of reports on task-oriented training in adult day-care centers for patients with chronic stroke.
Purpose: This study aimed to compare upper-extremity performance pre-, post-implementation, and after 6 months of the program in patients with chronic stroke at our adult day-care center.
Methods: Ten patients with chronic stroke underwent a voluntary upper-extremity functional training program comprising task-oriented training and transfer package. The frequency of training was 3 hours per day, 1 day per week, for 6 months. Main outcome measures included the Fugl-Meyer Assessment (FMA), Action Research Arm Test (ARAT), Box and Block Test (BBT), and Motor Activity Log (MAL). Repeated measures of one-way ANOVA were conducted for pre-, post-intervention, and after 6 months of upper-extremity functional assessments.
Results: There were significant improvements in all upper-extremity function assessments pre- and post-intervention ($p < .05$, effect size (f) = .75–1.04). Conversely, there was no significant improvement between post-intervention and after 6 months.
Conclusion: Our functional training program affected motor function, performance of the paralyzed upper-extremity, and participation status of the paralyzed upper-extremity in daily life. These results highlight the effectiveness of this program in patients with chronic stroke who are less affected by spontaneous recovery.

Keywords: adult day-care center, stroke, upper-extremity function, constraint-induced movement therapy, evidence

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1. Introduction

Stroke presents with a variety of symptoms. Hand paralysis post-stroke is a major factor that greatly reduces the quality of life (QOL) of patients with stroke [1]. Before 2000, regeneration of the damaged central nervous system in adults was considered difficult. Particularly, post-stroke hand paralysis was not expected to exhibit long-term functional improvement [2]. Accordingly, the basic approach of stroke rehabilitation was to acquire compensatory movements with the non-paralyzed hand. Since 2000, neuroregeneration [3] and synaptic plasticity [4] have received growing interest, and neuroscience-based neurorehabilitation has developed rapidly, thus facilitating long-term improvements in the paralyzed hand.

Constraint-Induced Movement Therapy (CIMT) is a method to improve the utility of the paralyzed hand and constitutes a typical example of neurorehabilitation. The use of CIMT is supported by evidence from numerous randomized controlled trials and meta-analyses [5]. CIMT has been reported to improve the QOL of patients with stroke [6]. The standard CIMT protocol [7] consists of 10 days of 6 hours of training per day (60 hours in total) for patients with chronic stroke. In this regard, CIMT is difficult to introduce into rehabilitation medicine due to time and personnel constraints alongside

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other factors [8]. Therefore, modified CIMT, in which the time, duration, and methods of intensive training are modified to suit the circumstances of each country, has been developed and demonstrated effectiveness [9]. In recent years, there has been a rapid increase in the number of reports on CIMT-based task-oriented training in acute-phase rehabilitation and convalescent rehabilitation in Japan. However, research on task-oriented training in Japanese adult day-care centers for patients with chronic stroke has been limited to case reports.

Therefore, we devised a voluntary upper-extremity functional training program that could be implemented at an adult day-care center and began offering this service in July 2019. Our adult day-care center provides a 3–4 hour-type service system and is unique in that food or bathing services are not provided; rather, the center specializes in rehabilitation. Users of this adult day-care center are proactively engaged in voluntary training programs developed by physical or occupational therapists according to their individual goals and care plans. This study aimed to examine the effects of the intervention pre- and post-program implementation performance and the long-term effects after 6 months.

2. Participants

2.1. Research participants

Referring to the criteria of Taub et al. [10], the following criteria were established for this program: (1) patients with hand paralysis post-stroke, (2) knee-mouth test 2 or higher, and finger function test 1b or higher in the motor items of the Stroke Impairment Assessment Set [11], (3) Mini-Mental State Examination (MMSE-J) score of 20 or higher, (4) patients with stroke for more than 180 days, (5) eligible for long-term care insurance, (6) independent in walking and toileting, (7) patients who could prepare for voluntary training by themselves, (8) patients who had not received drug therapy or brain stimulation therapy to improve upper-extremity function within 3 months, and (9) patients who had received permission from the attending physician.

Research participants comprised 10 individuals (6 men and 4 women, mean age: 64.3 ± 5.8 years) who met the above eligibility criteria. Participants implemented the program for 6 months over a 3-year period from July 2019 to the end of June 2022 and completed a follow-up 6 months after the intervention (Table 1).

G*Power 3.1.9.2 for Windows was used to determine the sample size. Statistical analysis by repeated measures one-way ANOVA was assumed, regarding previous studies [12], effect size (f) = .40, α error prob = .05, power (1-β error prob) = .80, correlation among repeated measures = .70. As a result, the required sample size was 8 participants. The number of participants was determined considering interruptions and withdrawal of research collaboration.

2.2. Ethical considerations

Three occupational therapists selected patients from among the adult day-care users who were suitable for this program. After obtaining permission from the attending physician, we explained the details of the program to the patients, family members, and care manager, both orally and in writing, and obtained their consent. This study was conducted in compliance with the ethical guidelines of the World Medical Association (Declaration of Helsinki, 1964 and Declaration of Tokyo, 1975, revised 2013). This study was approved by the Research Ethics Committee of Tokyo Bay Rehabilitation Hospital (No.293-2).

3. Methods

3.1. Intervention

3.1.1. Intervention protocol

The program was conducted once a week (every Saturday afternoon) for 3 hours a day for 6 months. One occupational therapist attended to every 3 to 6 participants, referring to the low-frequency long-term protocol by Page et al. [13]. The upper-extremity functional assessment was conducted 2 days during pre- and post-intervention periods (20–30 minutes per day).

This program was a CIMT-based voluntary upper-extremity functional training, consisting of Task-Oriented Training and Transfer Package as described by Morris et al. [14]. Transfer Package was implemented for each participant for approximately 0.5 hours of the 3-hour training period. In this program, the nonparalyzed hand was not restrained by mitts, and active upper-extremity functional training was conducted, incorporating bimanual movements. Figure 1 presents an overview of the implementation procedures of the program based on the items described below.

On the days when this program was not implemented and for 6 months after its implementation, circuit training [15] incorporating multiple tasks such as gait training, cardiopulmonary endurance training, balance training, and lower-extremity strength training was implemented besides the usual upper-extremity functional training to improve the level of independence in daily life. Usual upper-extremity functional training consists of gross movement training using a sanding board, upper-extremity ergometer, etc., grasp and pinch movement training using a plectrum, peg, string knot, etc., and activities of daily living training such as writing, chopstick operation, and computer operation.

Table 1 Basic information about the patients.

ID	Sex	Age	Years after stroke onset	Number of years since the start of use	Diagnostic name	Paralytic side	Number of visits per week	MMSE-J
A	female	60s	11	11	cerebral hemorrhage	left	3	29
B	male	60s	20	1	cerebral infarction	left	3	26
C	female	70s	2	2	cerebral hemorrhage	left	2	28
D	male	50s	1	0	cerebral infarction	right	3	29
E	female	70s	2	1	cerebral hemorrhage	left	1	30
F	male	60s	3	2	cerebral infarction	right	4	28
G	male	60s	1	0	cerebral infarction	right	3	30
H	male	60s	5	0	cerebral hemorrhage	left	1	29
I	male	60s	3	1	subarachnoid hemorrhage	left	2	30
J	female	60s	3	3	cerebral infarction	right	2	30

MMSE-J: Mini Mental State Examination-Japanese

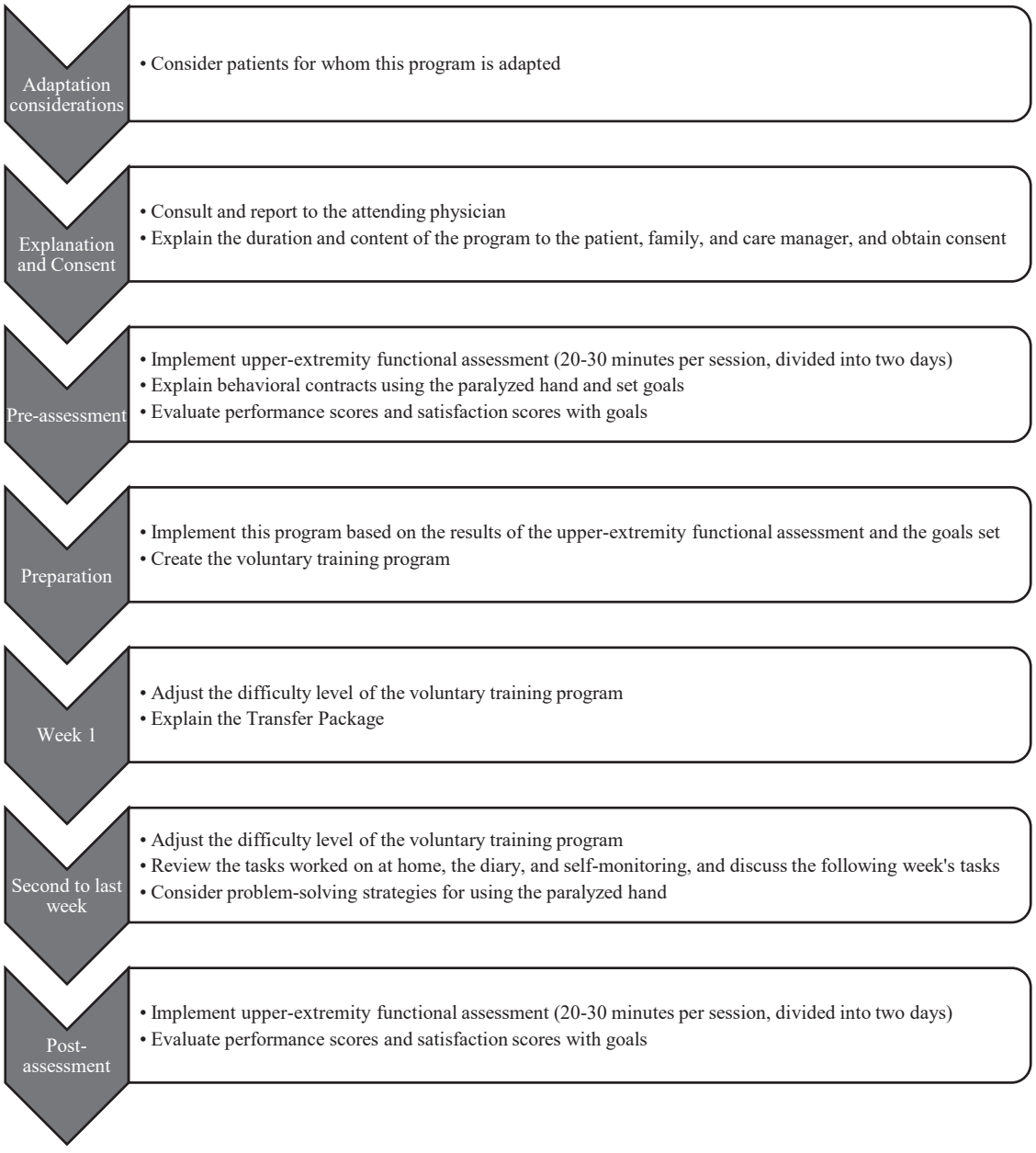

Fig. 1. Procedures for implementing this program.

3.1.2. Task-Oriented Training

Task-oriented training consisted of the Shaping Task, which involved step-by-step repetitive training to achieve a goal, and Task Practice, which was a simulated task using daily-use tools. The difficulty levels of both tasks were adjusted for (1) the patient (degree of freedom of joints, posture, and frequency of task), (2) the environment (spatial extent and surrounding environment for the task), and (3) tools and articles (shape, weight, and thickness of the articles, and introduction of self-help devices). The training tasks were designed to be completed in approximately 15 minutes. Occupational therapists prepared an agenda of approximately 10 types of voluntary training tasks per day. In addition, tasks of an appropriate difficulty level were provided according to the degree of improvement in patients' upper-extremity function.

Tasks were designed such that patients could perform them autonomously. The occupational therapists increased the level of difficulty according to patients' success in the tasks. If corrections during task performance were required, feedback regarding the method of movement for each task was provided either orally or via demonstration to enable the patients to elucidate the purpose of the movement and achieve a sense of accomplishment. When muscle tone was increased, or muscle fatigue occurred, active and passive stretches were performed during the task, and there were breaks between tasks.

3.1.3. Transfer Package

The Transfer Package consisted of (1) a behavioral contract and goal-setting for using the paralyzed hand, (2) a daily task list for using the paralyzed hand at home, (3) a diary on the use of the paralyzed hand, and (4) self-monitoring of the paralyzed hand including bimanual movements. These forms were modified from the methods of Morris et al. [14] and Takebayashi et al. [16] to facilitate implementation in an adult day-care center.

Before the start of this program, (1) behavioral contract and goal-setting for using the paralyzed hand were used to explain the importance of actively using the paralyzed hand at home during the program implementation period, and consent was obtained by signature. Subsequently, patients themselves or in collaboration with occupational therapists listed approximately 10 specific goals for the use of the paralyzed hand that they wanted to achieve through this program. Patients were instructed to rate the importance of each goal on a 10-point scale (1: not important at all to 10: very important). Moreover, patients and occupational therapists discussed and determined the order of priority for the goals based on paralyzed upper-extremity function. The three other forms (2) to (4) were conducted parallel with the task-oriented training.

In (2) daily task list for using the paralyzed hand at home, patients and occupational therapists held a weekly discussion and created 5 to 10 tasks according to upper-extremity function. After performing the task at home, patients self-evaluated their level of achievement on a 5-point scale (1: not at all possible to 5: very well done). Furthermore, patients were instructed to consider the reasons underlying the difficulty of the task and identify methods for improvement. Occupational therapists made training suggestions and devised the environment in collaboration with patients to enable patients to solve difficult tasks (e.g., use of self-help devices, changes in the form of objects, changes in the height of the workbench at which the operation was performed, and modifications or changes to the procedure of the operation or role of the paralyzed hand). To enable patients to actively use their paralyzed hands in daily life, we started with self-care situations that were acceptable and easy to perform. Usage methods were diversified to gradually expand the usage situations to instrumental ADLs.

In (3) diary on the use of the paralyzed hand, patients were instructed to recall situations in which they used the paralyzed upper-extremity every day and respond to 50 items regarding the use of the paralyzed hand by selecting from the following options: 1, use of non-paralyzed hand; 2, use of bimanual hands; 3, partial use of paralyzed hand; and 4, use of the paralyzed hand. In (4) self-monitoring of the paralyzed hand, including bimanual movements, patients were instructed to self-evaluate the degree to which they used the paralyzed hand in 22 situations, including bimanual movements on an 11-point scale (0.0: never used the hand to 5.0: able to use the hand as well as before the stroke) within 1 week prior.

3.2. Outcome measures

The effectiveness of the pre- and post-intervention, and after 6 months, was evaluated by motor function and motor performance of the paralyzed hand, as well as the participation status of the paralyzed hand in daily life. The following upper-extremity function assessment was used as the main outcome measures. Motor function of the paralyzed hand was evaluated using the upper-extremity motor items of the Fugl-Meyer Assessment (FMA) (66-point scale) [17]. Motor performance of the paralyzed hand was evaluated using the Action Research Arm Test (ARAT) (57-point scale) [18] and the Box and Block Test (BBT) [19]. Besides the paralyzed hand score, the BBT also used the BBT ratio (paralyzed hand

score/non-paralyzed hand score) measure. Participation status of the paralyzed hand was evaluated with the Amount of Use (AOU) and Quality of Movement (QOM) of the Motor Activity Log (MAL) [20].

Besides these, the evaluation of subjective aspects of achievement goals was used as a secondary outcome measure. For each of the 10 important goals of using the paralyzed hand, the degree of performance (1: not at all possible to 10: very possible) and satisfaction (1: very dissatisfied to 10: very satisfied) were rated on a 10-point scale [21].

3.3. Data analysis

Histograms were created for all data to confirm that no outliers were present. The normality of the evaluation scales was assessed using the Shapiro-Wilk test. Repeated measures of one-way ANOVA were conducted for pre-, post-intervention, and after 6 months of upper-extremity functional assessments that were normally distributed, and effect size partialη^2 and f (.10 ≤ small < .25, .25 ≤ medium < .40, and .40 ≤ large) were calculated. Bonferroni's multiple comparison test was used for pre, post, and after 6 months of data. Means (M) and standard deviations (SD) were calculated for the performance and satisfaction scales with achievement goals.

IBM SPSS for Windows, ver. 21.0 J was used for statistical analysis. The significance level was set at < 5%.

4. Results

Of the 10 patients in this study, 7 (cases A-E, G, and J) exhibited moderate upper-extremity paralysis (FMA scores: 20–46 points), and 3 (cases F, H, and I) exhibited mild upper-extremity paralysis (FMA score: 47 points or higher) [22] pre-intervention.

The effectiveness of the intervention revealed significant improvements in all upper-extremity functional assessments; FMA (F = 8.41, p = .003, f = .96), ARAT (F = 8.06, p = .003, f = .95), BBT (F = 9.77, p = .01, f = 1.04), BBT ratio (F = 9.04, p = .009), f = 1.00), MAL-AOU (F = 5.11, p = .017, f = .75), MAL-QOM (F = 8.69, p = .002, f = .95) (Table 2). Multiple comparisons showed significant differences in the following; pre - post for FMA (p = .018), pre - post (p = .036) and pre - after 6 months (p = .028) for ARAT, pre - post (p = .006) and pre - after 6 months (p = .046) for BBT, pre - post (p = .049) and pre - after 6 months (p = .032) for BBT ratio, pre - post (p = .044) for MAL-AOU, pre - post (p = .011) and pre - after 6 months (p = .032) for MAL-QOM (Fig. 2).

Table 3a presents the key achievement goals for the program set out by each patient and the degree of performance and satisfaction scores with these goals. Pre- and post- intervention, performance scores set for each goal improved from 2.67 ± 1.80 to 4.81 ± 1.51 and satisfaction scores from 3.01 ± 2.22 to 4.87 ± 2.02 (Table 3b).

5. Discussion

5.1. Intervention effectiveness and underlying mechanisms

This study examined the effectiveness of intervention with a voluntary upper-extremity functional training program among patients with chronic stroke. In this study, pre- and post-intervention periods and follow-up periods were equal to 6 months. There were significant improvements in all upper-extremity function assessments pre- and post-intervention.

First, we describe the short-term effects of this program pre- and post-intervention. Page et al. [13] divided patients with upper-extremity paralysis after stroke into three groups: modified CIMT group (n = 13), time-matched rehabilitation (TR) group (n = 12), and no treatment (control) group (n = 10). The study examined the effects of low-frequency, long-term modified CIMT, performed for 0.5 hours per day, 3 days per week for 10 weeks. According to this study, the amount of change in each assessment pre- and post- intervention was as follows; in FMA, modified CIMT group = +7.4 points, TR group = +4.6 points, control group = +2.8 points; in ARAT, modified CIMT group = +10.8 points, TR group = +3.0 points, control group = +0.9 points, in MAL-AOU, modified CIMT group = +2.1 points, TR group = +0.4 points, control group = −0.5 points, in MAL-QOM, modified CIMT group = +1.1 points, TR group = +0.3 points, control group = −0.3 points. In this study, the amount of change in each assessment pre- and post-intervention was +6.8 points in FMA, 11.6 points in ARAT, +0.97 points in MAL-AOU, and +0.95 points in MAL-QOM. Although the duration, frequency, and method of intervention differed between this study and the previous study [13], the pre-intervention values of each assessment were similar. In short, the improvement in FMA, ARAT, MAL-AOU, and MAL-QOM in this study exceeded that of the TR and control groups shown by previous studies. However, when compared to the amount of change in the modified CIMT group in the previous study [13], only ARAT showed comparable improvement in this study. The reason why the intervention results in this study were lower than the improvement in the modified CIMT group in the previous study may be due to the low frequency of intervention per week and the continuation of the program over a long period of time. The standard CIMT [7] has been highly effective

Table 2 Comparison before and after the program.

ID	FMA			ARAT			BBT		
	Pre	Post	After 6 Months	Pre	Post	After 6 Months	Pre	Post	After 6 Months
A	38	46	47	14	31	25	7	13	12
B	43	57	49	40	53	56	34	41	40
C	38	45	44	23	40	21	7	8	5
D	25	40	41	0	40	22	1	10	14
E	39	50	53	45	55	56	28	36	42
F	57	52	54	57	57	57	47	46	42
G	30	36	31	6	11	14	0	1	2
H	50	56	50	46	55	54	30	36	36
I	59	59	57	57	57	57	26	32	36
J	38	44	45	24	29	29	14	26	30
M	41.70	48.50	47.10	31.20	42.80	39.10	19.40	24.90	25.90
SD	10.89	7.61	7.48	20.66	15.50	18.21	15.83	15.72	15.92
p	.003			.003			.01		
ES	partial η^2 = .48 (f = .96)			partial η^2 = .47 (f = .95)			partial η^2 = .52 (f = 1.04)		

ID	BBT ratio			MAL AOU			MAL QOM		
	Pre	Post	After 6 Months	Pre	Post	After 6 Months	Pre	Post	After 6 Months
A	.12	.20	.17	1.00	2.60	1.80	1.00	3.20	2.40
B	.69	.82	.91	1.40	4.00	3.00	1.60	4.00	3.20
C	.15	.14	.11	2.25	3.25	2.00	1.75	2.00	1.50
D	.02	.21	.26	0.39	2.00	2.85	0.31	1.46	2.77
E	.43	.58	.68	4.00	3.33	5.00	3.00	3.33	4.00
F	.92	.84	.89	4.15	4.77	3.70	2.92	3.85	2.70
G	.00	.02	.04	1.17	1.00	1.55	0.67	1.17	1.00
H	.53	.59	.58	2.60	2.80	3.20	2.20	2.80	3.40
I	.43	.55	.56	2.75	4.75	3.00	2.75	3.00	3.00
J	.23	.47	.48	0.00	0.85	0.85	0.00	0.92	0.92
M	.35	.44	.47	1.97	2.94	2.70	1.62	2.57	2.49
SD	.30	.29	.31	1.42	1.38	1.19	1.10	1.11	1.04
p	.009			.017			.002		
ES	partial η^2 = .50 (f = 1.00)			partial η^2 = .36 (f = .75)			partial η^2 = .49 (f = .95)		

M: Means, SD: Standard Deviation, ES: Effect Size
FMA: Fugl-Meyer Assessment, ARAT: Action Research Arm Test, BBT: Box and Block Test
MAL: Motor Activity Log, AOU: Amount of Use, QOM: Quality of Movement

in short-term intensive training with high frequency; the previous study by Page et al. [13] was a modified CIMT with lower frequency and longer intension, modifying the standard protocol [7]. In this study, the intervention effect may have been lower due to the modification of the protocol to an even lower frequency and longer intension than in the previous study [13]. The intervention effects of this program are then discussed in comparison with the clinically meaningful changes reported in previous studies. In pre- and post-intervention, Motor functional assessment of the paralyzed hand revealed improvements equivalent to a clinically important difference (CID) score of 4.25 to 7.25 points, as reported by Page et al. [23] in FMA. Motor performance assessment of the paralyzed hand revealed an improvement over the smallest real difference (SRD) of 5.5 points as indicated by Chen et al. [24] in BBT and a minimum clinically important difference (MCID) of 5.7 points as reported by van der Lee et al. [25] in ARAT. Regarding in-life participation of the paralyzed hand, the MAL-AOU demonstrated an improvement over the MCID of 0.5 points reported by van der Lee et al. [26]. Performance scores for the achievement goal exceeded the Minimum Detectable Change (MDC) of 1.7 points, as reported by Cup et al. [27]. In this regard, we conjecture that the subjective aspects were influenced by patients' increased self-efficacy and motivation to use the paralyzed hand more willingly, with an increase in patients' successful

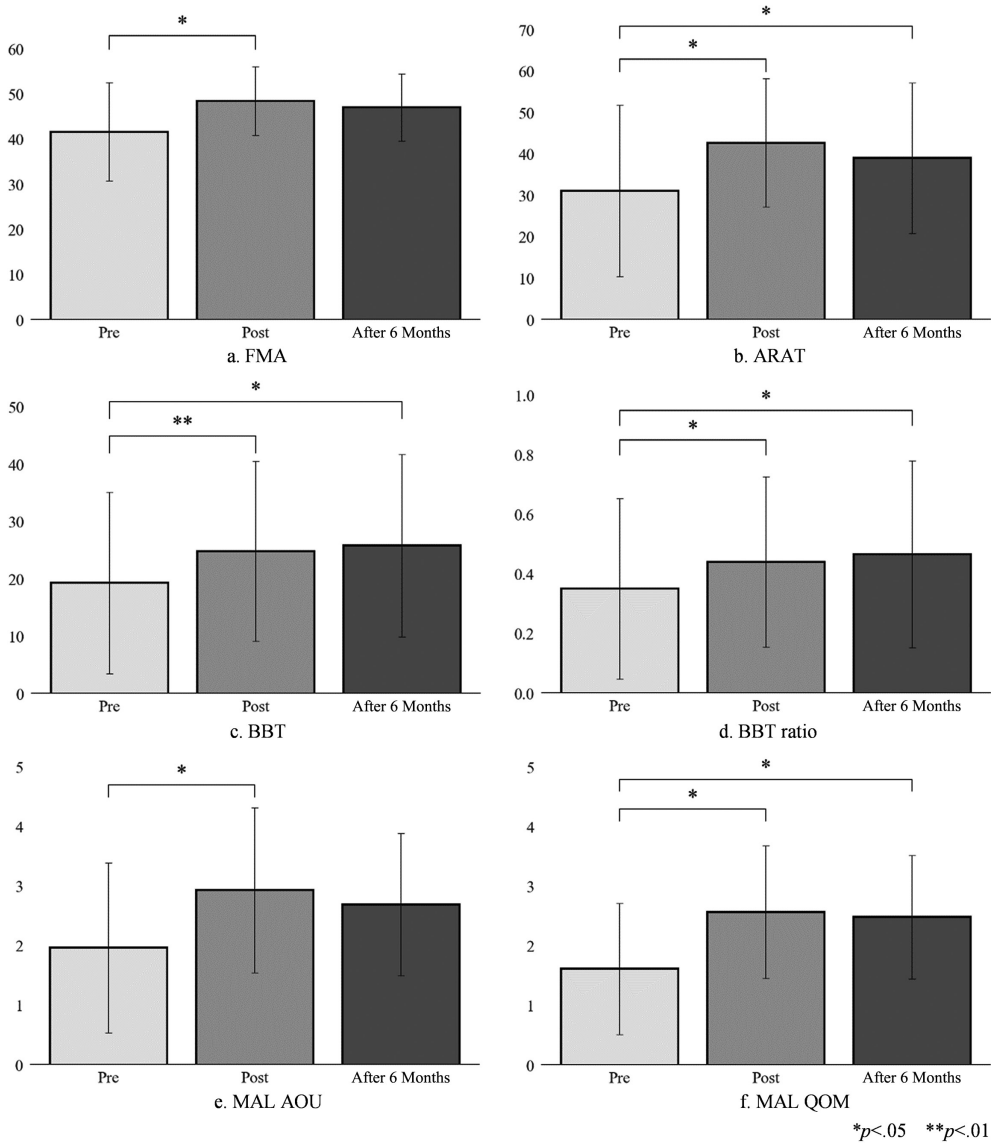

Fig. 2. Comparison of upper-extremity functional assessment pre-, post-intervention, and after 6 months.
There was a significant improvement in all upper-extremity function assessments pre- and post-intervention. On the other hand, there was no significant improvement between post-intervention and after 6 months.

experiences using the paralyzed hand in daily life.

Next, we discuss the long-term effects of this program. In this study, there was no significant difference between the post-intervention and after 6-month assessment data. This result suggests that this program showed a favorable long-term effect, not just a short-term effect. This program aimed to improve the utility of the paralyzed hand in daily life by implementing task-oriented training with a Transfer Package. Previous studies [16, 28] have reported that task-oriented training with a Transfer Package can result in the maintenance of short-term and good long-term effects. Schweighofer et al. [29] highlighted the necessity of using the paralyzed hand more than a certain frequency in daily life for the long-term recovery of the paralyzed hand after stroke. However, it was recently reported that task-oriented training alone does not result in significant differences in the degree of improvement of upper-extremity function compared with conventionally implemented training methods [30]. These findings suggest that the implementation of the Transfer Package in this program was the main reason for the positive long-term effects. In short, this program may be an effective intervention for the rehabilitation of the paralyzed hand after chronic stroke.

Regarding the effects of intervention for each case, cases A-D and J demonstrated clinically meaningful changes in FMA, BBT, ARAT, and MAL-AOU between pre- and post-intervention, except for BBT in case C

Table 3 Comparison of performance and satisfaction before and after program implementation.

a. Comparison of performance and satisfaction with representative achievement goals

ID	Representative goals	Performance scores		Satisfaction scores	
		Pre	Post	Pre	Post
A	laundry to fold	3	6	3	6
B	sharpen knives with a whetstone	3	5	2	5
C	wash dishes (pots and pans)	1	3	3	4
D	use a spoon and fork with my right hand	1	7	1	7
E	use rap well	1	7	NA	NA
F	open cartons of milk, juice, etc.	7	8	9	10
G	wash my left arm from elbow to shoulder with my right hand	3	6	3	5
H	hang sheets, futons, clothes, etc.	5	8	4	8
I	press and release the Shift key, Ctrl key on the computer	1	4	1	2
J	wash dishes	2	5	1	5

b. Comparison of performance and satisfaction with the average value of the achievement target

ID	Performance scores		Satisfaction scores	
	Pre	Post	Pre	Post
A	2.1	4.8	2.3	4.8
B	3.2	4.9	2.6	4.9
C	2.9	4.2	5.7	5.5
D	1.1	6.3	1.0	6.3
E	1.6	4.9	NA	NA
F	7.2	6.5	7.6	7.7
G	1.8	4.1	1.8	3.8
H	3.7	7.1	3.2	6.8
I	1.7	2.5	1.7	1.4
J	1.4	2.8	1.2	2.6
M	2.67	4.81	3.01	4.87
SD	1.80	1.51	2.22	2.02

M: Means, SD: Standard Deviation

and ARAT in Case J. Cases F and I exhibited particularly high pre-intervention FMAs of 57 and 59 points, respectively, and the ceiling effect did not result in significant changes in BBT or ARAT; however, MAL-AOU exhibited an improvement over 0.5 points of MCID. In contrast, cases E, G, and H did not demonstrate changes in MAL-AOU beyond MCID, although meaningful changes were observed in FMA and ARAT. We further examined the effects of the intervention on the performance scores of subjective aspects for each case. Six patients (Cases A, B, D, E, G, and H) exhibited improvements in the 10 achievement goals, and 9 patients (except Case F) exhibited improvements in the representative achievement goals of high importance, exceeding 1.7 MDC points. In other words, this program exerted certain effects on either the motor function and/or motor performance of the paralyzed hand or participation of the paralyzed hand in daily life, and the subjective evaluation of this program reflected the effects of the intervention.

Regarding the mechanisms underlying program effectiveness, the reported mechanisms of the efficacy of CIMT include the promotion of use-dependent plasticity (UDP) [4] and overcoming learned non-use [31]. According to the stage theory of central nervous reorganization by Swayne et al. [32], “training-induced synaptic strengthening” is considered a major mechanism of motor paralysis recovery in rehabilitation for patients with chronic stroke. Based on these findings, we believe that implementation of this program in adult day-care centers for patients with chronic stroke may be effective in promoting the aforementioned recovery mechanism, which is based on dose-response recovery.

5.2. Importance of program implementation in adult day-care centers

Patients with chronic stroke who attend adult day-care centers have a more realistic view of their surroundings, including household chores and hobbies. In addition, attendees of adult day-care centers are more

likely to promptly transfer the effects of rehabilitation to ADLs. Therefore, we believe that implementing this program for users with a high level of independence in ADLs and who wish to improve their paralyzed hands will be effective in maintaining and improving the motor function and performance of their paralyzed hands. Moreover, this program can address the needs of patients with chronic stroke who wish to use their paralyzed hands in daily life under long-term care insurance. The implementation of this program in adult day-care centers is expected to be developed in the future as a rehabilitation method for transitioning the paralyzed hand to daily living.

5.3. Limitations and future directions

This study adopted participant recruitment in single-center, pre/post/after 6 months comparative design with no control group. Therefore, it is unclear whether this program was more effective than conventional upper-extremity functional training. Furthermore, the amount of upper-extremity functional training may have affected the degree of improvement in this study. This is because the number of times each participant in the study used the adult day-care center was different, and, the amount of training during intervention periods and follow-up periods was not controlled. Furthermore, the number of participants in this study is small (n = 10), with one participant in his 50s, seven in their 60s, and two in their 70s, and the years after stroke onset are widely separated, with seven participants within 3 years, one within 5 years, and two over 10 years, so the relationship between participant age, the years after stroke onset and intervention effects has not been examined in this study. In addition, four participants have right paralysis, six have left paralysis, and seven participants have moderate upper-extremity paralysis, three have mild the paralyzed upper-extremity, so the impact of the paralytic side and severity of the paralyzed upper-extremity on intervention effects has not yet been examined.

In the future, to increase the evidence for this program, more studies with control groups after controlling the amount of training are required. It is also necessary to consider basic information about the participants that may affect the effectiveness of the intervention.

6. Summary and Conclusion

This study aimed to compare upper-extremity performance pre- and post-implementation and after 6 months of the CIMT-based voluntary upper-extremity functional training program in 10 patients with chronic stroke at our adult day-care center. The frequency of training was 3 hours per day, 1 day per week, for 6 months. The results showed significant improvement pre- and post-intervention in all assessments, confirming the positive long-term effect.

This study is novel in that it demonstrates the effects of low-frequency, long-term, voluntary upper-extremity functional training intervention in patients with chronic stroke who are less affected by spontaneous recovery. In addition, this study provides the foundation for a concrete methodology for upper-extremity functional training that can be implemented at adult day-care centers.

Conflict of interest

The authors have no conflicts of interest to disclose.

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Goal Setting Strategies and Goal-Directed Approach in Pediatric Occupational Therapy Practice: A Meta-Analysis

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Abstract: Introduction: Goal setting and goal-directed approaches are integral components of client-centered practice in pediatric occupational therapy, but the effectiveness of these approaches has yet to be systematically analyzed. This meta-analysis aimed to determine the effectiveness of goal setting and goal-directed approaches in pediatric occupational therapy practice.
Methods: We conducted a meta-analysis by searching multiple databases (PubMed, Scopus, Web of Science, ProQuest Central, CINAHL, and AMED) using the PRISMA checklist, the Cochrane Handbook for Systematic Reviews of Interventions, and the Revised Cochrane risk-of-bias tool for randomized trials template.
Results: Of the 14 studies identified, seven were included in the meta-analysis. The results indicated that a goal-directed approach had small to moderate clinical effects on the Canadian Occupational Performance Measure performance and satisfaction scores. The approach also had a moderate effect on parental self-efficacy, although there was no significant difference between groups in this outcome. However, no significant clinical effect of the goal-directed approach was seen in body structures and function.
Conclusion: The study's findings suggest that goal-directed approaches can improve parents' perception of their child's development and self-efficacy but may not significantly affect performance or body structures and function. Further research is necessary to develop evidence-based goal-setting approaches in pediatric occupational therapy practice.

Keywords: occupational therapy, pediatric, child, goal setting, goal-directed approach

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Introduction

Pediatric occupational therapy plays a crucial role in enhancing children's participation in activities of daily living (ADLs), which include such as feeding, eating, dressing, or toileting, as well as instrumental activities of daily living (IADLs), such as cooking, shopping, or using a telephone [1]. Occupational therapists also assist with educational, non-academic, extracurricular, as well as prevocational and vocational activities [2]. They address various functions such as upper extremity function, fine motor skills, visual-motor function, and skills for managing sensory processing issues, along with those required for specific occupations or tasks [1]. Several interventions such as Constraint-Induced Movement Therapy (CIMT); Cognitive Orientation to Daily Occupational Performance (CO-OP); Goal Activity and Motor Enrichment (GAME); Goal-Directed Training (GDT); and Task Training have shown promise in generating positive outcome in pediatric occupational therapy [3].

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Family-centred care, which emphasizes collaboration with families to support children's development, is considered the gold standard in pediatric occupational therapy [4]. Effective collaboration between the care team and the family, based on mutual understanding and respect, is essential for successful outcomes [5, 4]. Occupational therapists are advised to collaboratively develop goals and objectives, interventions, and progress monitoring plans with families [6].

Goal setting and a goal-directed approach are integral components of client-centred rehabilitation practice [7]. While various strategies and frameworks for goal setting have been proposed over the past decades [7], to our knowledge, their effectiveness in pediatric occupational therapy has not been systematically analyzed. Interestingly, a Cochrane systematic review and meta-analysis of goal-setting in adult rehabilitation found limited evidence of improved physical outcomes, but positive psychosocial outcomes such as quality of life, emotional state, and self-efficacy were observed [8]. Therefore, further investigation is needed to understand the effectiveness of goal setting and goal-directed approaches in pediatric occupational therapy. To address this gap, we conducted a meta-analysis of current goal-setting and goal-directed approaches in pediatric occupational therapy practice, aiming to inform future research needs.

Methods

Protocol and registration

The research protocol for this study was registered on PROSPERO (Registered ID: CRD42020206953) and the study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) checklist criteria [9].

Eligibility criteria

We applied the "Population Intervention Control Outcome and Study design (PICOS) criteria to assess study eligibility [10] as below:

P (Population): Pediatric occupational therapy practice

I (Intervention): Goal setting or Goal-directed approach

C (Comparison): No goal setting or no goal-directed approach (including usual care)

O (Outcome): Improve goal-related performance or participation.

Goal setting in this review followed the definition stated by [11, pp.235–250] as "a process in which an individual can determine and care about a desired endpoint or objective consciously" [11, pp.235–250]. *The goal-directed approach* in this paper followed the definition stated by [12] as "delivering intervention based on the identified individually tailored treatment goals after the goal-setting process". Goal-related performance refers to the effectiveness with which a child can perform tasks or activities associated with their goals. This may relate to their developmental needs, physical activities, and the challenges they face. Goal-related participation involves the child's engagement in tasks or activities tied to their goals. Although our primary focus in this study was to evaluate goal-related performance or participation, we also conducted a comprehensive analysis of other outcomes. This approach was undertaken to determine whether goal setting or a goal-directed approach had an impact on any additional outcomes.

Eligible studies were randomized controlled trials (RCTs), cluster-RCTs, or quasi-RCTs that investigated the goal setting or goal-directed approach delivered in pediatric occupational therapy practice. We excluded studies that did not clearly state that they had examined the effectiveness of goal-setting or goal-directed approaches compared to the control group. We also excluded studies that investigated goal setting for non-rehabilitation purposes targeting the general population. Moreover, we excluded studies if the studies did not clearly explain the goal-setting process, even if the study indicated that they provided goal-directed approaches. Additionally, if the approach was not clearly stated as goal-directed, we discussed whether the approach was originally designed to provide a goal-directed approach.

Search strategy

The initial search used three keywords: "child," "goal," and "occupational therapy." Synonyms of the keywords were also included in the search (refer to search strategies in Appendix A). The wildcard symbol (*) included variations of each keyword in the findings. Two authors (Y.O and K.T) searched the six digital databases: PubMed, Scopus, Web of Science, ProQuest Central, and CINAHL and AMED through EBSCO. To find the protocol of each RCT, we searched the selected articles in clinical trial registries, including ClinicalTrials.gov and ISRCTN registry, and conducted a hand search. The search strategy was developed by the first author (Y.O) in consultation with the last author (K.T), who has experience publishing several systematic review papers.

Screening process and data extraction

Title and abstract screening were completed by at least two authors, and full texts were screened when the authors could not decide about inclusion based on the title and abstract. The eligibility criteria for study selection were: (1) participants under the chronological

age of 18 who are given occupational therapy service(s) in any pediatric setting; (2) RCT study described a goal setting or goal-directed approach; (3) studies in English language.

The risks of bias assessments were conducted following the Cochrane Handbook for Systematic Reviews of Interventions [13]. Each author completed a critical appraisal for each RCT included in this study. Two reviewers completed this critical appraisal to assess the risk of bias. We have used the Revised Cochrane risk-of-bias tool for randomized trials (RoB 2) to evaluate the risk of bias. Any discrepancies regarding the risk of bias were discussed and resolved with all co-authors in this study.

An excel spreadsheet was used to collect and organize data from each study, including paper information, study setting characteristics, goal setting and goal-directed approach characteristics, and intervention characteristics. We also collected data on participant dynamics, intervention type and category, quality of intervention with each type, frequency and duration of intervention, outcome of intervention, presence of goal and types of goal/goal-directed approach, and used goal-setting tool. For continuous variables, we extracted sample sizes, means, and standard deviations (SD) from each intervention and control group. We reported the mean difference (MD) for each outcome in each study within a 95% confidence interval (CI). For dichotomous variables, we extracted the number of participants with that outcome and the total number of participants allocated in the intervention and control groups. We then calculated the risk ratio (RR) for each dichotomous variable in each study within 95% CIs. If there were more than two groups in the RCTs, we combined the outcomes of the groups to create a single pair-wise comparison. Meta-analysis was conducted using Review Manager 5.4 (RevMan).

Data synthesis and statical analysis

The identified RCTs were classified into three comparison groups based on the type of comparison being investigated. Comparison group A compared the outcome between participants who received goal setting versus those who did not receive it. Comparison group B compared the outcome between the intervention group receiving a goal-directed approach and the control group receiving a generic approach not specifically designed to help goal achievement after completing goal setting. Comparison group C compared the outcome between two groups that received goal-setting and delivered goal-directed approaches, which was not included in the meta-analysis as it did not compare the presence of goal setting or goal-directed approach versus its absence.

Meta-analysis was performed to determine the overall effect size. Standard Mean Differences (SMD) of the comparing factors were also calculated. The interpretation of SMD was based on the effect size magnitudes defined by Cohen [14]: small effect when the SMD was 0.2, medium effect when the SMD was 0.5, and large effect when the SMD was 0.8. Confidence intervals and p-values for each outcome were calculated to show the statistical power. Statistical heterogeneity was measured to show the variation in study outcomes. Substantial heterogeneity was present if I^2 was more than 50% [15].

Results

Characteristics of studies included

After screening 337 articles, 14 RCTs met the eligibility criteria and were included in this study (Fig. 1). Seven RCTs compared the outcome between the intervention group receiving a goal-directed approach and the control group receiving non-goal directed approach or usual care, categorized as group B (Table 1). The remaining seven RCTs compared the effectiveness of new goal-directed approaches and goal-directed usual care, categorized as group C (Table 2). No RCTs were identified that compared the outcome between participants who received and did not receive goal setting, falling under group A.

The risk of bias assessment showed that two studies [16, 17] had low risk in all domains, while one study [18] had high risk in all domains (Fig. 2). The overall risk of bias indicated that nearly 75% of the included articles had some concerns or high risk in selecting reported results (Fig. 3).

Over half of the identified articles involved goal setting identified by parents [16, 20, 21, 27, 28, 29, 31, 32], whereas four studies reported that goal setting involved both parents and children [17, 18, 19, 26]. Two studies described that they implemented goal setting, but did not provide further information [30, 33]. Regarding the outcome, all the identified studies, except for one [18], provided GAS t-scores instead of ordinal scores. A previous report suggests that clinically meaningful change scores from GAS are derived from the non-linear nature of ordinal scores, implying that GAS t-scores are not valid and that raw ordinal data should be used for analysis [34]. Additionally, another critical review of the literature emphasized the importance of using GAS as an ordinal scale rather than relying on GAS t-scores [35]. Considering this evidence and the limited number of studies using GAS raw scores as their outcome measure, we decided not to include GAS in our meta-analysis.

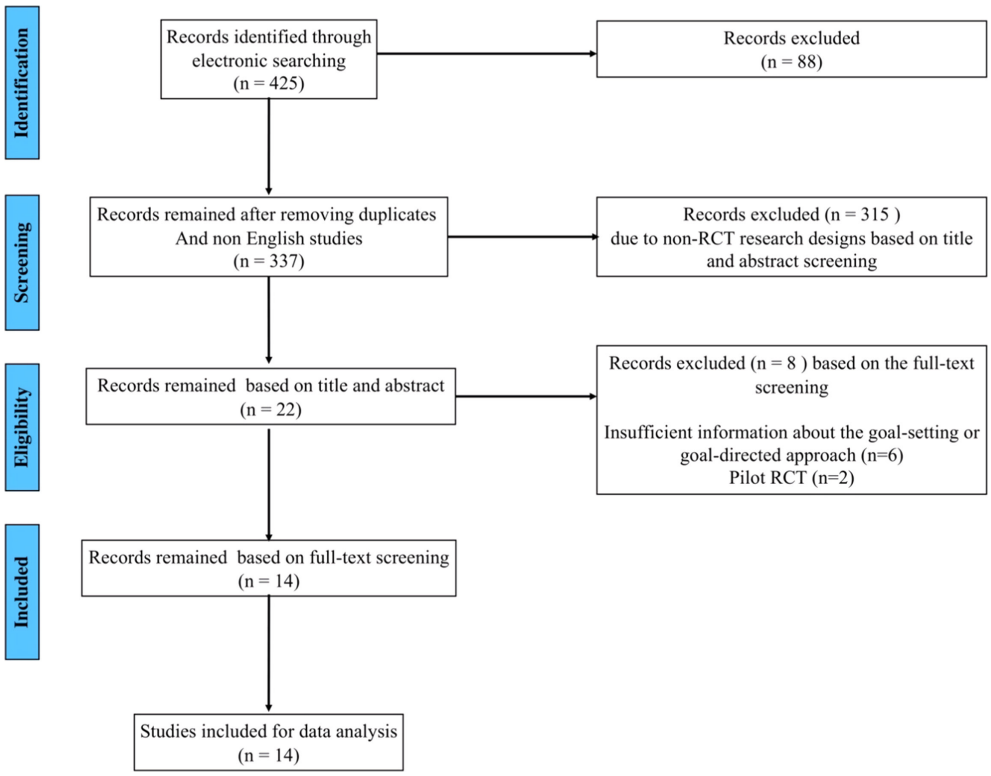


Fig. 1. PRISMA flow diagram

Effects of goal-directed approach

A total of seven studies contributed data to comparison group B, which compared the outcome between the intervention group receiving a goal-directed approach and the control group receiving a non-goal-directed approach or usual care upon completion of goal setting. The outcome measures included Canadian Occupational Performance Measure (COPM) performance, COPM satisfaction, parental satisfaction, and body structures and function measured with various assessments including Box and Block Test (BBT), Elbow flexors, Quality of Upper Extremity Skills Test (QUEST), and Assisting Hand Assessment (AHA). Overall, the goal-directed approach provided a small to moderate clinical effect on COPM performance (n = 152, SMD = 0.26; 95% CI: −0.32 to 0.85;) (Fig. 4a) and COPM satisfaction (n = 151, SMD = 0.40; 95% CI: −0.08 to 0.87) (Fig. 4b) and moderate to large effect on parental self-efficacy (n = 61, SMD = 0.73; 95% CI: 0.21 to 1.26) (Fig. 4c). A significant difference between the intervention and control group was not seen in the COPM performance and COPM satisfaction scores (p = 0.38 and p = 0.10 respectively). Furthermore, no significant clinical effect of the goal-directed approach was found in body structures and function (n = 119, SMD = −0.01; 95% CI: −0.37 to 0.35) with no significant difference between intervention and control group (p = 0.96) (Fig. 4d).

Heterogeneity synthesized result and the sub-analysis

The synthesis of results showed substantial heterogeneity in the COPM performance (I^2 = 68%) and COPM satisfaction (I^2 = 52%). The effect size was small to medium for COPM performance (0.20 to 0.70) and medium to large for COPM satisfaction (0.24 to 0.48) [19, 20]. The sub-analysis revealed that only one study from [16] showed a significant large difference in both COPM performance and satisfaction scores in the two-group comparison. No heterogeneity (I^2 = 0%) was found in the analysis of parental self-efficacy and body structures and function. Both identified studies in parental self-efficacy showed a nearly large positive effect size in the sub-analysis. Regarding body function, [21] showed a small negative effect size, whereas [17] showed a small positive effect size in the sub-analysis.

Discussion

This meta-analysis investigated the effectiveness of goal-directed approaches in pediatric occupational therapy practice. The results showed that although the goal-directed approach did not significantly improve COPM performance and satisfaction scores compared to non-goal-directed approaches, it had a significant positive effect on parental self-efficacy. This suggests that setting goals and providing opportunities for children

Table 1 Characteristics of RCTs in Comparison category B

Reference number	Author, year	Participants	Intervention groups (A)	Intervention groups (B)	Intervention groups (C)	Control group (s)	Outcomes
16	Ahmadi Kahjoogh et al., 2018	30 mothers aged between 25 and 50 year who has children with CP aged 5–11 years	Mothers received the weekly OPC sessions (n = 15)			Mothers (n = 15) received usual care consisting of neuro-developmental treatment sessions	COPM, The Sherer General Self-efficacy Scale measures self-efficacy on a five-point rating scale
17	Novak et al., 2009	36 children with CP aged 4 to 12 years of age	Children (n = 12) given eight-week OT home program intervention	Children (n = 12) given four-week OT home program intervention		Children (n = 12) no home program	COPM, QUEST, and CAPE
18	Azari et al., 2019	The participants were parents of children ages 3–10 (at point of recruitment) with ASD who presented at least one sensory pattern outside the typical range based on the SSP II	19 families who have children with ASD were given CI-ASD. The coach provided two training group sessions and 10 individual coaching sessions (over 11 weeks) for each mother to recognize strategies for improving their child's participation to achieve function			No treatment	The Demographic Questionnaire, SSP II, and GARS2, COPM, GAS, Parenting Sense of Efficacy Measures
19	Jackman et al., 2018	45 Children at the age of 4 to 15 years with CP or brain injury	Intervention group (A) (n = 15) received CO-OP only. All participants were encouraged to complete one hour of the daily home practice of goals, recorded in a logbook	Intervention group (B) (n = 15) received CO-OP + a functional hand splint. All participants were encouraged to complete one hour of the daily home practice of goals, recorded in a logbook.		The control group (n = 15) received functional hand splint only. All participants were encouraged to complete one hour of the daily home practice of goals, recorded in a logbook	(primary outcome) COPM and GAS (secondary outcome) BBT and wrist ROM
20	Wallen et al., 2007	80 children with a spastic quadriplegic, triplegic, or hemiplegic CP	Single set of BTX-A and 12 weeks of OT (n = 20)	BTX-A injections only (n = 20)	12 weeks of OT only (n = 17)	no intervention (n = 13)	(Primary outcome measures) COPM and GAS (secondary outcome measures) Melbourne Assessment or QUEST; PEDI; CHQ; Tardieu Scale/ROM; Parent questionnaire
21	Hoare et al., 2012	Children (n = 35) at the age of 18 months to 6 years with congenital spastic unilateral CP	BoNT-A + mCIMT (n = 17)			BoNT-A + conventional BOT (n = 17)	(Primary outcome) AHA (Secondary outcome) QUEST; PEDI; COPM; GAS
27	Schaaf et al., 2013	32 children with ASD, ages 4–8 years old, with sensory difficulties and their families	Children in the treatment group (n = 17) received 30 sessions of a manualized OT/ sensory integration intervention that followed sensory integration principles			The control group (n = 15) received "usual care", which included non-study related services such as speech and language services, behavioral interventions, educational programs and other therapies	GAS, PDDBI, PEDI, and VABS II

ASD: Autism Spectrum Disorder; CI-ASD: Contextual Intervention Adapted for ASD; SSP II: Short Sensory Profile II; GARS2: Gilliam Autism Rating Scale-II; COPM: Canadian Occupational Performance Measure; GAS: Goal Attainment Scaling; OT: occupational therapy; PDDBI: Pervasive Developmental Disorder Behavior Inventory; PEDI: Pediatric Evaluation of Disability Inventory; VABS II: Vineland adaptive Behaviour Scales II; CP: Cerebral Palsy; CO-OP: Cognitive Orientation to daily Occupational Performance; BTX-A: Botulinum Toxin Type-A; BBT: Box and Block Test; ROM: Range Of Motion; QUEST: Quality of Upper Extremity Skills Test; CHQ: Child Health Questionnaire; mCIMT: Modified Constraint Induced Movement Therapy; BOT: Bimanual Occupational therapy Training; AHA: Assisting Hand Assessment; CAPE: Children's Assessment of Participation and Enjoyment; and OPC: Occupational Performance Coaching.

Note: This table provides a comparison between the intervention group, which receives a goal-directed approach, and the control group, which is subjected to a non-goal-directed approach or standard usual care.

Table 2 Characteristics of RCTs in Comparison category C

Reference number	Author, year	Participants	Intervention groups (s)	Control group (s)	Outcomes
26	Vroland-Nordstrand et al., 2015	The children (n = 32) between 5 and 12 years were recruited from eight pediatric rehabilitation centres by 18 occupational therapists	Children were given intervention based on goals set by themselves (n = 17)	Children were given intervention based on goals set by their parents (n = 15)	(Primary outcome measure) GAS (the secondary outcome measure) COPM-P; The Caregiver Assistance Scale of PEDI
28	Lidman et al., 2015	20 children aged 18 months to 10 years with unilateral spastic CP	The children group (n = 10) was given BoNT-A injection two weeks before the eight-week OT intervention and another BoNT-A injection after six months and conducted an eight-week OT intervention again. Two blocks of therapy. After the first 8-week blocks of intervention, families were instructed to resume their usual therapy but refrain from other interventions for the upper limb	Children (n = 10) were given two blocks of OT intervention twice but not BoNT-A injections	(Primary outcome measures) AHA (Secondary outcome measurements) Active and passive ROM in elbow extension and supination of the forearm was measured in sitting position
29	de Brito Brandao et al., 2012	16 children with hemiplegia received CIMT and HABIT	CIMT or HABIT	No treatment	PEDI and COPM
30	Sakzewski et al., 2012	Children (n = 64) with unilateral CP at the age of 5 to 16 years who could follow instructions had a Modified Ashworth Scale score of not more than three for the distal upper limb and were recruited.	The interventions used either a CIMT (n = 32) or BIM approach (n = 32)	No treatment	(Primary outcome) CPQOL-Child, Two versions were used: the CPQOL-Child self-report for nine-year-old and above children and the proxy version (secondary outcome) KIDSCREEN-52 self-report, KIDSCREEN-52 parent proxy report
31	Wallen et al., 2011	50 children aged between 18 months and eight years with spastic hemiplegic CP were recruited between 18 months and eight years.	Intensive 8-week block of therapy, including attending weekly occupational therapy sessions with their usual or local therapists and completing a home programme. mCIMT (n = 25) The protocol required that the mitt be worn for 2 hours per day (in sessions of minimum 30 min), seven days per week for eight weeks.)	Intensive OT (n = 25) 8 weeks of OT to achieve parents' goals, and included techniques aimed at minimizing impairment (e.g. stretching, casting, splinting) and enhancing activities (e.g. motor training, environmental modification, and practice of specific goal activities).	(Primary outcome) COPM (secondary) GAS, AHA, Revised Pediatric MAL or MTS
32	Olesch et al., 2010	24 children with CP who is aged between one year, six months, and five years	Children (n = 12) allocated to the BoNT-A + OT group received three series of injections of BoNT-A in 16-week cycles in addition to twice-weekly. All children received a twice-weekly OT programme for six weeks after BoNT-A injection or at a comparable time for the control group. The study therapist provided the first two weeks of intense therapy for both groups. After this, therapy was provided at the same intensity by the child's community therapist or, if the community therapist was unavailable, by the study therapist for the remaining four weeks	OT alone: Same intervention but not given BoNT-A injection (n = 12)	(Primary Outcome) COPM and GAS (Secondary outcome) MTS, spasticity, QUEST and PDMS-FM
33	Russo et al., 2007	43 Children with hemiplegic CP, aged 3 to 16 years	21 children given BoNT-A into the affected upper limb and weekly occupational therapy: Weekly 1-hour standardized occupational therapy sessions under the supervision of a pediatric occupational therapist were performed over four weeks	Children participated in OT sessions without being given BoNT-A (n = 22)	(Primary outcome) AMPS and GAS (Secondary outcome) The Self-Perception Profile for Children and the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children, Self-Care Domain of PEDI and PedsQL 4.0. The pain was reported at baseline and the 3- and 6-month follow-up using a visual analogue scale.

CP: Cerebral Palsy; BoNT-A: Botulinum Toxin Type-A; OT: Occupational Therapy; AHA: Assisting Hand Assessment; ROM: Range of Motion; GAS: Goal Attainment Scaling; COPM-P: Canadian Occupational Performance Measure - Performance scale; PEDI: Pediatric Evaluation of Disability Inventory; CIMT: Constraint-Induced Movement Therapy; HABIT: Hand-Arm Bimanual Intensive Therapy; BIM: Bimanual Intensive training; CPQOL: Cerebral Palsy Quality of Life; mCIMT: Modified constraint-induced therapy; OT: Occupational Therapy; MAL: Motor Activity Log; MTS: Modified Tardieu Scale; QUEST: Quality of Upper Extremity Skills Test; PDMS-FM:Peabody Developmental Motor Scales – Fine Motor; AMPS: Assessment of Motor and Process skills; PedsQL 4.0: the Pediatric Quality of Life Inventory.

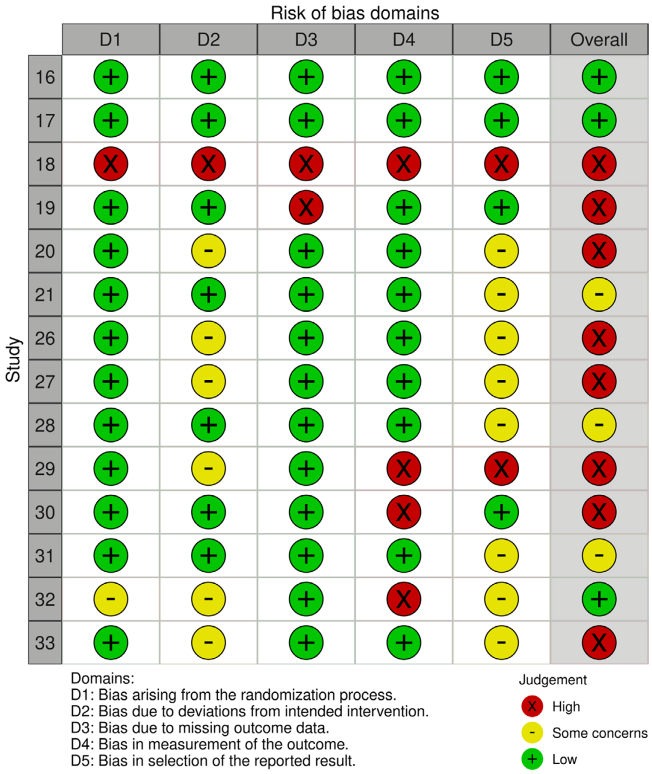


Fig. 2. Visualizing Bias Risk Across Five Domains and Overall for Each Study.
Note. This provides an overview of the bias risk associated with each study.

to work towards them can effectively enhance parents' perceptions of their children's development. However, given the limited number of studies supporting this result, careful interpretation is needed. Further research is essential to confirm the reliability of this finding and its clinical implications. While there is an increased perception among parents regarding their children's development, it remains uncertain whether children's goal-directed performance and satisfaction, as well as body function, truly improve as a result of receiving goal-directed approaches. Additionally, it is still unclear whether the current goal-directed approaches are the most effective method for facilitating children's development. Pediatric practice recognizes the importance of parents' engagement for children's development, and the study highlights the importance of family-centered care for child development. The Phoenix Theory of Attendance, Participation, and Engagement introduced six critical components that explain a child's journey to development, including the parent's feelings, skills, knowledge, logistics, values and beliefs, and relationship with the therapist [22]. This emphasizes the importance of parents' contribution to children's rehabilitation outcomes. To successfully facilitate family-centered care with parents' involvement, therapists need to work collaboratively with parents, foster a sense of working in partnership, and discuss the therapy plan, possible outcomes, and parent's expected involvement [23, 24]. This indicates the importance of parents and therapists to share their mutual understanding of children's development. Having said that, setting goals with mutual agreement is key to facilitating this process [24]. Despite the importance of family-centered care, further investigation is required to see how it can be more effectively delivered by providing quality goal setting and goal-directed approaches. There is still confusion among clinicians about the definition of parental training, which highlights the need for clarity in this area [25].

Our meta-analysis found no significant clinical effect of a goal-directed approach on body structures and function. This may be attributed to the nature of the goals set and the type of goal-directed approach utilized in the studies included in our analysis. Specifically, over half of the studies focused on activity and participation-related goals (n = 4) and employed interventions that targeted performance-specific skills related to these goals (activity n = 1; task n = 3; action n = 1). Meanwhile, two studies focused on goals related to body structures and function, and three studies utilized interventions that targeted voluntary movement or mental processes. These findings suggest that pediatric occupational therapy practice may benefit from prioritizing activity and participation-based goal setting and intervention, with a focus on children's participation

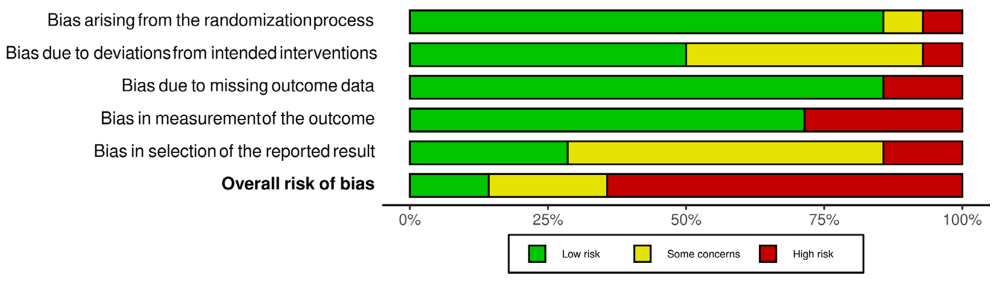
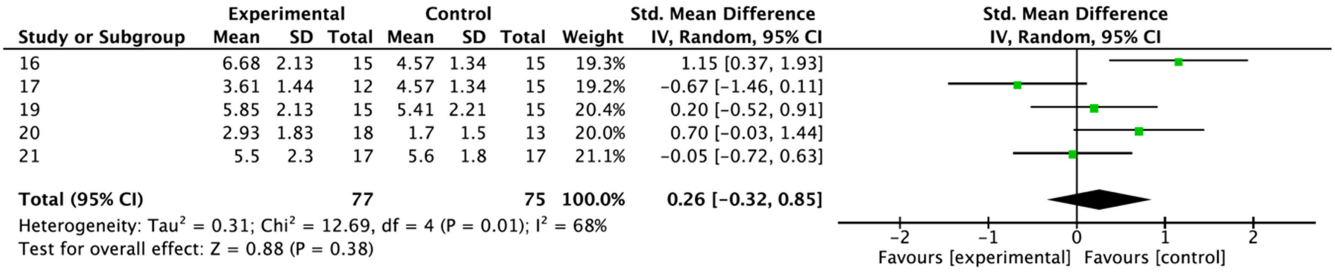
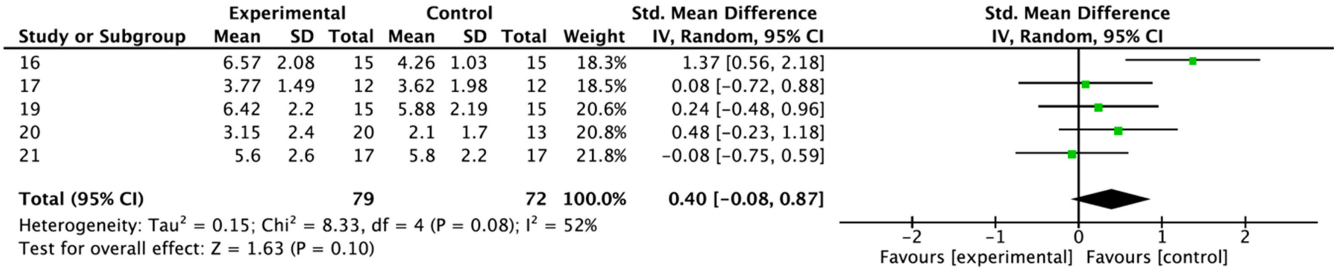


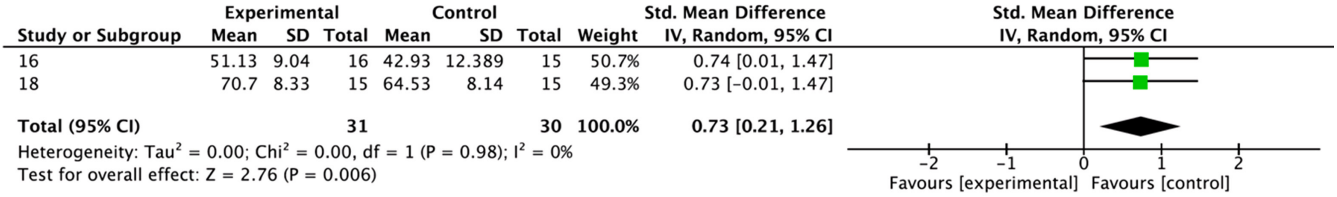
Fig. 3. Overall Bias Risk Assessment.
Note. This presents a graphical depiction of the collective overall risk of bias across the identified articles.



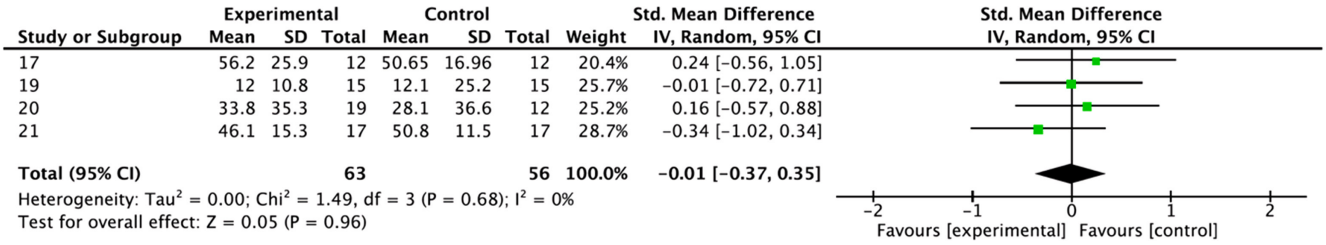
(a) Canadian Occupational Performance Measure performance



(b) Canadian Occupational Performance Measure satisfaction



(c) Parental Satisfaction



(d) Body Structures and Function

Fig. 4. Forest Plots for the Pooled Data in each outcome.
Note. This showcases a series of forest plots, each dedicated to a specific outcome under consideration.

outcomes and parents' perceptions of goal attainment, rather than exclusively concentrating on improvements in body structures and function when implementing a goal-directed approach.

This meta-analysis aimed to investigate the effectiveness of goal-directed approaches and goal setting in pediatric occupational therapy practice, compared to non-goal directed approaches or usual care with no goal setting. However, no randomized controlled trials were found comparing the effectiveness of goal setting in two groups, leaving a question of how to deliver goal setting effectively in pediatric occupational therapy practice. One of the identified RCTs investigated the efficacy of two goal-setting approaches (child self-identified goals and parent-identified goals) in a goal-directed, task-oriented intervention program. This study concluded that children can reliably identify goals to the same extent as their caregiver for receiving a goal-directed intervention program [26]. However, there is limited research that clearly explains the child's involvement in goal setting with their caregiver and these factors in detail. This indicates the need for further research to maximize goal achievement and attainment in pediatric occupational therapy through effective goal setting and a goal-directed approach.

Several limitations are found in this study's findings.

First, the search was limited to occupational therapy studies, which may have excluded relevant studies from other fields. Additionally, some studies that included goal setting may have been missed if they did not mention it in the title or abstract. It is important to expand the search to other fields and investigate goal setting in pediatric rehabilitation more comprehensively. Second, this meta-analysis did not differentiate between top-down and bottom-up approaches, which may have affected the findings. Further investigation is required to determine if there are any differences in the effectiveness of these approaches. Furthermore, many of the identified studies had a high risk of bias, and the overall sample sizes were small. This may have reduced the rigor and reliability of this meta-analysis's findings. Additionally, there was substantial heterogeneity in three out of the five outcomes analyzed, and some analyses included only two studies, which is a relatively low number for a typical meta-analysis. Moreover, one study [21] included in the meta-analysis used the COPM as a secondary outcome measure, which may have affected the power of the study compared to others. Finally, the meta-analysis did not include any studies in the comparison group that did not involve goal setting or a goal-directed approach, which may have limited the inclusion of RCTs in the analysis. Therefore, the reliability and quality of the findings in this meta-analysis remain uncertain, and the evidence's quality should be considered low to very low due to these limitations.

Conclusion

This review analyzed 14 randomized controlled trials, with seven studies examining the effects of a goal-directed approach on health outcomes for pediatric clients compared to non-goal-directed approaches or usual care. The identified studies utilized different clinical contexts and measured various outcomes. The studies provided some evidence that goal-directed approaches can help parents perceive improved satisfaction and performance toward their child's development and increase parents' self-efficacy. However, the findings should be interpreted with caution, considering the overall risk of bias in the identified studies, heterogeneity in some outcome data, and limited number of studies included in the analysis. Further research is required to better understand goal setting in pediatric occupational therapy and guide evidence-based goal setting for each pediatric population.

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Key findings

- A goal-directed approach can improve parental perception, but it may not have a significant impact on goal achievement or children's performance.
- A goal-directed approach may not lead to significant improvement in body structures and function.

What the study has added

This study has provided insights into the effectiveness of goal-directed approaches in improving parental perception but emphasizes the need for further research on goal setting and goal-directed approaches.

Conflict of interest

The authors have no conflict of interest to declare.

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Appendix A

Search strategies

Search terms

Concept	Searched terms
Child	(child*[tw] OR kid*[tw] OR pead*[tw] OR ped*[tw] OR youth*[tw] OR adolesc*[tw] OR baby*[tw] OR infant*[tw] OR student*[tw] OR preschool*[tw] OR teenager*[tw])
Goal	goal*[tw]
Occupational therapy	“Occupational therap*”[tw]

Pubmed

Search Terms	Search limits	Number of identified articles
(child*[tw] OR kid[tw] OR pead*[tw] OR ped[tw] OR youth*[tw] OR adolesc*[tw] OR baby*[tw] OR infant*[tw] OR student*[tw] OR preschool*[tw] OR teenager*[tw]) AND goal*[tw] AND “Occupational therap*”[tw]	Full text Abstract English RCT only	31

Scopus

(TITLE-ABS-KEY
((child* OR kid OR pead* OR ped OR youth* OR adolesc* OR baby* OR infant* OR student* OR preschool* OR teenager*) AND goal* AND “Occupational therap*”)) AND ((clinic* W/1 trial*) OR (randomi* W/1 control*) OR (randomi* W/2 trial*) OR (random* W/1 assign*) OR (random* W/1 allocat*) OR (control* W/1 clinic*) OR (control* W/1 trial) OR placebo* OR (quantitat* W/1 stud*) OR (control* W/1 stud*)) AND
(LIMIT-TO (LANGUAGE , “English”))

Number of identified articles: 291 documents

ProQuest Central

ab((child* OR kid OR pead* OR ped OR youth* OR adolesc* OR baby* OR infant* OR student* OR preschool* OR teenager*) AND goal* AND “Occupational therap*”) AND ((clinic* W/1 trial*) OR (randomi* W/1 control*) OR (randomi* W/2 trial*) OR (random* W/1 assign*) OR (random* W/1 allocat*) OR (control* W/1 clinic*) OR (control* W/1 trial) OR placebo* OR (quantitat* W/1 stud*) OR (control* W/1 stud*)

Search Language: English
Number of identified articles: 12 documents

Web of Science

#1: child* OR kid OR pead* OR ped OR youth* OR adolesc* OR baby* OR infant* OR student* OR preschool* OR teenager*
#2: goal*
#3: “Occupational therap*”
#4: (clinic* W/1 trial*) OR (randomi* W/1 control*) OR (randomi* W/2 trial*) OR (random* W/1 assign*) OR (random* W/1 allocat*) OR (control* W/1 clinic*) OR (control* W/1 trial) OR placebo* OR (quantitat* W/1 stud*) OR (control* W/1 stud*)

#4 AND #3 AND #2 AND #1: 4 documents

CINAHL AND AMED

(child* OR kid OR pead* OR ped OR youth* OR Adolesc* OR baby* OR infant* OR student* OR preschool* OR teenager*)
AND goal* AND “Occupational therap*” AND (random*) OR (clinic*) OR (control*) OR (trial*) OR (placebo*) OR (quantitat*)

Number of identified articles: 88 documents

■ORIGINAL ARTICLE

Analysis of Published Case Reports in the Case Report Registration System Using a Topic Model

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Abstract: Objective: This study aimed to determine the purpose of occupational therapy for patients with cerebrovascular disorders in Japan and analyze case studies registered with the "Japan Association of Occupational Therapists' Case Report Registration System."
Methods: The analyzed cases were selected from the database, and case studies on cerebrovascular disorders registered between 2017 and 2021 were extracted. A topic model was used to analyze the text from the "purpose of report" section of these publicly available case studies. The recovery status was set as an external variable, and topic characteristics for each recovery status were examined.
Results: A total of 352 case studies (80, 201, and 71 in the acute, recovery, and maintenance phases, respectively) were included. In the acute phase, motor function-related topics were the most prominent, followed by those related to daily living. In the recovery phase, topics related to interventions for improving the activities of daily living, including those addressing higher brain dysfunction and using the Modified Total Dose of Laughter Protocol, were extracted. During the maintenance phase, topics related to interventions aimed at improving activity participation levels, including returning to work, were extracted. Distinctive topics related to driving, returning to work, and improving upper limb function were identified with no significant deviation.
Conclusion: This study elucidated the objectives of occupational therapy interventions for cerebrovascular diseases and highlighted key topics across different recovery phases. Further analyses of a broader range of diseases may uncover additional aspects of occupational therapy practices in Japan.

Keywords: topic model, stroke, occupational therapy

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1. Introduction

The Japanese Occupational Therapy Association launched a case report registration system on September 1, 2005 [1]. In this system, occupational therapists register case reports summarizing occupational therapy interventions for individual clients. Reports that pass the review process are made publicly available to the members of the Japanese Occupational Therapy Association. This system aims 1) to enhance the quality of occupational therapy practice among members through the creation of case reports, 2) to generate evidence-based documentation of occupational therapy outcomes through the analysis of case reports, and 3) to showcase the achievements of occupational therapy practice both internally and externally. The registered case reports include a wide range of occupational therapy practices and outcomes. Considering that occupational therapy is aimed at assisting each client to achieve a personalized and unique life, the diversity in the methods and results is a defining feature. Therefore, the accumulated reports from both quantitative and qualitative perspectives should be analyzed to effectively demonstrate the out-

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comes of occupational therapy.

By the end of October 2023, the largest number of case reports on physical disabilities had been registered in the case report registration system. Furthermore, the recovery status at the time of the intervention in this area included approximately 650 cases in the acute phase, 854 in the recovery phase, and 404 in the maintenance phase. The most frequently reported disorder in the physical disability category was cerebrovascular disease (966 cases, excluding head injuries). This indicates that analyzing the characteristics of occupational therapy for individuals with cerebrovascular disorders can highlight the distinctive features of occupational therapy in Japan. As of 2021, the Japanese Occupational Therapy Association had 62,142 registered occupational therapists, many of whom work in medical facilities targeting conditions that cause physical disabilities, particularly cerebrovascular disorders [2]. However, the data in this system are presented in structured texts, including titles, report purposes, case introductions, and occupational therapy evaluations, making quantitative analysis challenging.

Text mining, a methodology focused on analyzing text data, has undergone significant developments in recent years [3]. Although some medical-related studies have used text mining to analyze trends in case studies and research papers [4–6], no research has quantitatively analyzed the accumulated case study reports in occupational therapy. This gap may be attributed to the difficulty of simultaneously analyzing text data structured within multiple frameworks related to occupational therapy interventions, making it challenging to visualize the inherent characteristics of the text. In this system, the text data are structured based on the occupational therapy process, with one of the most explicit elements being the "purpose of the report." This section functions similarly to an abstract in an article, succinctly summarizing the report and highlighting the content that the author wishes to emphasize. Therefore, by analyzing the text data of the "purpose of the report" section based on the process of occupational therapy for cerebrovascular disorders, which are the most frequently registered case in this system, the trends and characteristics of occupational therapy for individuals with cerebrovascular disorders in Japan may be clarified.

This study aimed to analyze reports on cerebrovascular disorders, the most frequently registered cases in the field of physical disability, by extracting the "purpose of the report" from accumulated case reports across the acute, recovery, and maintenance phases. Through text mining analysis, the study sought to quantitatively clarify the characteristics of occupational therapy in each phase, thereby providing insights into the distinctive features of occupational therapy for cerebrovascular disorders in Japan.

2. Materials and Methods

Case reports were selected from the database of the Case Report Registration System on the Japanese Occupational Therapy Association website. These reports are registered and publicly available to members of the Japanese Occupational Therapy Association. The search criteria were as follows: specialty area, physical disabilities; recovery states: acute phase, recovery phase, and maintenance phase; disease code: 0201; cerebrovascular disorders; and registration years:2017–2021. The analysis method involved extracting the text from the "reporting objectives" section of the registered and publicly available case reports. Subsequently, a cleansing process was performed to standardize synonyms, abbreviations, and varied expressions. A topic-modeling approach was employed, utilizing the types and frequencies of words within the text to uncover the underlying meaning of the entire text. Recovery states (acute, recovery, and maintenance phases) were set as external variables, and the features of the topics within each recovery state were examined. The framework for the recovery states was based on Japan's institutional background. For patients with stroke, the acute phase spans approximately two weeks from onset, the recovery phase extends from the acute phase to 3–6 months, and the maintenance phase generally refers to the period beyond the recovery phase. Statistical analyses were conducted using the text-mining software KH Coder [2, 3]. As an ethical consideration, only case reports for which consent forms were obtained from the participants or their families were registered in the Case Report Registration System and made publicly available to the members of the Japanese Occupational Therapy Association.

2.1 Topic model

A topic model is a method for analyzing themes within text data and extracting the most conceptually abstract elements. Latent Dirichlet allocation (LDA) is one of the most commonly used techniques in topic modeling; it is a Bayesian model that estimates hidden latent topics in various discrete data, such as text data [9]. LDA is a probabilistic model used for clustering, assuming that each word in a document follows a probability distribution associated with a topic. Moreover, it analyzes the latent meaning of an entire document based on the types and frequencies of words within the document.

The characteristics of topic modeling are as follows. In traditional cluster analysis (k-means), a word belongs to only one cluster. By contrast, topic modeling allows

words to be classified into multiple clusters. For example, the word "run" could refer to both physical activity and business management. In traditional clustering, "run" would be assigned to only one cluster, potentially introducing ambiguity in cluster interpretation. In topic modeling, the word "run" can be assigned to separate clusters representing physical activity and business management based on context. This method provides a more accurate interpretation of the clusters.

For topic modeling, the desired number of topics should be preset. The two widely used evaluation metrics for determining the optimal number of topics are perplexity [10], which measures the model's generalization performance, and coherence [11–13], which assesses the interpretability of each topic to evaluate topic quality. In this study, the KH Coder utilizes the "ldatuning" package in the free statistical software R to calculate perplexity and coherence. The results were presented graphically, allowing researchers to visually determine the optimal number of topics. Using the determined number of topics, the topic proportions for each external variable were calculated. The topic with the highest proportion was considered most suitable for each external variable.

3. Results

A total of 352 case reports published from 2017 to 2021 were retrieved from the Case Report Registration System database (Tables 1 and 2). All reports were evaluated by assessors, and only those that passed the review were registered in the system.

Table 1 Overview of the number of reports.

	2017	2018	2019	2020	2021	Total
Acute phase	15	13	12	25	15	80
Recovery phase	37	49	29	44	42	201
Maintenance phase	8	19	14	17	13	71
Total	60	81	55	86	70	352

Table 2 Demographic data.

		Acute phase	Recovery phase	Maintenance phase
Gender	Female	35	99	26
	Male	45	102	45
Age	Over 80	18	42	10
	70–79	15	54	12
	60–69	23	45	22
	50–59	13	22	15
	40–49	7	25	8
	Under 39	4	13	4

3.1 Determining the number of topics

For analysis using a topic model, the optimal number of topics should be determined, which is analogous to selecting the number of clusters in conventional cluster analysis. Based on the results of the analysis (Fig. 1), 18 topics were deemed to be the most appropriate and analyzed.

We analyzed all 18 topics and calculated the topic proportions to explore which recovery states each topic

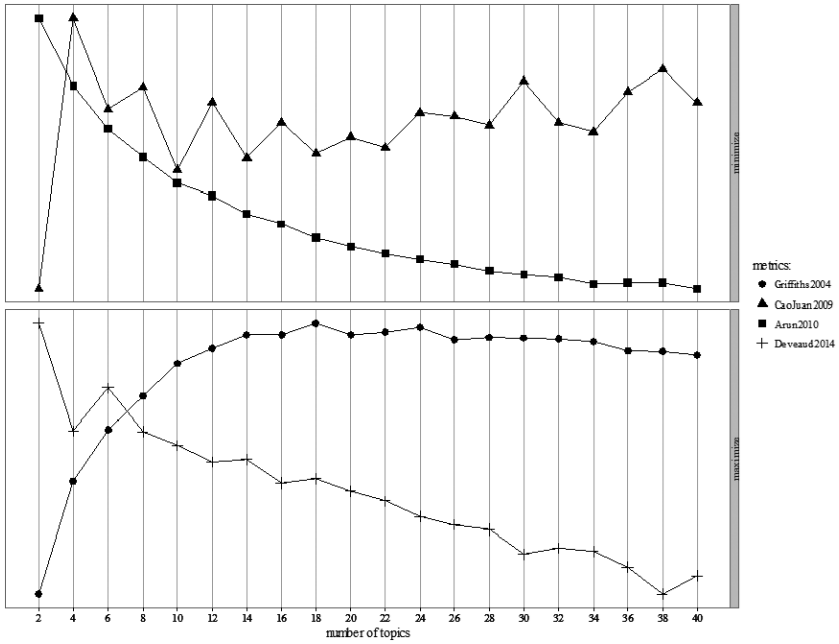

Fig. 1. Determining the number of topics.

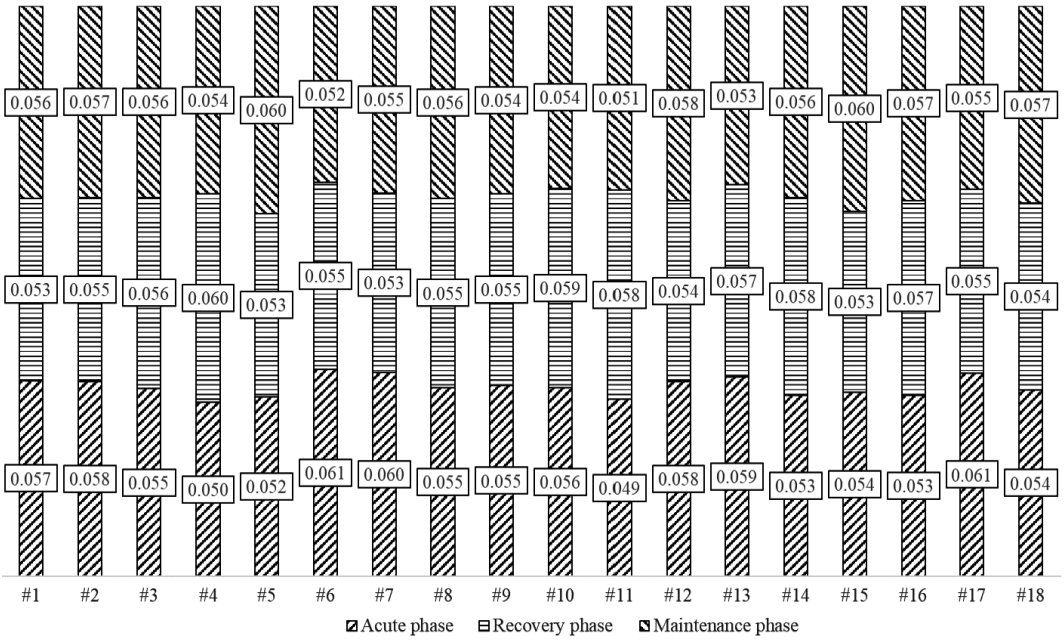

Fig. 2. Topic ratio.

represented (Fig. 2). The results indicate that topics #1, #2, #6, #7, #12, #13, and #17 were specific to the acute phase. Meanwhile, topics #4, #10, #11, #14, and #16 were specific to the recovery phase. Conversely, topics #5, #12, #15, #16, and #18 were specific to the maintenance phase. Finally, topics #3, #8, and #9 were common to all recovery states. In this study, topics with a topic ratio of 0.060 or higher were considered to have strong features, while topics with a ratio above 0.057 but below 0.060 were considered more distinctive.

3.2 Acute phase topics

Topics #6, #7, and #17 exhibited strong features in the acute phase, with topics #1, #2, and #12 being more distinct than the others (Table 3). The acute phase topics focused on motor function and included interventions aimed at enhancing daily life activities and not solely limited to motor function.

3.3 Recovery phase topics

Topic #4 exhibited strong features in the recovery phase, with topics #10, #11, #14, and #16 being more distinct than the other topics (Table 4). Recovery phase topics primarily focused on cases involving returning home after discharge. Additionally, topics related to interventions aimed at improving the activities of daily living (ADLs) and instrumental activities of daily living (IADLs) as well as activity and participation levels using the Management Tool for Daily Life Performance (MTDLP), created by the Japan Association of Occupational Therapists, were observed.

3.4 Maintenance phase topics

Topics #5 and #15 exhibited strong features in the maintenance phase, with topics #2, #12, #16, and #18 exhibiting more distinct features than the other topics (Table 5). These topics focused on the impact of changes in functional aspects and activity levels, such as returning to work or resuming hobbies, during the maintenance phase. Additionally, topics related to the MTDLP were observed during this phase.

3.5 Common topics

The analysis identified topics that were specific to any recovery state (topics common to all states) (Table 6). These topics included ADLs, such as movements at home, driving, and returning to work, highlighting interventions aimed at improving functional independence and upper limb function across all recovery states.

4. Discussion

This study focused on exploring the “purpose of reporting” cerebrovascular disorders in the field of physical disability, which has numerous case reports registered in the Japan Occupational Therapists Association case report system. We aimed to clarify the purpose of occupational therapy interventions for stroke survivors in Japan based on their recovery status. Employing the text-mining technique of topic modeling, specifically within reports targeting stroke, this study aimed to determine the distinctive features of occupational therapy. By limiting the analysis to case reports on stroke, which

Table 3 Acute phase topics.

Topic number	Word	Probability of appearance
#1	Improvement	0.370
	Motor	0.219
	Upper limb	0.203
	Hemiplegia	0.111
	Training	0.016
#2	Hemiplegia	0.487
	Use	0.247
	Daily life	0.095
	Stroke	0.052
	Onset	0.049
#6	Function	0.445
	Upper limb	0.185
	Possible	0.101
	Cerebral infarction	0.070
	Stroke	0.052
#7	Life	0.444
	Acute phase	0.094
	Suffer	0.088
	Cerebral infarction	0.050
	Progress	0.041
#12	Case	0.287
	Occupational therapy	0.096
	Difficulty	0.084
	Decline	0.079
	Cerebral infarction	0.076
#13	Case	0.247
	Disability	0.211
	Result	0.164
	Higher brain dysfunction	0.106
	Cerebral infarction	0.078
#17	Training	0.216
	Improvement	0.188
	Left	0.091
	Suffer	0.089
	Decline	0.078

Table 4 Recovery phase topics.

Topic number	Word	Probability of appearance
#4	Home	0.207
	Family	0.180
	Discharge from hospital	0.177
	Return	0.142
	Hope	0.049
#10	Intervention	0.385
	Possible	0.103
	Patient	0.082
	Cerebral hemorrhage	0.077
	Obtain	0.077
#11	Recovery phase	0.232
	Ward	0.229
	Hospitalization	0.223
	Case	0.062
	Hope	0.062
#14	ADL	0.181
	Severe	0.170
	Assistance	0.164
	Mitigation	0.086
	Progress	0.075
#16	Activity	0.175
	Role	0.166
	Acquisition	0.152
	MTDLP	0.150
	Reacquisition	0.121

MTDLP, Modified Total Dose of Laughter Protocol

accounted for the highest number of registrations, this study aimed to extract occupational therapy characteristics with greater clarity. Given the nonlinear logarithmic nature of neurological recovery in stroke [14, 15] and the heterogeneous nature of functional recovery [16], our findings provide evidence-based insights. Topics related to functional aspects were identified in the acute phase, those associated with both functional aspects and living at home were prevalent in the recovery phase, and those related to daily life were identified in the maintenance phase.

Topic modeling, a tool suitable for text data analysis, has been proven effective in extracting the unique features of occupational therapy in Japan from large datasets [17, 18]. Enabling the classification of a single word into multiple topics, a capability not present in conventional cluster analyses such as k-means and topic modeling, facilitated the extraction of distinctive features of occupational therapy in Japan.

However, certain topics did not exhibit significant differences across the phases based on the estimation results. These topics likely represent areas universally addressed by occupational therapists across all recovery phases. Interventions related to “driving” and “return to work,” essential aspects of daily life, were consistently addressed across all phases. Although the specific intervention methods may vary by phase, this study focused on the “objectives of reporting” and might not have fully elucidated the differences in intervention methods for these common topics. Hence, future studies should explore this aspect by focusing on different elements, such as the structured framework of “intervention progress.”

The study found that topics containing the term “MTDLP” appeared in both the recovery and maintenance phases. Additionally, these MTDLP-related topics included terms such as “activity” and “role.” Developed by the Japan Association of Occupational Therapists

Table 5 Maintenance phase topics.

Topic number	Word	Probability of appearance
#2	Hemiplegia	0.487
	Use	0.247
	Daily life	0.095
	Stroke	0.052
	Onset	0.049
#5	Implemented	0.232
	Opportunity	0.119
	Occupational therapy	0.119
	Rehabilitation	0.103
	Obtain	0.087
#12	Case	0.287
	Occupational therapy	0.096
	Difficulty	0.084
	Decline	0.079
	Cerebral infarction	0.076
#15	The goal	0.224
	Case	0.190
	Rehabilitation	0.168
	Implementation	0.066
	Progress	0.050
#16	Activity	0.175
	Role	0.166
	Acquisition	0.152
	MTDLP	0.150
	Reacquisition	0.121
#18	Case	0.447
	Direct	0.130
	Result	0.108
	ADL	0.102
	Decline	0.032

MTDLP, Modified Total Dose of Laughter Protocol; ADL, activities of daily living

Table 6 Common topics.

Topic number	Word	Probability of appearance
#3	Actions	0.455
	Case	0.212
	Independent	0.116
	Withdrawal	0.052
	Result	0.038
#8	Resume	0.172
	Driving	0.148
	Support	0.136
	Assessment	0.092
	Practice	0.068
#9	Right	0.280
	Hemiplegia	0.271
	Left	0.192
	Improvement	0.061
	Support	0.034

from 2008 to 2010, the MTDLP is a tool used for comprehensive assessment and management following a multidisciplinary approach that considers aspects such as physical and mental functions, activities, and participation, as well as individual and environmental factors [19]. This suggests that Japanese occupational therapists actively addressed the "activity" and "participation" of patients with cerebrovascular disorders during the recovery and maintenance phases using the MTDLP tool. However, this effect was not observed during the acute phase. This discrepancy may indicate a greater focus on interventions aimed at improving physical functioning in the acute phase, consistent with the neurological recovery trajectory of stroke [14, 15]. Although occupational therapy interventions for the acute phase of stroke have not yet been well established in Japan [20], recent stroke practice guidelines [21] suggest potential future developments in this area.

This study focused on the most prevalent occupational therapy interventions for cerebrovascular disorders in Japan. These results provide insight into the distinctive features of occupational therapy interventions during the acute recovery and maintenance phases. The results of this study offer valuable insights for young occupational therapists to learn from their predecessors, facilitate comparisons with other countries, and guide further studies. However, to our knowledge, no "case report registration system" has been established in countries other than Japan, and no previous case reports have summarized the characteristics of occupational therapy at the national level. Therefore, this study represents a pioneering effort toward summarizing the characteristics of occupational therapy in each country outside Japan. Accumulated research findings from such efforts can contribute to the advancement of occupational therapy worldwide. Occupational therapy addresses a wide range of conditions, including mental and developmental disorders, warranting further analysis across diverse areas. This effort aims to highlight Japan's achievements in occupational therapy globally, contributing to its foundation and offering crucial support to individuals worldwide.

5. Summary and Conclusions

In this study, we extracted the "objectives of reporting" from case reports publicly released by the Japan Association of Occupational Therapists. We analyzed the characteristics of occupational therapy in the acute, recovery, and maintenance phases of cerebrovascular

diseases. The results suggest that during the acute phase, the interventions focused on improving motor function while enhancing the performance of ADLs. In the recovery phase, the interventions were aimed at managing higher brain function deficits and included activity- and participation-level interventions using the MTDLP. In the maintenance phase, the interventions were aimed at improving activity and participation levels, including the ability to return to work. Occupational therapy for cerebrovascular disease in Japan seemed tailored to the recovery stage of cerebrovascular disease. The use of the MTDLP, developed by the Japan Association of Occupational Therapists, in activity- and participation-focused interventions represents a distinctive feature.

Limitation

One limitation of this study is its focus solely on Japanese occupational therapy for cerebrovascular diseases within the realm of physical disabilities and did not represent all occupational therapy interventions in the areas of developmental disabilities and mental disorders. Additionally, our analysis primarily relied on extracting and examining the "objectives of reporting" from publicly available text data. Consequently, details regarding the intervention methods specific to each phase could not be fully elucidated, constituting another limitation.

Conflict of interest

The authors declare that they have no conflict of interest.

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■ORIGINAL ARTICLE

Mental Practice with Inverse Video Presentation in Combination with Functional Electrical Stimulation for Upper Limb Paralysis: A Single-Case Study

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Abstract: Objective: To investigate mental practice (MP) with inverse video in combination with functional electrical stimulation in a patient with left-sided hemiplegia with severe upper limb paralysis using a single-case design.
Methods: In a single case, the total intervention period for the ABA approach was 9 weeks. The participants were patients with stroke and motor paralysis in their upper extremities who could perform MP, and those who consented to the intervention study were recruited. The duration of each phase was 3 weeks, and each session lasted for 60 min/day. Neuromuscular stimulation and peg manipulation, among others, were performed in period A, while MP was performed using inverse video and functional electrical stimulation in period B. The effectiveness of the ABA approach was analyzed using the 2-standard deviation (2-SD) band method.
Results: The mean values of each efficacy index in period B were as follows: Fugl–Meyer Assessment-upper extremity, 50.3; Motor Activity Log (Amount of Use subscale), 3.8 and Motor Activity Log (Quality of Movement subscale), 3.8; and Action Research Arm Test (left), 44.0, which were higher than the mean + 2-SD values in period A. Furthermore, a significant improvement was observed in the paralyzed upper limb with the application of the integrated volitional control electrical stimulator (IVES) plus MP intervention using inverted video.
Conclusion: The synergistic effect of IVES and MP intervention using laterally inverted video resulted in an improvement in the function of the paralyzed upper limb.

Keywords: stroke, mental practice, functional electrical stimulation

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1. Introduction

The intervention methods for stroke-induced upper limb motor paralysis include motor therapy, functional electrical stimulation, constraint-induced movement therapy, mental practice (MP) with repeated motor imagery (MI), and numerous techniques, including Action observation therapy [1–4]. Although these intervention methods' effectiveness has been studied singly, they are usually employed in combination in clinical settings as multiple intervention techniques [5]. However, no clearly defined treatment protocol exists for severe upper limb paralysis. Therefore, rehabilitation programs for severe upper limb paralysis are a challenge in clinical practice.

MP entails continuous repetition of MI to improve the performance of motor tasks. The physical environment does not limit MP; it can be performed irrespective of the degree of motor paralysis and can be provided as an independent intervention. Systematic reviews have reported MP intervention's effect in patients with post-stroke motor paralysis [6, 7]. The combination of brain-computer interface, MP, and occupational therapy is reportedly a promising approach to promote sensory-motor recovery and functional independence of the upper limb in the daily activities of individuals with stroke [8]. The intervention effect of functional electrical

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stimulation, which can be performed from the paralyzed upper limb to the cerebral cortex, irrespective of the degree of motor paralysis, has also been demonstrated. Moreover, voluntary movement-triggered electrical stimulation is reportedly more effective than non-triggered electrical stimulation [9].

The vividness of the participant's perception of the MI of the task is essential [10] for the effective performance of MP. Additionally, the regions and degrees of brain activity differ between first-person and third-person MI [11]. However, during first-person MI of the upper extremities, the premotor cortex, auxiliary motor, primary motor, primary somatosensory, superior parietal lobe, and inferior parietal lobe are activated, similar to the brain activity observed during actual movement [12]. The vividness of MI can be improved by making the participants watch a video of themselves performing the task with their hands [13]. Based on these observations, we conducted a study regarding a combined intervention with MP and functional electrical stimulation for a patient with left-sided hemiplegia with severe upper limb paralysis admitted to a convalescent rehabilitation ward. We used inverted images of the patient's upper limb on the non-paralyzed side and asked the patient to perform MP while viewing simulated images displaying the paralyzed upper limb's movement. A voluntary movement-assisted integrated volitional control electrical stimulator (IVES) was used for functional electrical stimulation to facilitate the paralyzed upper limb's voluntary movement. Here, we reported the effects of a combined intervention with MP and functional electrical stimulation with inverse video using a single-case ABA design.

2. Materials and Methods

2.1. Participant

The patient was a right-handed woman in her 50s with cerebral infarction who developed left hemiplegia, higher brain dysfunction, and dysarthria. She was admitted to an acute care hospital, where she was diagnosed with Moyamoya disease-induced cerebral infarction, primarily in the right frontal lobe. On day 21, post-onset, the patient was transferred to a convalescent rehabilitation hospital. Before her illness, she could independently perform all activities of daily living (ADLs) and instrumental ADLs, and her job was related to sales. The paralyzed upper limb showed slight voluntary movements; however, she could not grasp objects and had difficulty using the limb in daily life. Although higher brain dysfunction was observed, which manifested as attention and organization impairment, it did not interfere with her daily life. Upper extremity function was assessed using the Fugl–Meyer Assessment-upper extremity (FMA-UE), 16; Amount of Use (AOU), 0 and Quality of Movement (QOM), 0 on the Motor Activity Log (MAL); and Action Research Arm Test (ARAT), 6.

The Ethics Committee of Nagasaki Rehabilitation Hospital approved this study. The participant provided consent after receiving information about the research.

2.2. Intervention

2.2.1 Design

This study incorporated a single-case ABA design. Baseline phase A (1–3 weeks) comprised joint range-of-motion exercises, neuromuscular stimulation, grasping plastic bottles, and stacking blocks and pegs; it was graded according to paralyzed upper limb function recovery. The intervention period, frequency, and duration were 9 weeks (3 weeks each for phases A, B, and A), daily, and approximately 1 h, respectively. During phase B (4–6 weeks), MP with inverted imagery was combined with functional electrical stimulation, and the MP tasks were similar to those in baseline phase A. During the return to phase A (7–9 weeks), identical to baseline phase A, joint range-of-motion exercises, neuromuscular stimulation, and exercises involving grasping plastic bottles and building blocks were performed using similar techniques across all phases. The intervention was staged according to paralyzed upper limb function recovery using stacking tasks, pegs, and other objects (Fig. 1).

2.2.2. Efficacy evaluation

The FMA-UE, AOU and QOM items on the MAL, and ARAT were used as efficacy indices. Assessments were conducted at three evaluation points for each period every alternate week and then compared (Fig. 1).

2.2.3. Images for MP

The vividness of the MI of the task was measured using the Visual Analog Scale (VAS) to determine the presentation method of the reversed images. The cortical regions' activity during the MI of the task was measured using near-infrared spectroscopy (NIRS) for the VAS. Additionally, the participant was asked to mark the clarity of the MI on a 100-mm horizontal line whose ends were designated as "0 (no MI at all)" and "100 (very clear MI)." To evaluate the presentation method of "the inverse video," we compared the following conditions: (1) no inverted video, (2) inverted video of another person's hand, and (3) inverted video of the patient's hand (non-paralyzed upper limb) while performing the MI of the task. MP was implemented under high oxygenated hemoglobin (oxy-Hb) values measured using the NIRS during MI.

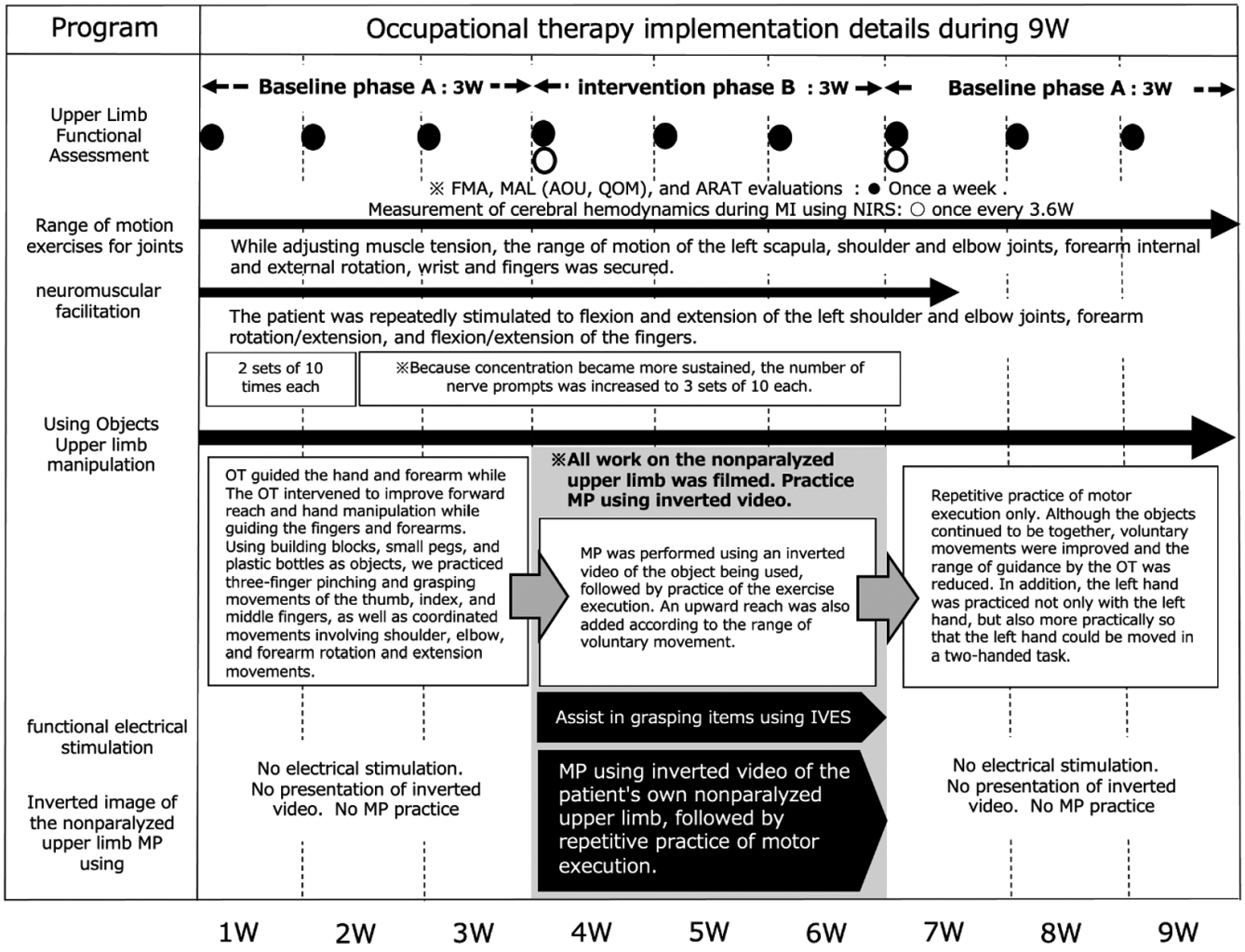

Fig. 1. Occupational therapy implementation during the intervention phase.

Baseline phase A comprised joint range-of-motion exercises, neuromuscular stimulation, grasping plastic bottles, stacking blocks, and pegs, and was graded according to the paralyzed upper limb's functional recovery. In intervention phase B, MP using inverted images was combined with functional electrical stimulation, and the MP tasks were similar to those in baseline phase A. During the return to baseline phase A, the patient was given MP tasks similar to those in baseline phase A.

MP: mental practice.

2.2.4. Activity of cortical regions during the MI using inverted video

NIRS measurements were performed using an optical topography system (ETG4000, Hitachi Medical Corporation, Japan) in an evaluation room (private room with a temperature of 24°C) at Nagasaki Rehabilitation Hospital, exercising caution not to introduce stimuli from the surroundings. The cutting zone was used as a reference (Fig. 2). A study reported no difference in the optical path length between the left and right target areas for this NIRS probe [14]. NIRS probes were arranged in a 4 × 4 optode probe configuration for the cutting zone per the International 10–20 system. The distance between the optodes of 24 channels was 3.0 cm [15]. The NIRS system emitted light at two different wavelengths (625 and 830 nm) over the scalp, and the relative change in near-infrared light absorption was measured. These values are based on the modified Beer–Lambert law [16–17]. NIRS measurements are reportedly non-invasive, safe, and reproducible [1, 2, 19].

The regions of interest were the left and right sensorimotor cortex (SMC), premotor area (PMA), prefrontal cortex (PFC), pre-supplementary motor area (pre-SMA), and supplementary motor area (SMA). Based on previous studies, the left SMC, right SMC, SMA, pre-SMA, left PMA, right PMA, left PMA, right SMA, right SMA, left SMC, right SMC, left SMC, right SMA, left SMC, right SMA, left PMA, right PMA, left PFC, and right PFC were selected for channels 18 and 22; 21 and 24; 9, 12, 13, and 16; 2, 5, and 6; 8, 11, and 15; 10, 14, and 17; 1 and 4; 2 and 3; 3 and 4; 4; 5 and 6; 6 and 7; 7 and 8; 8, 8, 9, and 10; 9, 12, and 13; 16, 8, 11, and 15; 10, 14, and

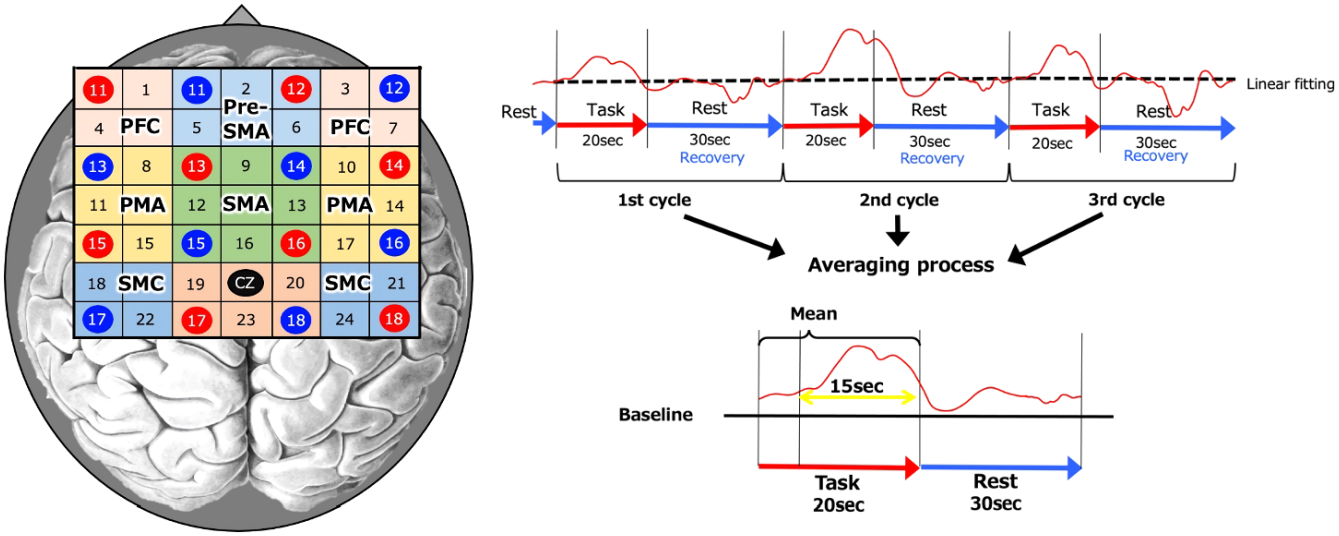

Fig. 2. Diagram showing the channel configuration of the 4 × 4 optode probe set for NIRS waveform analyses using the integral method.

The NIRS probes were arranged with reference to the Cz per the International 10–20 system. The red and blue circles indicate the NIRS sensors and detectors locations, respectively.

The red curve represents the NIRS waveform. The average waveforms were obtained by determining the mean of data measured using a three-cycle block design. The vertical axis represents the oxy-Hb concentration (mM × mm), and the horizontal axis represents the time course of one cycle of task performance and rest period. The average value of oxy-Hb measured between 5 and 20 s during the task (15 s, yellow line in the average graph) was calculated.

NIRS: near-infrared spectroscopy, oxy-Hb: oxygenated hemoglobin, Cz: cutting zone.

17; 1 and 4; and 3 and 7, respectively [20–23].

NIRS measurements were performed using a block design with three consecutive cycles with 20 s of the MI task alternating with 30 s of rest per condition [23]. Since oxy-Hb is reportedly a clearer indicator of activation than deoxygenated hemoglobin [24], the change in oxy-Hb concentration during the MI task was employed as an index of regional cerebral hemodynamics. The data obtained were analyzed using the integral mode, where the data acquired from the three cycles were added and averaged to obtain the regional oxy-Hb concentration changes. Baseline data were averaged over a 5-s period, each immediately before the start and after the end of the MI tasks [25, 26]. The data used during the MI task included the 15-s data from 5 s after the start of the MI task to 20 s after the end of the MI task, considering the time required for cerebral blood flow to increase with neural activity [27]. The oxy-Hb values for each region were converted to the Z-score. Obvious artifacts, if any, were removed from the waveform, and the average waveform was calculated using integral analysis.

2.2.5. Creation of inverted images

A tablet (iPad, Apple, USA) and a free application software (SymPlayer, Masakiyo Tachikawa, Japan) were used to capture the videos and edit the inverted videos, respectively. The inverted images included the approach practiced on the paralyzed upper extremity during the intervention and were changed as the task was graded. Therefore, the video of the activity being performed with the non-paralyzed upper limb was captured immediately before the approach for the paralyzed upper limb, and an inverted video was created and presented using the free application software (Fig. 3). This inverted video can be edited in approximately 1 min.

2.2.6. Functional electrical stimulation

The IVES (OG Wellness), which is a voluntary movement assistance device, was used. The power assist mode was set to 10% minimum and 24% maximum outputs. The IVES gel 2-pole conductor was attached to the forearm flexor muscle group (around the muscular belly of the palmaris longus), where the left-hand flexion was observed. Additionally, the duration of continuous use was < 20 min. After performing MP while watching the inverted image, the IVES stimulus was effectively used during the actual movement. When the patient grasped a peg or a block of wood, voluntary muscle contraction of the fingers was strengthened. Consequently, MP stimulated brain activity, and the IVES amplified the stimulation from the elimination to the brain.

2.2.7. Data analysis

Upper limb function was analyzed using the 2-standard deviation (2-SD) band method [9, 28]. This method adds the mean and 2-SD values of the data

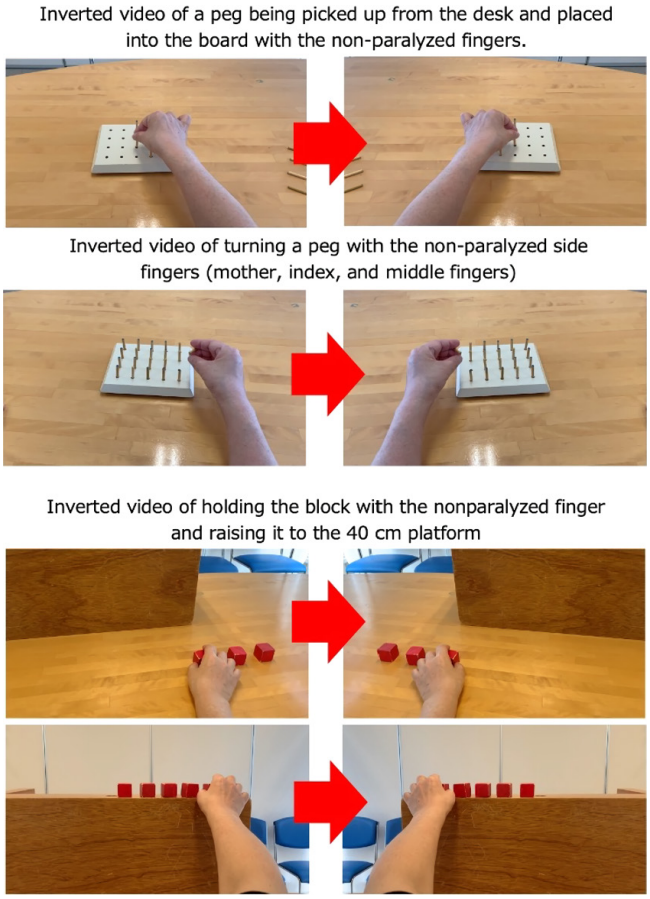

Fig. 3. Representative inverted images presented during MP in intervention phase B.
The inverted image approach was used for the paralyzed upper extremity during the intervention, and the images were changed as the task was graded. Therefore, the video of the approach being performed on the non-paralyzed upper limb was captured immediately before the intervention for the paralyzed upper limb, and an inverted video was created and presented using application software.
MP: motor practice.

(FMA, MAL, and ARAT) obtained in the baseline period A (1–3 weeks). The data showed a significant improvement in period B if at least two consecutive data points in period B (4–6 weeks) exceeded the corresponding mean + 2-SD values of baseline period A (1–3 weeks), and the data in baseline period A (7–9 weeks) were below the corresponding values in period B. The FMA, MAL, and ARAT instruments were used to assess the paralyzed upper extremity function.

Since single-patient data on the VAS (Fig. 4) and oxy-Hb values (Fig. 5) derived during MI cannot be compared, this study's data were used solely as a reference for selecting the presence or absence of images and the effect of the lateral reversal of images.

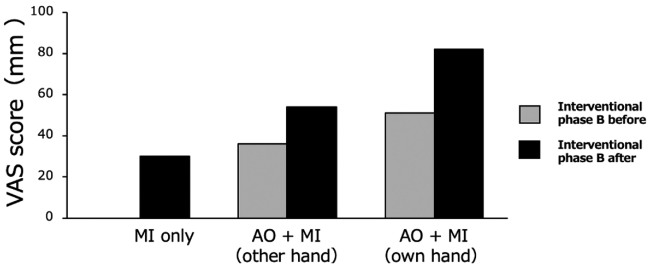

Fig. 4. Vividness of the MI in the paralyzed upper limb (VAS) in different inverted image presentation methods.
The VAS values were higher after phase B than before phase B.
VAS: visual analog scale, MI: motor imagery.

3. Results

The VAS scores were higher when the MI was performed while the patient watched her hand inversion videos. The oxy-Hb values were also higher in the bilateral PFC, pre-SMA, bilateral PMA, and bilateral SMC regions. Therefore, the patient's inverted hand images were used in this MP intervention.

In the combined intervention with MP and IVES using the patient's hand reversal video, the VAS scores (representing the clarity of the MI) and oxy-Hb values in the pre-SMA, bilateral PMA, bilateral SMC, and SMA regions were higher after period B (week 6) than before period B (week 4) (Figs. 4 and 5).

The mean values in the baseline period A were FMA-UE, 24.7; MAL (AOU), 0.5; MAL (QOM), 0.6; and ARAT (left), 15.7. However, the mean values for period B were FMA-UE, 50.3; MAL (AOU), 3.8; MAL (QOM), 3.8; and ARAT (left), 44.0. The mean values for period A plus 2-SD were FMA-UE, 45.5; MAL (AOU), 2.3; MAL (QOM), 2.5; and ARAT (left), 34.1. Specifically, the mean + 2-SD value was higher for ≥ 2 assessment points in period A, and significant improvement was observed in the combined intervention with MP and IVES using the reversed video (Fig. 6).

4. Discussion

4.1. MI vividness and oxy-Hb in MI

During the MI of the paralyzed upper extremity, the VAS scores and oxy-Hb values were higher when MI was performed by presenting the inverted video of the patient's non-paralyzed upper extremity. A study investigating differences in the presentation methods using inverted images in healthy adults revealed that oxy-Hb value in the cortical regions was significantly higher in the condition where the patient's hand was inverted than that where no inverted images or where inverted

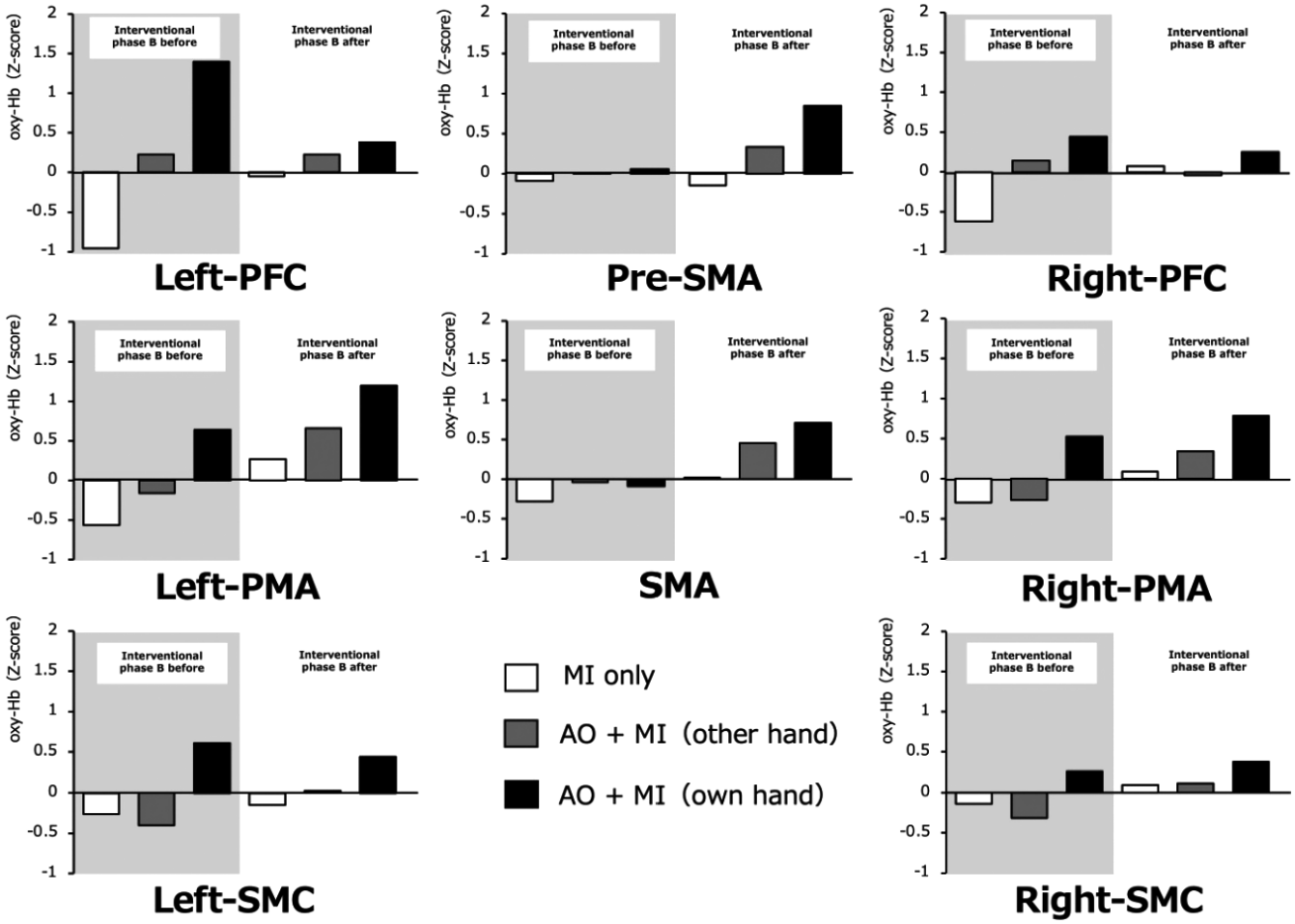

Fig. 5. Oxy-Hb in the MI in the different inverted image presentation methods.
Oxy-Hb values in the pre-SMA, bilateral PMA, bilateral SMC, and SMA regions were higher after period B than before period B.
SMC: sensorimotor cortex, PMA: premotor area, PFC: prefrontal cortex, pre-SMA: Pre-supplementary motor area, SMA: Supplementary Motor Area, oxy-HB: oxygenated hemoglobin, MI: motor imagery.

Protocol	Baseline phase A			intervention phase B			Baseline phase A		
	1 W	2 W	3 W	4 W	5 W	6 W	7 W	8 W	9 W
FMA	16.0	22.0	36.0	44.0	50.0 *	57.0 *	59.0 *	63.0 *	65.0 *
Average+2SD		45.5							
MAL (AOU)	0.0	0.3	1.2	2.0	4.4 *	5.0 *	5.0 *	5.0 *	5.0 *
Average+2SD		2.3							
MAL (QOM)	0.0	0.3	1.5	2.0	4.4 *	5.0 *	5.0 *	5.0 *	5.0 *
Average+2SD		2.5							
ARAT	6.0	17.0	24.0	33.0	46.0 *	53.0 *	57.0 *	57.0 *	57.0 *
Average+2SD		34.1							

Fig. 6. Change in the paralyzed upper limb's function.
The mean + 2-SD value was greater in baseline phase A at ≥ 2 evaluation points in intervention phase B. A significant improvement was observed with the combined intervention with MP and IVES using an inverted image.
MP: motor practice, SD: standard deviation, IVES: integrated volitional control electrical stimulator.

images of another person's hand were presented [10]. Furthermore, a positive correlation was found in another study focusing on the relationship between MI vividness and corticospinal tract excitability during MI in healthy adults [29]. Therefore, the result that the VAS score after period B exceeded that before period B suggests that it could be attributed to the improvement in the paralyzed upper limb function. In this case, we performed

MI while presenting inverted images of the patient's non-paralyzed upper limb, similar to previous studies on healthy participants, to increase MI clarity and cortical area activity.

4.2. Change in upper limb function on the paralyzed side

A systematic review reported that MP was an effective intervention in patients with stroke, revealing intervention effects on post-stroke motor paralysis [6]. In a study evaluating the task performance of AO + MI, dart throwing, basketball throwing, and golf tasks were performed under the conditions of AO only, MI only, and AO + MI, was shown to be superior to MI alone [30–33]. From these studies, it can be concluded that the conditions for better performance are the use of participants' hand videos and the AO + MI combination. The effects of the paralyzed upper limb voluntary movements and voluntary movement enhancement by IVES on the SMC in patients with stroke were investigated using NIRS. The result revealed an increase in cerebral blood flow in the SMC on the disabled side during IVES compared to that during voluntary movements. Furthermore, cerebral blood flow in the SMC of the disabled side increased during IVES compared to that during voluntary exercise. Another study showed that the FMA score tends to improve when cerebral blood flow in the SMC of the impaired side is increased via IVES [34]. In our study, we performed MP using inverted images of the patient's contralateral non-paralyzed limb, which showed high oxy-Hb values (consequently high VAS scores for MI) to further enhance the effects of MP during phase B. The high oxy-Hb values in the cortical area before the paralyzed upper limb movement indicate a state where neural activity was likely to occur. Moreover, the IVES application to enhance voluntary movements during the paralyzed upper limb movement was believed to increase activity in the cortical area. We believe that the synergistic effects of the combined use of MP and functional electrical stimulation using inverted video contributed to brain plasticity and neural network construction, leading to functional improvement of the paralyzed upper limb. The interventions were performed in stages according to the paralyzed upper limb's function at the time, and the inverted images were changed when the task or difficulty level was altered. Therefore, we believe that MP was performed while maintaining high MI vividness at when point and that significant functional improvement of the paralyzed upper limb and high oxy-Hb values (consequently VAS scores and MI) were observed due to these timely and appropriate modifications during the pre- and post-intervention period B assessments.

4.3. Future Issues

The effectiveness of MP using inverted images of the patient's non-paralyzed upper limb has not been verified in a randomized controlled trial in patients with stroke. Therefore, conducting such studies in this patient population is necessary to verify the effect of MP using inverted images of the patients' non-paralyzed upper limbs.

5. Summary and Conclusion

The combination of MP and functional electrical stimulation using inverted images of the patient's non-paralyzed upper limb was an effective intervention for a patient with stroke-induced hemiplegia with severe upper limb paralysis. When performing MP, using an inverted video of an individual hand is beneficial to increase the vividness of the MI. Furthermore, it was proven in a single case that adding functional electrical stimulation to MP using inverted video increased the possibility of functional improvement.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

Ethics Approval

This study was approved by the local Ethics Committee of Nagasaki Rehabilitation Hospital. All experimental procedures were conducted in accordance with the Declaration of Helsinki (World Medical Association, 2013).

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■ORIGINAL ARTICLE

Occupational Dysfunction as a Factor Affecting Changes in Quality of Life Before and After Hospitalization in Patients with Parkinson's Disease

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Abstract: Objectives: Rehabilitation of inpatients with Parkinson's disease (PD) with occupational dysfunction associated with disease progression is important to prevent decreased quality of life (QOL) in the community. However, the factors associated with changes in QOL before and after hospitalization are not clear. The purpose of this study was to clarify changes in the QOL, occupational dysfunction, and apathy of inpatients with PD before and after hospitalization, and to identify factors associated with changes in QOL.
Methods: This prospective case series study included inpatients with PD for whom occupational therapy was prescribed. The assessment items included the 39-item Parkinson's Disease Questionnaire (PDQ-39), Classification and Assessment of Occupational Dysfunction (CAOD), and Apathy Scale (AS). These assessments were performed at the time of hospitalization and at 1 month post discharge. A generalized linear mixed model (GLMM) was used to identify factors of change in QOL.
Results: Twelve patients were included in the analysis (age, 75.3 ± 6.5 years; duration of illness, 56.2 ± 39.2 months; most common H&Y Stage, II and III) and all were discharged home. CAOD was a significant explanatory factor for change in QOL at hospitalization and 1 month after discharge ($p = 0.034$).
Conclusions: CAOD was demonstrated to be related to changes in the QOL of inpatients with PD. It was suggested that focusing on and supporting patients' occupational dysfunction contributes to their QOL in the community after discharge from hospital.

Keywords: occupational dysfunction, quality of life, Parkinson's disease, generalized linear mixed model

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Introduction

Rehabilitation of Parkinson's disease (PD) inpatients is important to prevent a decreased quality of life (QOL) and connect the patient to community life after discharge from hospital. PD is a chronic progressive neurodegenerative disease characterized by various non-motor symptoms, such as psychiatric symptoms, sleep disorder, and autonomic neuropathy, in addition to motor symptoms. QOL consists of physical abilities/capabilities, psychological status, social status, economic status/employment, and community spirit, and there are two major aspects of quality of life: The environmental aspect of quality of life and health-related quality of life (HRQOL) [1]. HRQOL includes comprehensive and disease/symptom-specific measures, and the 39-item Parkinson's disease questionnaire (PDQ-39) is one of the disease/symptom-specific measures. In this study, QOL was defined as HRQOL determined by PDQ-39. Previous studies have shown that the Hoehn & Yahr

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severity classification (H&Y severity classification), movement lability, impaired postural reflexes, gait disturbance, activities of daily living (ADL), and psychiatric symptoms are associated with the quality of life of patients with PD [2–4]. In addition, it was reported that the QOL of outpatients with PD decreased after 1 year in comparison to that at baseline [5]. Inpatients with PD are provided with rehabilitation such as exercises to improve the physical function and ADL, in parallel with treatment, including drug adjustment, and live in a well-equipped inpatient environment. However, the living environment after discharge from hospital is different from that during hospitalization. Specific strategies are needed to maintain the ADL at the time of hospitalization and prevent a decrease in QOL in their community life after discharge from hospital.

Oguro et al. [4] showed that focusing not only on motor symptoms but also on non-motor symptoms is necessary to maintain and improve the QOL of patients with PD. In a longitudinal study of outpatients with PD, among the sub-items of the non-motor symptoms rating scale (Non-Motor Symptoms Scale: NMSS), sleep and fatigue, mood and apathy, and attention and memory were described as predictors of changes in QOL [6]. D'lorio et al. [7] showed that PD outpatients with low QOL had depression and apathy, and the combination of depression and apathy affected the QOL. There are few reports on apathy, although there have been scattered studies on QOL and depression, and opinions are divided on the relationship between longitudinal changes in QOL and apathy. Therefore, it is important to investigate the relationship between QOL and apathy in inpatients with PD.

PD patients are expected to present with occupational dysfunction, in which ADLs, leisure time, work, and other tasks become progressively more difficult as their motor symptoms slowly progress. Occupational dysfunction means the inability to perform daily activities appropriately [8]. In a cross-sectional study of community-dwelling elderly participants, including patients with PD, it has been suggested that improvement in occupational dysfunction was associated with improvement in QOL and decreased depression [9]. However, the degree of occupational dysfunction and its relationship to QOL specific to patients with PD is not clear.

Previous studies have identified factors associated with disease-specific QOL [10–12]. However, few studies have examined the association between QOL and multiple variables such as occupational dysfunction and apathy longitudinally, and it is unclear how each factor affects QOL. There are also scattered studies on community-dwelling patients with PD or outpatients with PD, although the changes in QOL before and after hospitalization and the factors associated with these changes remain to be elucidated. It is possible to consider the factors involved in changes in QOL from multiple perspectives, such as whether occupational dysfunction and apathy are related to changes in QOL in a general rehabilitation setting. The clarification of these factors will contribute to patient support during hospitalization to maintain and improve their QOL in the community after discharge from the hospital.

The purpose of this study was to clarify changes in the QOL, occupational dysfunction, and apathy of inpatients with PD before and after hospitalization, and to identify factors associated with changes in QOL.

Methods

Participants

The study participants were patients with PD who were hospitalized at the Department of Neurology, Yokohama Minato Red Cross Hospital, from June 2020 to June 2021, and who were prescribed occupational therapy. Patients who gave their consent after receiving an explanation about this study were eligible to participate. Patients with a score of ≤ 23 on the Japanese version of the Mini-Mental State Examination (MMSE-J) were excluded from the study. The sample size for the paired *t*-test was calculated using G*power 3.1.9.7 for Microsoft Windows with an effect size of 0.9 and power of 0.8, and it for GLMM was determined to refer to the previous tutorial article [14]. The required sample size was 12 subjects for the paired *t*-test and the GLMM respectively, which recruited 12 subjects for this study.

Procedure

General information, such as sex, age, duration of illness, purpose of hospitalization, H&Y stage, and the levodopa equivalent dose (LEDD) at hospitalization and discharge, duration of hospitalization, occupational therapy performed, destination, and family members living with the participants, and employment were collected from the participants, medical records and other medical staff. Each assessment scale was assessed at hospitalization, discharge, and 1 month after discharge. Assessment items included the MMSE-J at hospitalization, the Functional Independence Measure (FIM) at hospitalization and discharge, and the 39-item Parkinson's Disease Questionnaire (PDQ-39), Classification and Assessment of Occupational Disability (CAOD), and Apathy Scale (AS) at hospitalization and 1 month after discharge. All assessments at hospitalization were performed within one week of hospitalization. Assessment forms for one month after discharge were mailed one week before

discharge and were returned within a week of arrival. Occupational therapy during hospitalization performed standard assessments and interventions for PD patients.

Data Analysis

Basic statistics for age, duration of illness, duration of hospitalization, LEDD, and MMSE-J were calculated. After confirming normality by the Shapiro-Wilk test, each variable at hospitalization and discharge or at hospitalization and 1 month after discharge were compared by a paired *t*-test or Wilcoxon's signed rank test. The H&Y stages were compared between hospitalization and discharge using Fisher's exact test. A generalized linear mixed model (GLMM) was used to identify factors associated with change in QOL. In the GLMM, the PDQ-39 was used as the objective variable, while CAOD total, AS total, and LEDD were used as explanatory variables, and the time of evaluation was used as a dummy variable (at hospitalization = 0; 1 month after discharge = 1) to identify hospitalization and 1 month after discharge, and to account for individual differences in QOL, the participant's identification number was entered as a random intercept in the variable effects. Fixed effects in GLMM were analyzed as CAOD, AS, and time (dummy variables), and random effects as patient ID (1-12).

P-values of < 0.05 were considered statistically significant. Statistical analyses were conducted using SPSS Statistics 27 for Microsoft Windows (IBM, USA) and R (version 4.1.1).

Ethical statements

This study was approved by the Yokohama Minato Red Cross Hospital Voluntary Clinical Research Review Committee (approval number: 2020-4). The purpose and content of the study were explained, and performed in accordance with the principles of the Declaration of Helsinki. The purpose and content of the study were explained, and written informed consent was obtained from each participant. We also explained that participation in this study was voluntary and that participants would incur no disadvantage even if they did not agree to participate or withdrew their consent.

Results

Characteristics of the participants

The characteristics of the participants are shown in Table 1. Of the 22 participants in this prospective case-series study, 10 with MMSE-J scores of ≤ 23 and no return after discharge were excluded. Thus, a total of 12 participants were included in the analysis. The age of the participants was 75.3 ± 6.5 years and the duration of illness was 52.6 ± 39.2 months. Eleven patients lived with their families and four were employed. The most common H&Y stage at hospitalization was Stage II ($n = 6$), followed by Stage III ($n = 4$). The MMSE-J score at hospitalization was 27.3 ± 2.1, and the most common occupational therapy was physical function training and basic movement training ($n = 10$ each). Occupational therapy was carried out once a day, 6 days a week, for 20–40 minutes by seven occupational therapists with 4 to 15 years of experience. Occupational therapy included physical functional training (e.g., stretching or upper limb functional training), getting up and standing up, and ADL and IADL training (e.g., toileting, dressing, and cooking). The most frequent occupational therapies were physical functional training, getting up and standing up. The duration of hospitalization was 15.4 ± 5.6 days, and all patients were discharged home.

Relationship between each assessment scale and before and after hospitalization

The results of the paired *t*-test and Fisher's exact test for comparisons between hospitalization and discharge or 1 month after discharge are shown in Tables 1 and 2. Fisher's exact test showed no significant difference in the H&Y stage between hospitalization and discharge ($p = 0.667$). LEDD was significantly increased at discharge in comparison to hospitalization, and the patients were taking approximately the same dose at 1 month after discharge. The FIM total and motor scores were significantly higher at discharge, but the cognitive scores were unchanged at both hospitalization and discharge. The PDQ-39 was significantly improved at 1 month after discharge ($p = 0.017$), while CAOD and AS were not significantly different. Eight (66.6%) had an AS of ≥ 16 on hospitalization, and seven of these plus one new patient were still apathetic at 1 month after discharge.

Causes of change in quality of life

The results of the GLMM, with the objective variable being the change in QOL, are shown in Table 3. CAOD was the significant explanatory factor for change in QOL at hospitalization and 1 month after discharge ($p = 0.034$). AS and LEDD were not statistically significant ($p = 0.137$ and $p = 0.076$).

Discussion

To prevent the deterioration of QOL of patients with PD after discharge from hospital, it is necessary to find important approach points for rehabilitation at hospitalization. This study focused on daily activities in the community before and after hospitalization using

Table 1. Characteristics of the participants

Characteristics	Hospitalization	Discharge	p-value
Sex (male/female)	6/6	–	–
Age (years)	75.3 ± 6.5	–	–
Duration of illness (months)	52.6 ± 39.2	–	–
Hoehn & Yahr stage[†]			
Stage I	1	1	
Stage II	6	9	
Stage III	4	2	0.667
Stage IV	1	0	
Stage V	0	0	
Living situation pre-hospitalization			
Members of the same family (yes/no)	11/1	–	–
Work (yes/no)	6/6	–	–
Purpose of hospitalization			
Drug-adjusted hospitalization	7	–	–
Scrutiny/diagnostic hospitalization	4	–	–
Emergency hospitalization	1	–	–
MMSE-J (points)	27.3 ± 2.1	–	–
LEDD (mg)[††]	392.9 ± 337.8	552.3 ± 251.5	0.014*
FIM total (points)[†††]	110.3 ± 19.3	117.6 ± 9.8	0.028*
Motor score (points)	77.7 ± 16.0	84.5 ± 7.6	0.028*
Cognitive score (points)	32.7 ± 4.2	33.1 ± 3.0	0.317
Occupational therapy during hospitalization			
physical training[a]		10	
basic action training[a]		10	
home exercise guidance[a]		8	
ADL/IADL training[a]		6	
Duration of hospitalization (days)	–	15.4 ± 5.6	–
Transfer destination (home)	–	12	–

Values represent n, mean ± standard deviation. Fisher's exact test was used for Hoehn & Yahr stage[†]. The Shapiro-Wilk test was used to confirm normality, the paired *t*-test was used for the LEDD[††], and Wilcoxon's signed rank test was used for the FIM score[†††]. a: Number of all participants who have implemented the program.
MMSE-J, Japanese version of Mini Mental State Examination; LEDD, Levodopa equivalent daily dose; FIM, Functional Independence Measure; ADL, activities of daily living; IADL, instrumental activities of daily living.
* $p < 0.05$

Table 2. The mean values and comparisons between the time of hospitalization and 1 month after discharge

	Hospitalization	1 month after discharge	p-value
LEDD (mg)	392.9 ± 337.8	564.9 ± 246.0	0.007**
PDQ-39 total (points)	69.3 ± 33.6	49.4 ± 25.3	0.017*
CAOD total (points)	50.1 ± 20.2	46.1 ± 26.7	0.582
AS total (points)	15.8 ± 7.7	18.5 ± 6.0	0.107

Values represent n, mean ± standard deviation. The Shapiro-Wilk test was used to confirm normality, Paired t-tests were used for item.
LEDD, Levodopa equivalent daily dose; PDQ-39, 39-item Parkinson's Disease Questionnaire; CAOD, Classification and Assessment of Occupational Dysfunction; AS, Apathy Scale.
* $p < 0.05$, ** $p < 0.01$

Table 3. Factors involved in changes in QOL as estimated by the GLMM

Explanatory Variables	Estimated value	Standard error	p-value
CAOD	0.34	0.16	0.034*
AS	1.05	0.71	0.137
LEDD	0.03	0.02	0.076
Assessment phase	−26.74	5.62	< 0.001***

QOL, Quality of Life; GLMM, Generalized linear mixed model; CAOD, Classification and Assessment of Occupational Dysfunction; AS, Apathy Scale; LEDD, Levodopa equivalent daily dose.
* $p < 0.05$, *** $p < 0.001$

CAOD and AS and examined their association with changes in QOL during hospitalization and discharge. Furthermore, factors related to changes in QOL of patients with PD were estimated by a GLMM using occupational dysfunction, apathy, and LEDD as explanatory variables and occupational dysfunction was identified. The ability to perform daily activities appropriately was possibly an important factor for QOL, despite the use of factors that may influence PD symptoms. In this study, most patients had a grade II or III H&Y severity classification, had an excellent cognitive function, and were independent in their ADL. After approximately two weeks of hospitalization and drug adjustment, the LEDD increased; however, there was no change in the H&Y severity classification and their FIM motor score was improved. Patients with PD who started levodopa therapy showed improvements in "motor experiences of daily living" and "motor examination" of the UPDRS and H&Y severity classification from baseline to 1 year [15]. In addition, regarding the process after the onset of PD, patients responded well to dopamine replacement therapy for about 5 years after the onset of motor symptoms and symptoms improved. Thereafter, it became difficult to treat them as the wearing-off phenomenon, dyskinesia, and other side effects of levodopa began to appear [16]. Because the duration of illness of the participants in this study ranged widely from 4 to 113 months, and because they were hospitalized for only 15.4 days, their ADLs improved but their severity of illness did not change. At one month after discharge, there were no significant differences in CAOD or AS, but improvement was observed in the PDQ-39. Meng et al. [17] reported that PD inpatients who received rehabilitation (e.g., physical function training and gait exercise) for two weeks showed improved total, mobility, emotional well-being, stigma, communication, and cognitive impairment scores on the PDQ-39 after three months, and intensive rehabilitation improves the QOL of patients with PD who have a low QOL. In this study, hospitalization including occupational therapy interventions, such as ADL training and physical function training may have improved the ADL at discharge and the QOL at one month after discharge. Furthermore, 42.7% of all participants had apathy at baseline and no change in apathy at 6, 12, and 18 months in an 18-month longitudinal study of PD patients with H&Y severity classification grade I-III with an average disease duration of 5.27 years [18]. In relation to QOL, patients with apathy have more functional disability, anxiety, and depression than those without apathy, and it is clear that these factors are related to a lower QOL. In this study—as in previous studies—there was no change in apathy. However, 66% of the patients had apathy at admission, which may lead to an increase in apathy and a decrease in QOL as the disease stage progresses. Apathy is one of the non-motor symptoms that precede the onset of motor symptoms [16], and it is necessary to focus on apathy from the early onset, through rehabilitation and other means, in order to prevent a decrease in QOL.

In contrast to findings on factors related to QOL, this study showed the importance of assessing the subjective status of daily activities, which cannot be determined by objective measures of ADL ability. CAOD was identified as a factor related to changes in QOL at one month after discharge from hospital. Regarding occupational dysfunction, Morohoshi et al. [9] reported that reducing occupational dysfunction may improve the QOL of elderly people living in the community who have physical dysfunction associated with orthopedic and neurological diseases such as stroke and PD. Although there was no change in CAOD one month after discharge from hospital, the participants were able to maintain their CAOD scores at hospitalization, which indicates that they perceived that they were able to perform daily activities appropriately as they did before hospitalization. Inpatients with PD who are hospitalized may show an improved QOL at one month after discharge by maintaining their pre-hospital condition without worsening their occupational dysfunction. It is important to focus on occupational dysfunction during the rehabilitation of inpatients. It was suggested that interventions focusing on daily activities that patients found difficult would improve their QOL in the community after discharge from hospital. AS and LEDD were not identified as explanatory factors for QOL. In the overall population, although apathy in outpatients with PD exceeded the cutoff value in 31.3% of patients at baseline, 35.0% of patients at 6 months, and 37.8% of patients at 18 months, it was reported that severe depression and motor symptoms, not apathy, were factors that predicted a worse QOL [19]. Regarding LEDD, Katia et al. [20] reported that the administration of dopamine improved the motor function and ADL in patients with

PD and improved their QOL at 3 and 6 months from the baseline period. AS and LEDD were not explanatory factors in this study because predictors of QOL at one month after discharge were examined. Further long-term data may need to be considered.

Participants in this study were inpatients with PD for whom occupational therapy was prescribed, however, we did not examine the specific content of the occupational therapy intervention. In the future, it will be necessary to examine the content of interventions and their effect on QOL to consider interventions in occupational therapy during hospitalization for the purpose of maintaining and improving QOL. CAOD was identified as a factor related to changes in QOL, even though CAOD did not significantly improve at one month after discharge from hospital in comparison to during hospitalization. Participants with different purposes of hospitalization were included, and CAOD might have changed if the purpose of hospitalization could have been controlled for. Furthermore, although the GLMM provides an adequate estimator even with a small number of participants [13], it might have provided more clarity on factors related to changes in QOL if more than 12. However, this study was successful in collecting data on QOL and occupational dysfunction after discharge from hospital, despite the lack of existing studies examining community life after discharge in inpatients with PD, which is a progressive disease. The results of this study were useful in helping to identify points of approach for occupational therapy during the hospitalization of patients with PD to maintain their QOL in the community.

Conclusions

This study was conducted to investigate changes in QOL, occupational dysfunction, and apathy in patients with PD during hospitalization and one month after discharge, and to examine factors related to changes in QOL. The patients' QOL improved before and after hospitalization, while their occupational dysfunction and apathy were not changed. In addition, CAOD was identified as a factor related to changes in QOL. The subjective status of being able to perform daily activities appropriately in the community after discharge from hospital as before hospitalization may affect the QOL in the first month after discharge from hospital. It was suggested that focusing on and supporting patients' occupational dysfunction contributes to their QOL in the community after discharge from hospital.

Conflict of interest statement

The authors declare no conflicts of interest in association with the present study.

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■ORIGINAL ARTICLE

Postoperative Effects of Occupation-Based Interventions in Patients with Brain Tumors: A Pilot Study

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Abstract: Objective: Considering that cases of brain tumor are increasing globally, addressing anxiety and depression in patients while coping with treatment-related adverse events is important. Hence, in this study, we aimed to test and compare the effectiveness of two types of interventions in patients with brain tumors who underwent craniotomy: (1) an occupation-based intervention designed with an occupational choice-decision support system and (2) an impairment-based intervention.
Methods: For this prospective parallel-group study, we screened 101 patients who underwent brain tumor resection during the study period; 59 patients were excluded because they did not meet the eligibility criteria (n = 40) or due to missing data (n = 19), and ultimately, 42 patients were included in the analysis. Propensity score matching to pair six cases from each group with a patient with similar background characteristics was performed. The duration of treatment was until discharge. Anxiety and depression were evaluated using the Hospital Anxiety and Depression Scale.
Results: The occupation-based intervention group showed a significant improvement in anxiety ($p < 0.05$). Depression was significantly worse after the intervention in a pre- and post-intervention comparison of the occupation-based intervention group ($p < 0.05$).
Conclusion: Implementing interventions and guidance targeting meaningful and instrumental activities of daily living based on clear goals that are aligned with patient expectations could influence the psychological state of patients at discharge from the hospital, reducing anxiety after discharge. The depressive symptoms may be influenced by the environment owing to the outbreak of the new coronavirus during the intervention period (UMIN Test ID: UMIN000043614).

Keywords: brain tumor, brain surgery, tumor resection, occupation-based intervention, Aid for Decision-making in Occupation Choice

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Introduction

The number of patients with brain tumors is increasing worldwide, with 21.3 cases per 100,000 people in 2014 [1]. In Japan, the number of cases increased from 3.5 cases per 100,000 people per year in 2000 to 4.1 cases per 100,000 people per year in 2015 [2]. The principal factors contributing to this surge in case numbers are an increased awareness of diagnostic screening for brain diseases and prolonged life expectancy.

Brain tumor disease is characterized by symptoms such as headache (50%), epileptic seizure (20–50%), cognitive dysfunction (30–40%), and neurological impairment (10–40%) [3]. Additionally, 41% and 48% of patients may present with depression and anxiety, respectively [4]. Among cancers, patients with brain tumors

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exhibit the highest incidence of depressive symptoms, surpassing that of the general population by more than nine times [5]. As these psychiatric symptoms are associated with a reduced quality of life (QoL), shorter survival, and suicidal ideation in patients undergoing surgery for brain tumors [6], rehabilitation intervention for symptoms of anxiety and depressive are important.

Interventions for the rehabilitation of patients with brain tumors are currently the same as those used for patients with stroke. However, brain tumors differ from stroke because of their progressive nature and the various adverse events associated with treatment [7]. Multidisciplinary rehabilitation [8], upper limb dysfunction [9], cognitive impairment [10, 11], QoL [12, 13], activities of daily living (ADL) [14], and depression [15, 16] have been identified as specific targets for rehabilitation in patients with brain tumors. Interventional studies on the role of occupational therapists (OTs) in promoting the participation of patients with cancer in activities are needed. Occupational therapy interventions, using a health promotion approach, may encourage participation in meaningful activities, including exercise [17]. Occupation-based intervention (OBI) is especially used to promote well-being in patients with cancer. Sagari et al. [18] reported that in patients who underwent hematopoietic stem cell transplantation, a meaningful OBI established using the Aid for Decision-making in Occupation Choice (ADOC) resulted in a greater improvement in QoL and mental health than an intervention focused on disability and physical function, also known as impairment-based intervention (IBI). OBI also exhibits beneficial effects on anxiety and depressive symptoms in patients with burns [19].

OBI is a comprehensive conceptual framework of occupational therapy based on the theory of occupational behavior proposed by Reilly [20]. OBI is an intervention wherein assessment and intervention are occupation-based and focused on meaningful goals shared by the patient and therapist [21]. OTs assess a patient's disability and incorporate interventions that focus on the individual's life activities to maintain the patient's health. OTs in Japan often use goal-setting tools such as the Activities of Daily Living Improvement Management and the Canadian Occupational Performance Measure (COPM) to implement OBI [22, 23]. Recently, Japanese OTs have developed an iPad application called ADOC to facilitate participation in in-activity decision-making and work-based goal setting [24]. The ADOC application allows clients and OTs to select important tasks from a list of daily life task illustrations. The effectiveness of OBI using ADOC has been reported in patients [25], highlighting the utility of ADOC when performing OBI.

Except for a few case reports, no interventional study has investigated the effect of OBI in patients with brain tumors [26]. Moreover, comparative studies, which are rare in patients with brain cancer [9], even in Western countries, tend to focus primarily on improvement in cognitive/physical function. Studies examining the effectiveness of maintenance or improvement interventions are lacking, especially for anxiety and depressive symptoms [27]. These gaps in the literature have contributed to the assessment of the effect of OBI in patients with brain tumors becoming an urgent issue. As OBI is effective in addressing psychiatric symptoms [18, 19], it may be applicable in patients with brain tumors. Therefore, in this study, we aimed to investigate whether OBI-based Occupational therapy is effective in maintaining and improving anxiety and depression in patients with brain tumors. We utilized the ADOC to set goal tasks and compare the outcomes of a meaningful OBI to those of an IBI.

Methods

Study Design

This prospective parallel-group study was performed at a single center, conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of the Shinshu University Faculty of Medicine (test number: 5029). The study was registered with the UMIN Clinical Trial Registry System (UMIN Test ID: UMIN000049799). Written informed consent was obtained from all study participants.

Study Population

The study participants were patients who had undergone surgical brain tumor resection. The eligibility criteria were as follows: age ≥ 20 years, ability to provide informed consent for participation, tumor resection that included craniotomy, no history of congenital disorders or diseases of the central nervous system, and a Mini-Mental State Examination-Japanese Version (MMSE-J) score of ≥ 24. Symptoms of anxiety and depression and QoL assessment were set at an MMSE score ≥ 24 owing to the nature of the self-administered assessment.

Participants

Between January 1, 2020 and January 31, 2022, 101 in-patients were enrolled in the study. Eligible patients hospitalized between January 1, 2020 and March 31, 2021 were assigned to the IBI group, and those hospitalized between April 1, 2021 and January 31, 2022 were assigned to the OBI group. The IBI group served as the control group, and the OBI group was the intervention

group with an established intervention protocol.

Intervention

The intervention was initiated after surgery. All interventionists were OTs trained in OBI using ADOC. Each intervention was conducted five times a week for 20–60 min. The duration of intervention was 2–3 weeks. Interventions began one day after surgery and the general condition of the patients was monitored.

Intervention in the OBI group proceeded following similar intervention rates to the extent feasible [18, 25]. The intervention method based on the definition of OBI was as follows: first, the patient and OT shared goals, and the patient and OT assessed and intervened on the identified meaningful tasks; the OTs assessed the actual performance of the meaningful tasks and intervened in real situations to determine how the meaningful tasks could be accomplished. Occupational therapists interviewed the patients using ADOC four days after surgery when their general condition was stable to identify occupational therapy goals. The subjects were asked to select important tasks applicable to "things they want to be able to do," "things they want to try anew," "things they have trouble doing," "things they are worried about," and "things they need to be able to do." Thereafter, two-thirds of the participants received intervention for the meaningful tasks selected by ADOC, and one-third received functional practice associated with the tasks selected by ADOC. For example, when the ADOC-selected task was cooking, a situation that simulated the home environment was set up, and the participants practiced making items that they frequently made at home for family members. At the final intervention, specific written instructions were provided for the tasks selected in the goal setting.

Impairment-based intervention focuses on the patient's disability or psychosomatic function and structure and is defined as an intervention aimed at improving functional impairment [18, 25]. In the IBI group, referring to protocols from similar intervention studies, after assessment of motor and cognitive functions, two-thirds of the patients practiced functions, and one-third practiced ADL and instrumental ADL (IADL) [18, 25]. Goal-setting tools such as ADOC and COPM were not used. Functional exercises included aerobic exercise, strength exercises, balance exercises (modified Borg Scale score 4 or higher), and cognitive training.

Outcomes

Patient demographic and clinical characteristics (e.g., age, sex, grade of tumor, postoperative chemotherapy, postoperative radiation therapy, marital status, employment status, duration of hospitalization, and time since surgery) were collected from clinical records. For the pre-intervention baseline evaluation, patients who met the eligibility criteria were informed of the purpose of the study, and informed consent was obtained. The pre-intervention baseline assessment was performed one to two days prior to surgery. Rehabilitation interventions were initiated postoperatively and completed at discharge or transfer, during which participants' baseline demographics and rehabilitation were assessed.

The main outcomes were anxiety, depression, and QoL. Anxiety and depression were assessed using the Hospital Anxiety and Depression Scale (HADS) [28]. The HADS comprised seven items for anxiety (HADS-A) and seven items for depression (HADS-D). The total score obtained from both subscales (HADS-A + HADS-D) were used to assess symptoms of depression and anxiety. The items are rated on a 4-point scale from 0 to 3, with higher scores indicating higher levels of anxiety and depression. QoL was assessed using the Core Quality of Life questionnaire (QLQ-C30) developed by the European Organization for Research and Treatment of Cancer (EORTC) [29]. This questionnaire contains 30 items that assess health-related QoL in cancer patients using global health status or QoL, functional, and symptom scales. The functional scale includes physical, role, cognitive, emotional, and social status items, while the symptom scale includes items assessing nausea and vomiting, fatigue, dyspnea, pain, insomnia, loss of appetite, diarrhea, and financial status. Higher scores on the global health status and functional scales indicate good QoL, while higher scores on the symptom scale indicate a greater symptom burden.

The secondary outcomes were hemiplegia, muscle strength, gait speed, cognitive function, and ADL. Hemiplegia was assessed using the Brunnstrom recovery stages (BRS) [30]. Muscle strength was assessed by hand-grip strength using a Jamar hydraulic hand grip dynamometer. Gait speed was assessed using the 10-m Walk Test (10MWT) [31]. Cognitive function was evaluated using the MMSE-J [32]. The ability to perform ADLs was assessed using the Functional Independence Measure (FIM) [33].

Propensity Score Matching

In the comparative analysis between the OBI and IBI groups, propensity score matching was employed to align the background factors of the two groups [34]. To calculate the propensity score, we used logistic regression and included the length of hospital stay, which was significantly different between groups. Additionally, logistic regression analysis was performed by adding FIM motor and cognitive items as explanatory variables for ADL [35] and cognitive function [36] variables,

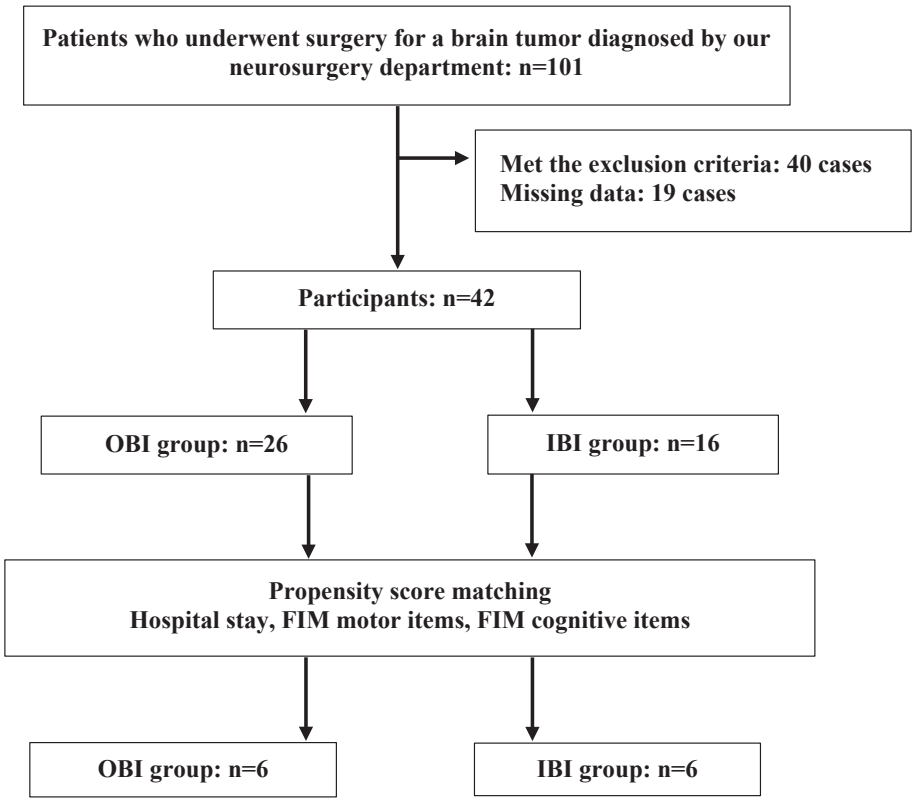

Fig. 1. Flowchart of patient selection.
OBI, occupation-based intervention; IBI, impairment-based intervention; FIM, functional independence measure.

which are predictors of anxiety and depression, and one-to-one matching was performed.

Statistical Analysis

Propensity score matching was performed to pair six cases from each group with similar background characteristics. The χ^2 test and Mann–Whitney *U* test were used to compare patient demographics and final assessment data between the groups. The Wilcoxon signed-rank test was used to compare the pre- and post-intervention endpoints in each group. The bell curve feature in Excel 2016 (Social Survey Research Information Co., Ltd. Tokyo, Japan) was used for statistical analysis. For all analyses, a *p*-value less than 0.05 was considered to indicate a statistically significant difference.

Table 1 Patient and clinical characteristics.

Characteristics	IBI group ($n = 6$)	OBI group ($n = 6$)	*p*-value
Sex (male)	2 (33%)	1 (17%)	0.505[a]
Age (years)	54.3 ± 10.7	42.8 ± 17.4	0.149[b]
WHO grade	2.8 ± 1.5	1.8 ± 1.2	0.218[b]
Postoperative chemotherapy	0 (0%)	0 (0%)	1[a]
Postoperative radiation therapy	0 (0%)	0 (0%)	1[a]
Married	5 (83%)	5 (83%)	1[a]
Employed	4 (67%)	3 (50%)	0.558[a]
Hospitalization period (days)	17.8 ± 1.3	17.3 ± 1.8	0.558[b]
Postoperative period (days)	11.2 ± 1.5	10.3 ± 2.3	0.217[b]

Numerical values are represented as mean ± standard deviation.
OBI, occupation-based intervention; IBI, impairment-based intervention; WHO, World Health Organization
[a] χ^2 test
[b] Mann–Whitney *U* test

Results

Overall, 101 patients who underwent brain tumor resection between January 1, 2020 and January 31, 2022 were screened; 59 were excluded for not meeting the eligibility criteria ($n = 40$) or due to missing data ($n = 19$), and ultimately, 42 were included in the analysis. Eligible patients hospitalized between January 1, 2020 and March 31, 2021 were assigned to the IBI group ($n = 16$), and those hospitalized between April 1, 2021 and January 31, 2022 were assigned to the OBI group ($n = 26$). Propensity score matching was used to select six cases each from the OBI and IBI groups to align the background factors (Fig. 1).

The patient demographics and baseline clinical characteristics are presented in Table 1. There were no significant differences in patient characteristics between the groups. The most frequently selected categories for

Table 2 Inter-group and intra-group comparisons of assessments in the control and intervention groups

	IBI group (n = 6)		OBI group (n = 6)		Baseline	OBI vs. IBI	Before and after IBI intervention	Before and after OBI intervention
	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention				
BRS upper limb	6 (6–6)	6 (6–6)	6 (6–6)	6 (6–6)	–	–	–	–
BRS fingers	6 (6–6)	6 (6–6)	6 (6–6)	6 (6–6)	0.361	0.317	–	–
BRS lower limbs	6 (6–6)	6 (6–6)	6 (6–6)	6 (6–6)	–	–	–	–
Grip strength	22 (21–35)	25.8 (25.8–34.8)	14.8 (11–22)	22.5 (22.5–24.5)	0.230	0.462	0.096	0.068
10 m (comfortable)	6.1 (6.1–6.5)	6.9 (6.9–9.5)	6.3 (6.3–7.2)	7.9 (7.9–9.2)	0.654	0.654	0.285	0.715
10 m (max)	5.7 (5.7–6.0)	11.5 (11.5–14.3)	4.0 (4–4)	6.0 (6–6.2)	0.087	0.328	0.002*	0.144
FIM total	126 (126–126)	126 (126–126)	126 (126–126)	126 (126–126)	0.138	0.400	0.317	0.179
FIM motor	91 (91–91)	91 (91–91)	91 (91–91)	91 (91–91)	0.138	0.317	0.317	–
FIM cognitive	35 (35–35)	35 (35–35)	35 (35–35)	35 (35–35)	–	0.139	–	0.179
MMSE-J	28.5 (28.5–29)	29.5 (29.5–30)	29.5 (29–30)	29.5 (29–30)	0.075	0.817	0.285	0.563
EORTC physical functioning	90 (90–98.3)	87 (87–87)	96.5 (96.5–100)	93 (93–98.3)	0.404	0.325	0.892	0.157
EORTC role functioning	91.5 (91.5–100)	83 (83–95.8)	100 (100–100)	75 (75–95.8)	0.531	0.741	0.285	0.102
EORTC cognitive functioning	83 (83–95.8)	91.5 (91.5–100)	100 (100–100)	83 (83–95.8)	0.071	0.422	0.102	0.058
EORTC emotional functioning	75 (75–81)	79 (79–95.8)	87.5 (87.5–100)	89 (89–100)	0.370	0.737	0.130	1.000
EORTC social functioning	67 (67–91.8)	67 (67–67)	100 (100–100)	91.5 (91.5–100)	0.138	0.361	0.285	0.179
EORTC global health status	41.5 (41.5–50)	54 (50–64.8)	79 (79–83)	50 (50–50)	0.018*	0.157	0.207	0.045*
EORTC fatigue	16.5 (16.5–30.3)	33 (33–33)	11 (11–22)	27.5 (27.5–33)	0.557	0.44	0.140	0.063
EORTC nausea and vomiting	8.5 (8.5–17)	0 (0–0)	0 (0–0)	0 (0–0)	0.055	0.902	0.705	0.317
EORTC pain	0 (0–24.8)	33 (21–33)	0 (0–0)	24.5 (4–33)	0.460	0.557	0.102	0.140
EORTC dyspnea	16.5 (16.5–33)	33 (33–33)	0 (0–0)	0 (0–24.8)	0.241	0.212	0.179	0.317
EORTC insomnia	33 (33–33)	33 (33–33)	0 (0–0)	33 (33–57.8)	0.082	0.528	1.000	0.039*
EORTC appetite loss	33 (33–33)	0 (0–24.8)	0 (0–24.8)	33 (33–33)	0.268	0.074	0.317	0.058
EORTC constipation	33 (33–58.5)	33 (8.3–33)	0 (0–0)	33 (33–33)	0.071	0.93	0.683	0.102
EORTC diarrhea	0 (0–0)	0 (0–0.8)	0 (0–0)	0 (0–0)	1.000	0.598	0.785	1.000
EORTC financial difficulties	0 (0–24.8)	0 (0–0.8)	0 (0–24.8)	33 (33–33)	1.000	0.138	0.654	0.102
HADS Anxiety	5.5 (5.5–6.8)	6 (6–8.5)	5.5 (5.5–6.8)	2.5 (2–3)	0.935	0.040*	0.246	0.027*
HADS Depression	8 (8–8.8)	9 (9–9.8)	6 (5–7)	10.5 (10.5–11.8)	0.226	0.328	0.104	0.025*
HADS Anxiety + Depression	12.5 (12–15.3)	15 (15–17.8)	10.5 (10.5–14.8)	12.5 (12.5–15.3)	0.469	0.335	0.113	0.130

Values are represented as median (1st quartile to 3rd quartile).
BRS, Brunnstrom recovery stages; EORTC, European Organisation for Research and Treatment of Cancer; HADS, Hospital Anxiety and Depression Scale; FIM, Functional Independence Measure; MMSE-J, Mini-Mental State Examination-Japanese Version; IBI, impairment-based intervention; OBI, occupation-based intervention
OBI: Occupational therapy focused on meaningful occupation for goals shared by the patient and therapist.
IBI: Occupational therapy focused on disability or psychosomatic function and structure.
Baseline: The pre-intervention baseline assessment was performed one to two days prior to surgery.
*$p < 0.05$

setting ADOC goals were driving, work, and cooking, in that order. A comparison of the post-intervention OBI group and IBI group showed significant improvement in HADS-A items in the OBI group ($p < 0.05$). A significant worsening in 10MWT (max) items in the IBI group after intervention ($p < 0.05$) was observed when the groups were compared pre- and post-intervention. The OBI group showed a significant worsening in overall QoL, insomnia, and HADS-D after the intervention ($p < 0.05$). There were no differences in the other endpoints (Table 2).

Discussion

Although earlier studies have examined the effectiveness of OBI using the ADOC under some conditions, this study is the first to examine the effectiveness of an OBI in patients undergoing rehabilitation following brain tumor surgery. Patients who received OBI showed greater improvement in anxiety than the group that received IBI.

Our research is modeled after the study conducted by Sagari et al. [18], who examined the effectiveness of OBI using ADOC in patients with hematopoietic tumors. Their study reported greater improvements in QoL and mental health in patients who received OBI than in those who received IBI. Other studies reported beneficial effects of OBI on anxiety and depressive symptoms in patients with burns [19]. This finding was concurrent with our study, in which implementation of OBI reduced anxiety in patients who had undergone cerebral surgery for brain tumors.

In our study, patients who received OBI were required to engage in selective meaningful occupation-based tasks based on the goals established using the ADOC during their hospitalization. Patients with glioma

who undergo craniotomy have been reported to experience a cognitive decline for several months after surgery [37]. Therefore, such patients could be anxious about social participation after discharge from the hospital [38]. We hypothesized that the implementation of interventions and guidance based on clear goals established using the ADOC, targeting meaningful ADLs and IADLs, which were in line with the patient's expectations, could influence the psychological state of patients about to be discharged from the hospital and help reduce anxiety and promote social participation after discharge.

In this study, we found that OBI can be implemented early in the postoperative period for patients with brain tumors. Occupational therapy provided in hospitals overseas does not provide adequate OBI due to lack of treatment time and equipment [39]. Patient-centered goal setting has also been reported to be difficult to implement in a hospital setting [40]. This is also true for post-operative brain tumor patients; there are only a few reports on interventions offered in hospitals focusing on improving physical function [9]. However, in this study, joint decision-making was conducted using an illustrated goal-setting tool called ADOC, which allowed the intervention to focus on the tasks that the patients valued early in the postoperative period. The patients were discharged directly from the hospital, and their ability to self-manage their lives was considered important. This was easier to teach in the OBI than in the IBI and may have contributed to the success on the anxiety items.

In the OBI group, there was significant improvement in HADS-A results after intervention, but HADS-D results worsened. The timing of the evaluation in this study was set at baseline before surgery and at discharge after the intervention. A previous study had reported that depressive symptoms in patients with brain tumors worsened during the postoperative weeks compared to those in the preoperative period [41]. A study on the postoperative course of patients with digestive cancer reported that anxiety symptoms initially improved after surgery, followed by a delay in the improvement of depressive symptoms [42]. As the average postoperative hospital stay of the patients in our study was only 11 days, depressive symptoms may have improved in the future considering the early improvement observed after OBI. Given that anxiety symptoms occur more frequently than depressive symptoms [4], this intervention is applicable to many patients. Additionally, improvement in anxiety symptoms is important for working-age patients with brain tumors, enabling them to engage in high-level activities, such as work and household chores, soon after hospital discharge.

Additionally, a new type of coronavirus was prevalent during the intervention period, and the older adults in the community feel more isolated and less socially involved owing to their inability to go outside to prevent infection [43]. The same is true for younger patients, whose remote work reduces opportunities for social interaction and may affect psychological distress [44]. These findings suggest that the environment in which it is difficult to practice the activities selected in the OBI may have influenced the depressive symptoms.

Between the pre- and post-intervention, the OBI group showed worsening overall QoL, insomnia, and HADS-D. This finding is consistent with the fact that insomnia, which occurs in approximately 50% of patients who undergo brain surgery [45], is associated with global health status/QoL [46] and symptoms of depression [47] as measured using the EORTC questionnaire. Therefore, insomnia likely affects the global health status/QoL in these patients negatively. Furthermore, the overall QoL and insomnia scores of the OBI group, as measured by the preoperative EORTC, were better than the global reference value of the EORCT in patients with brain tumors [48]. Therefore, the difference between the pre-intervention and postoperative period was expected. However, despite these trends, anxiety can be alleviated in patients with brain tumors who received OBI, albeit temporarily.

According to previous studies employing similar interventions, the intervention period was implemented for 4 to 17 weeks [18, 25, 39]. In the current study, most of the patients were discharged from the hospital approximately 11 days after surgery; thus, the short duration of interventions and the difficulty in promoting behavioral change and motor learning were likely responsible for the discrepancy in QoL results and social function. While extending the intervention period is challenging in the acute phase in Japan, healthcare systems in other countries may allow for longer interventions. In Japan, post-discharge follow-up and interventions should be considered to improve self-management skills in the future.

Our study has a few limitations. First, the lesion, surgery, and frequency of intervention by physical and speech therapists may have affected the results. In addition, although neuropsychological examination was conducted using the MMSE, the results may have been affected by the lack of detailed testing for memory impairment and executive dysfunction. Second, the sample size was small. The sample size was calculated using G*Power [49], but with significantly fewer study participants. The coronavirus epidemic during the period of this study made it difficult to recruit study participants due to inpatient restrictions, which may have affected the sample size. Third, the study did not employ a randomized controlled trial design, which may have

introduced various biases. We are currently conducting another study with a larger sample size to examine the usefulness of this program in a randomized controlled trial setting.

Notwithstanding the limitations, this study is the first to examine the efficacy of OBI postoperatively in patients with brain tumors. In this study, we report that OBI, which involved tasks derived from goal setting in the early postoperative period considering life after hospital discharge, reduced post-discharge anxiety. If the desired effect is achieved, a new perspective on occupational therapy strategies for patients with brain tumors can be obtained. In addition, because OBI incorporates many practical exercises, the benefits may aid in the return to work and society.

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Conflict of Interest

There are no conflicts of interest to disclose with regards to this study.

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■ORIGINAL ARTICLE

The Relationship between Activity and Participation and the Quality of Life of People with Dementia in Care Facilities

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Abstract: Background: Quality of life (QOL) for people with dementia is a concept that includes not only functional disability and ability to perform activities of daily living (ADL) but also engagement in activity/participation. Previous studies have not included all variables related to functional disability, ability to perform ADL, and activity/participation in their analyses, and it is unclear the extent to which these factors are associated with QOL. Thus, this study aimed to identify factors associated with the QOL of institutionalized people with dementia by including functional factors and activity/participation reported in previous studies as variables.
Methods: This was a cross-sectional study. Multiple regression analysis with the forward-backward stepwise selection method was performed to analyze factors associated with QOL of institutionalized people with dementia, including the number of items of activity/participation, cognitive function, ADL independence, behavioral and psychological symptoms of dementia (BPSD), pain, and overall muscle strength, all of which have been reported to be associated with QOL.
Results: The number of items of activity/participation and BPSD were significantly associated with subjective QOL, wheras BPSD, the number of items of activity/participation, and ADL independence were significantly associated with objective QOL.
Conclusion: Activity/participation may be one of the significant factors associated with QOL of institutionalized people with dementia. Additionally, BPSD and ADL independence are important factors associated with QOL. A comprehensive combination of approaches that increase activity/participation, reduce BPSD, and improve ADL independence has the potential to improve the QOL of institutionalized people with dementia.

Keywords: dementia, quality of life, activity and participation

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Introduction

In developed countries, including Japan, the aging of society poses increasingly serious challenges. The number of people with dementia in aging societies is increasing rapidly.

Dementia is one of the most serious health problems among older adults. Approximately 6 million people in Japan had dementia in 2020, and many of them required nursing care and living in care facilities while receiving specialized care and support [1]. People with dementia experience a decline in activities of daily living (ADL) due to cognitive impairment. The functional decline in dementia is progressive and irreversible, and interventions are only effective in controlling the disease progression without fundamental improvements [2]. Therefore, it is important to support people with dementia in improving their quality of life (QOL) while acknowledging their functional decline [3, 4].

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Lawton proposed that QOL for people with dementia includes not only functional disability and ability to perform ADL but also engagement in activity/participation [5]. Previous research has shown the associations between QOL of institutionalized people with dementia and various factors, including cognitive function [6], ADL independence [6], behavioral and psychological symptoms of dementia (BPSD) [7], pain [8], and overall muscle strength [9]. These studies indicate how functional impairments and limitations in ADL performance contribute to reduced QOL for institutionalized people with dementia [6–9]. Regarding the association between activity/participation and QOL, Brooker et al. reported that interventions to increase diversity in activities improved the QOL of institutionalized people with dementia [10]. Furthermore, a systematic review by Uceda-Portillo et al. showed that engagement in a wider range and variety of activity/participation is essential for improving the QOL of institutionalized people with dementia [11]. These findings indicate that activity/participation, specifically engaging in a wider variety of activity/participation, can enhance QOL for people with dementia [10, 11]. Therefore, it was inferred that engaging more items of activity/participation would be important factor in improving QOL [10, 11]. Thus, although numerous factors have been reported to be associated with the QOL of institutionalized people with dementia [6–11], previous studies have not included all variables among functional disability, ability to perform ADL, and activity/participation in their analyses [5], and the extent to which these factors are associated with QOL remains unclear.

The number of items of activity/participation is limited by the decline in cognitive and physical functions in institutionalized people with dementia [12]. However, even if cognitive, physical functions and ability to perform ADL decline, it is possible to increase the number of items of activity/participation [13] and achieve a high QOL through environmental adjustments and staff involvement [10]. Thus, we predicted that the number of items of activity/participation would be one of the important factors associated with QOL in institutionalized people with dementia [10, 11] and that QOL would be explained by several of functional factors reported in previous studies [6–9] in addition to the number of items of activity/participation.

This study aimed to identify factors associated with the QOL of institutionalized people with dementia by including them as variables of the functional factors and the number of items of activity/participation reported in previous studies [6–11]. This study will allow us to investigate whether and to what extent QOL and the number of items of activity/participation are associated, including previously reported factors [6–9]. Activity/participation is an important factor that can be improved by nonpharmacologic interventions and support. This study may help develop rehabilitation programs and care systems for people with dementia, thus improving their QOL.

Materials and methods

Study design

This was a cross-sectional study conducted at elderly care facilities in Japan between August 2021 to June 2023.

Participants

Older adults with dementia residing in two elderly care facilities in Aichi Prefecture, Japan, were included in this study. Dementia was diagnosed based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition criteria. The inclusion criterion was older adults aged 65 years or above who had mild to moderate cognitive impairment, as indicated by a Mini-Mental State Examination (MMSE) score ranging from 10 to 23 [14]. The exclusion criteria included older adults with severe cognitive impairment (MMSE $\leq$ 9), significant visual or hearing impairment, or speech impairment hindering communication with the examiner.

Measurements

QOL

Self-report subjective QOL scales and proxy-report objective QOL scales have been developed to assess the QOL of people with dementia, and the importance of assessing both has been reported [5, 15]. Both subjective and objective QOL were evaluated using the Japanese version of the Quality of Life in Alzheimer's Disease (QOL-AD) [16, 17]. The QOL-AD is a widely used dementia-specific scale developed by Logsdon et al. [18]. It is a highly reliable and valid tool for assessing the QOL of people with mild to moderate dementia (MMSE $\geq$ 10 points) and can be used to assess both subjective and objective QOL [19]. The QOL-AD comprises 13 items, including physical health, energy, mood, living situation, memory, family, marriage, friends, self as a whole, ability to do chores around the house, ability to do things for fun, financial situation, and life as a whole. Following the scoring instructions, participants who had no family members were asked about blood relatives, and those not married were asked about their closest relatives. Although most participants did not do chores, they were asked to indicate how they felt about their ability to do chores. Each item is scored on a 4-point scale (1 = "poor," 2 = "fair," 3 = "good," 4 = "excellent").

The total score ranges from 13 to 52, with higher scores indicating a better QOL.

Activity/participation

The number of items of activity/participation at the time of the survey was measured using the Activity Card Sort-Japan Version (ACS-JPN). The original ACS [20] was developed in the United States and has been modified to align with cultural and social contexts [21–25]. The ACS-JPN was developed to fit the Japanese social and cultural contexts [26], enabling quantitative measurement and statistical analysis of activity/participation among older adults in Japan. The ACS-JPN comprises 72 activity items covering four domains: instrumental ADL, low-physical-demand leisure activities, high-physical-demand leisure activities, and social and cultural activities. In the ACS-JPN, a photo card representing an activity from one of these categories is presented, and the client or caregiver reflects on the situation and categorizes the activity based on whether it is performed or not.

Cognitive function

Cognitive function was evaluated using the MMSE [27]. The MMSE is the most widely employed screening instrument for cognitive impairment. A lower score on the MMSE, ranging from 0 to 30, indicates a greater degree of cognitive impairment.

ADL independence

Independence in ADL was evaluated using the Barthel Index (BI) [28]. The BI comprises 10 fundamental ADL items, including feeding, grooming, bathing, dressing, bowel and bladder control, toilet use, transfers, mobility, and stair climbing. The total score ranges from 0 to 100, indicating the individual's ability to perform the activity independently. Higher scores reflect a higher level of independence, whereas lower scores indicate a higher level of dependence and functional impairment.

BPSD

BPSD was assessed using the Neuropsychiatric Inventory-Nursing Home version (NPI-NH) [29]. The NPI-NH is a specifically designed tool for evaluating and quantifying BPSD in nursing home residents. It measures the frequency and severity of 10 commonly observed psychiatric symptoms in people with dementia, including delusions, hallucinations, agitation, depression, anxiety, euphoria, apathy, disinhibition, irritability/lability, and aberrant motor behavior. Caregivers rate for both the frequency and severity of these 10 items. The total score ranges from 0 to 120. A higher score indicates a higher severity of BPSD.

Pain

Pain levels were evaluated using the Numerical Rating Scale (NRS) [30]. The NRS is commonly used to assess the intensity of pain experienced in the entire body or a specific body part. NRS is an 11-point scale ranging from 0 (no pain) to 10 (unbearable pain). People verbally provide a number to indicate the intensity of their current pain. The NRS is suitable for people with mild-to-moderate cognitive decline [31].

Grip strength

Grip strength is an indicator of overall muscle strength [32]. Since not all participants were able to stand, measurements were conducted in a seated position, either in a chair or a wheelchair, to ensure standardized conditions. A Smedley grip strength meter was used, and measurements were taken twice on each side. The average of the maximum values from both sides was then calculated and used for analysis.

Procedures

Occupational therapists, physical therapists, and caregivers at the facility cooperated in the assessment of each outcome. The subjective QOL was evaluated through interviews conducted by occupational therapists with the participants using an interview format. The objective QOL, activity/participation, and BPSD were evaluated by caregivers who provide daily care for the residents. Pain and grip strength assessments were conducted by occupational therapists and physical therapists, respectively.

Data analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences for Windows (version 27.0, IBM Corp., Armonk, NY, USA). Continuous variables were tested for normal distribution using the Shapiro–Wilk test.

Multiple regression analysis with the forward–backward stepwise selection method was performed to investigate the factors associated with QOL. Variables with multicollinearity effects were excluded based on correlation analysis (correlation coefficient (r) > 0.9) [33]. The dependent variables included subjective and objective QOL-AD, whereas the independent variables included ACS-JPN, MMSE, BI, NPI-NH, NRS, grip strength, age, and gender. Separate multiple regression models were created for subjective and objective QOL-AD. The relationships between the independent and dependent variables were analyzed.

Ethics

This study was approved by the Ethics Committee

(Approval No.: 21-009) and the procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki. Informed consent was obtained from the family members of the participants, and written consent was obtained. The participants received oral and written explanations of the study, and informed assent was obtained before the initiation of the study. They were informed that their participation was voluntary, there would not be any disadvantages if they chose not to participate, and they had the right to withdraw from the study at any time.

Results

Participant characteristics

We identified 91 residents from the target facilities. Among them, 24 had severe dementia and 14 were not diagnosed with dementia. Overall, 53 participants were included in this study. Of the 53 participants, 19 were males, and 34 were females, with an average age of 86.0 ± 5.7 years. All participants agreed to participate in the study. Table 1 presents the means and standard deviations for each measurement item. The mean scores for subjective and objective QOL-AD were 29.8 ± 6.5 and 26.9 ± 4.9, respectively. According to the result of the Shapiro–Wilk test, all measures were assumed to be normally distributed except for gender.

Table 1 Attributes of participants and assessment results

Characteristic	N = 53
Sex	
Female	34 (64%)
Male	19 (36%)
Age: 86.0 ± 5.7 (mean ± SD)	
QOL-AD	
Subjective	29.8 ± 6.5
Objective	26.9 ± 4.9
ACS-JPN	12.8 ± 3.2
MMSE	15.7 ± 3.2
BI	54.5 ± 19.3
NPI-NH	5.6 ± 4.3
NRS	0.58 ± 0.95
Grip strength (N)	114.9 ± 38.9

Notes: QOL-AD = Quality of Life in Alzheimer's Disease. ACS-JPN = The Activity Card Sort-Japan Version. MMSE = The Mini-Mental State Examination. BI = The Barthel Index. NPI-NH = The Nursing Home Version of the Neuropsychiatric Inventory. NRS = The Numerical Rating Scale.

Multiple regression analysis

All variables were included as independent variables in the multiple regression analysis based on the correlation analysis. The analysis results revealed a significant association between the ACS-JPN score (β = 0.501, $p < 0.001$) and the NPI-NH score (β = −0.380, $p < 0.001$) and the subjective QOL score (adjusted R^2 = 0.575) (Table 2). Furthermore, a significant association was observed between the NPI-NH score (β = −0.510, $p < 0.001$), the ACS-JPN score (β = 0.387, $p < 0.001$), and the BI score (β = 0.183, p = 0.025) and the objective QOL score (adjusted R^2 = 0.676) (Table 3). The residuals did not exceed ± 3, and the Shapiro–Wilk test confirmed that the residuals were normally distributed. The Durbin–Watson ratios were 1.797 and 2.020, respectively, which were close to 2.

Table 2 Stepwise multiple regression for subjective QOL

Model	B	SE	β	p-value	95%CI of B		VIF
Constant	19.936	3.338		< 0.001	13.231	26.641	
ACS-JPN	1.021	0.215	0.501	< 0.001	0.590	1.452	1.357
NPI-NH	−0.569	0.158	−0.380	< 0.001	−0.886	−0.252	1.357

Notes: Adjusted R^2 = 0.575, ACS-JPN = The Activity Card Sort-Japan Version. NPI-NH = The Nursing Home Version of the Neuropsychiatric Inventory. MMSE = The Mini-Mental State Examination. BI = The Barthel Index. NRS = The Numerical Rating Scale.

Table 3 Stepwise multiple regression for objective QOL

Model	B	SE	β	p-value	95%CI of B		VIF
Constant	20.009	2.249		< 0.001	15.490	24.529	
NPI-NH	−0.577	0.100	−0.510	< 0.001	−0.779	−0.376	1.362
ACS-JPN	0.596	0.139	0.387	< 0.001	0.317	0.875	1.417
BI	0.047	0.020	0.183	0.025	0.006	0.087	1.082

Notes: Adjusted R^2 = 0.676, NPI-NH = The Nursing Home Version of the Neuropsychiatric Inventory. ACS-JPN = The Activity Card Sort-Japan Version. BI = The Barthel Index. MMSE = The Mini-Mental State Examination. NRS = The Numerical Rating Scale.

Discussion

In this study, to clarify the factors associated with the QOL of institutionalized people with dementia, analyses were conducted including the number of items of activity/participation, cognitive function, ADL independence, BPSD, pain, grip strength, age, and gender as variables. Age and gender distribution of the participants included herein was similar to those reported in previous studies on people with dementia [7, 34]. Furthermore, the mean subjective and objective QOL-AD scores were comparable to those reported in previous study on institutionalized people with mild to moderate dementia in Japan (subjective QOL: 28.9 ± 6.0; objective QOL: 27.0 ± 4.7) [35]. Multiple regression analysis revealed that activity/participation and BPSD were significantly associated with subjective QOL, and, BPSD, activity/participation, and ADL independence were significantly associated with objective QOL. These findings suggest that the higher the number of items of activity/participation performed and the lower the BPSD, the higher the subjective QOL. Additionally, the higher the level of ADL independence, the higher the objective QOL.

Relationship between QOL and activity/participation and other variables

Supporting our hypothesis, the results of this study revealed that the number of items of activity/participation was associated with both subjective and objective QOL. Additionally, among the factors reported in previous studies [6–9], BPSD was associated with both subjective and objective QOL, whereas ADL independence was associated solely with objective QOL. The study results indicate that activity/participation is significantly associated with both subjective and objective QOL, despite the inclusion of other previously reported functional factors [6–9]. Previous studies also showed that engagement in activities has a positive impact on the QOL of institutionalized people with dementia. Uceda-Portillo et al. reported that residents with more diverse activity/participation had higher levels of QOL [11]. These findings are consistent with those of our study. Considering that previous studies have not analyzed functional disability, ability to perform ADL, and activity/participation all together [6–11], the extent to which these factors are associated with QOL was unclear. Our results indicate that among previously reported factors [6–11], the number of items of activity/participation may be one of the important factors influencing QOL. Activity/participation is believed to facilitate self-expression, the achievement of personal goals, and recognition by others [36]. Our results suggest that activity/participation may improve subjective QOL of institutionalized people with dementia by providing emotional fulfillment, self-affirmation, meaning and life purpose [5]. Furthermore, activity/participation has been reported to not only enhance QOL but also promote positive relationships between institutionalized people with caregivers and friendly contact with other residents [37]. Therefore, activity/participation may have a significant impact on objective QOL as rated by caregivers. Institutionalized people with dementia have been reported to have a significantly lower QOL than people with dementia living at home [38], and people with dementia are deprived of activity/participation opportunities when they reside in institutions compared with those living at home [12]. Based on these studies, we can assume that institutionalized people with dementia have lower QOL because of limited activity/participation, an inference that is supported by the present results. The study results suggest that increasing the number of items of activity/participation is important for improving the QOL of institutionalized people with dementia.

Some previous studies showed that BPSD negatively affects subjective and objective QOL in institutionalized people with dementia [8, 34, 39]. Furthermore, Missotten et al. found that BPSD accounted for 17.99%–34.45% of the total QOL score [40]. Our study results are consistent with these findings, which revealed that BPSD is also an important factor for QOL. BPSD is a distressing and life-disrupting factor for people with dementia themselves and reduces subjective QOL [41]. Additionally, previous studies showed that care burden affects objective QOL [42]. BPSD and ADL dependency increase care burden [43–45]. Therefore, in this study, BPSD and ADL independence were associated with objective QOL. Moreover, objective QOL of institutionalized people with dementia has been reported to be influenced by functional ability [39]. This indicates that caregivers as evaluators tend to determine objective QOL based on the degree of disability and dependence on caregivers [39]. Therefore, in this study, ADL independence was more strongly associated with objective QOL than with subjective QOL.

In this study, no significant correlation was observed between QOL and cognitive function, pain, and grip strength, which have been previously noted in people with dementia. Views on QOL and cognitive function among people with dementia are inconsistent [46]. A previous study reported a positive correlation between cognitive function and QOL in bivariate analyses, but multivariate analyses adjusted for confounding factors failed to confirm this clear relationship [47]. These findings are consistent with those of our study. Missotten et al. divided people with dementia into five groups based on cognitive function and found that the severe

dementia group, who had the lowest cognitive function, showed significantly lower QOL than the other groups. However, no significant differences were observed among the other four groups [40]. Since this study included people with mild-to-moderate dementia, it was speculated that cognitive function may not have affected QOL. Furthermore, few studies have been conducted to investigate the relationship between QOL and pain in people with dementia [8]. Pain was not a common symptom caused by dementia, the mean NRS score in this study was low (0.58 ± 0.95), and the fact that most of the participants had good pain control also led us to speculate that there was no relationship between pain and QOL. Although previous studies have inconsistently reported that grip strength, or overall muscle strength, is associated with QOL in institutionalized people with dementia [48], others have not [49]. Our results support the latter, and multivariate analysis may have revealed more relevant factors [49]. QOL is a multifaceted concept, and components of QOL-AD used in the current study may not be strongly associated with grip strength or overall muscle strength.

Practical implication

The study results may indicate that increasing opportunities for activity/participation and decreasing BPSD are important for the subjective QOL of institutionalized people with dementia. Additionally, improving ADL independence is important for the objective QOL. These results may provide valuable insights for future rehabilitation delivery methods. Therapists may need to focus their interventions on increasing activity/participation, reducing BPSD, and maintaining and improving ADL independence to improve QOL.

Many institutionalized people with dementia have been reported to have few opportunities for activity/participation and spend most of their day in idleness [12, 50]. Additionally, since people with dementia do not have the ability to initiate activities on their own [51], their activity/participation status changes depending on the involvement of their surroundings, such as therapists. Therefore, rehabilitation therapists should consider planning regular events and social interaction opportunities and providing activities according to individual interests and abilities. It is important not only to simply increase the number of items of activity/participation but also to provide meaningful activities for residents. However, many care facilities have difficulty getting residents to participate in activities on a daily basis [50] due to organizational constraints, such as personnel shortages. Additionally, some studies have mentioned other aspects. Mowrey et al. suggest that caregivers may not be aware of what activities and how to provide for residents [52]. Thus, therapists can provide caregivers with information about residents' interests, preferences, appropriate levels of difficulty, skills needed for activities, and how to provide activities during the daytime. Therapists with limited activity options and variations cannot offer activities that meet the needs and interests of residents. Therefore, therapists should enhance their knowledge and skills and prepare work materials and environments to provide various activity programs tailored to residents.

Nonpharmacologic interventions, such as behavioral therapy and environmental adjustments, should be the first line treatment for BPSD, and pharmacotherapy can be combined if necessary [53, 54]. The context in which BPSD occurs has been reported to be highly related to daily situations [55]. Thus, therapists can improve BPSD in people with dementia through person-centered interventions and appropriate conversations with people with dementia [56]. Developing and executing intervention plans tailored to individual BPSD symptoms and providing appropriate training and information to staff may decrease BPSD, thus improving the QOL of people with dementia.

For maintaining and improving ADL independence, it is important to provide not only activity/participation but also rehabilitation targeting physical and cognitive functions, appropriate nursing care, and environmental adjustments that can improve individual ADL abilities.

A comprehensive combination of the above approaches that increase activity/participation, reduce BPSD, and improve ADL independence has the potential to improve the QOL of institutionalized people with dementia. Future research and practice in care facilities should consider developing programs and approaches, taking these factors into account and verifying their effectiveness.

Limitations

This study has some limitations. This cross-sectional study included a limited number of participants from two Japanese facilities. Thus, it is necessary to carefully consider whether the results of this study can be generalized to all institutionalized people with dementia. Additionally, this study quantitatively analyzed only the number of items of activity/participation that the participants engaged in. It is crucial to pay attention to the type of activity/participation offered and the level of engagement in activity/participation [57]. It should be noted that the presence or absence, frequency, and duration of engagement in activity/participation that is important to the participants may be associated with QOL. Furthermore, this study revealed associations

between subjective and objective QOL and each of the factors, including activity/participation. However, the causal relationship is not yet clear.

Future studies including a larger number of institutionalized people with dementia from wider geographic areas are needed. Considering the possibility that engagement in activity/participation that is important to residents and occupational balance may contribute to QOL, and clarifying causal relationships will contribute to improving the QOL of institutionalized people with dementia.

Conclusion

This study showed that the number of items of activity/participation and BPSD were significantly associated with subjective QOL, and BPSD, activity/participation, and ADL independence were significantly associated with objective QOL. Activity/participation is a significant factor influencing the QOL of institutionalized people with dementia. The study findings may have important implications for future rehabilitation programs.

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Declaration of interest statement

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

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■ORIGINAL ARTICLE

Evaluating the Psychometric Properties of the Occupational Self-Assessment Short Form Japanese Version: A Rasch Analysis Study

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Abstract: Introduction: The Occupational Self-Assessment Short Form (OSA-SF) Japanese version is a measure of the person's occupational competence and self-perception of value, and is a tool to facilitate client-centered practice. Studies on the OSA-SF Japanese version have been limited and its characteristics have not been examined in healthy adults. The purpose of this study was to evaluate the reliability and validity of the Japanese version of the OSA-SF.
Methods: Participants were recruited through convenience sampling from students affiliated with three occupational therapist training colleges in Japan. Participants were asked to complete the Japanese version of the OSA-SF to assess their self-perception of occupational competence and value. The psychometric properties of the OSA-SF were examined using Rasch analysis (partial credit model).
Results: Responses were received from 302 respondents. Both the Competence and Value scales fit the Rasch model and showed appropriate rating scale functioning, dimensionality, item and person fit, item hierarchies, and item and person reliability. The Value scale tended to be biased toward high person ability and low item difficulty.
Conclusion: The OSA-SF Japanese version was shown to be a reliable and valid instrument for evaluating occupational competence and value in healthy adults. In Japan, the use of OSA-SF is expanding to healthy adults. The short form is expected to be utilized in occupational therapy in the field of prevention and in testing the effectiveness of education for students, since it is shorter and easier to complete.

Keywords: Model of human occupation, occupational self-assessment short form Japanese version, assessment, healthy adults, Rasch analysis

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1. Introduction

Occupational Therapy (OT) is an occupation-focused, occupation-based practice in which occupation has purpose and value to the client [1]. Hence, there is a need to promote client-centered practice that focuses on client-specific occupation [2]. Client-centered practice requires gathering information to understand what is important and meaningful to the client, collaborating with the clients to set goals that lead to engagement in occupations that support participation in daily life, and encouraging proactive engagement in OT [3]. The first modern OT model to explicitly state its focus on occupation was the Model of Human Occupation (MOHO), and it is also a client-centered practice [4]. MOHO is a conceptual and practical model that focuses on finding meaningful occupation for the client and engaging his or her volition in that occupation [4], which supports occupation-based practice.

The Occupational Self-Assessment (OSA) is one of the client-centered assessments developed based on MOHO [5, 6]. The OSA consists of questions that correspond to the MOHO constructs of volition, habituation, and performance, and can capture the client's occupational competence, value, and environmental influences [5, 6]. In a literature review conducted by Shinohara [7], OSA was used in 51 studies across various research

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designs, excluding meta-analyses, demonstrating its usefulness in both clinical and research settings.

Conversely, the time required to perform OSA has been a barrier to application in short-term, brief OT practices such as acute care, thus Popova [8] developed the Occupational Self-Assessment-Short Form (OSA-SF), and validated its reliability and validity. OSA-SF was created by reducing the number of items from 21 in the original version to 12 through iterative elimination of items using Rasch analysis, and can be implemented in a shorter time compared to OSA. The original version of the OSA-SF has been tested for reliability and validity by Rasch analysis, showing good rating scale functioning, dimensionality, goodness of fit, and item targeting [8]. In Japan, it has been translated by Yamada [6], but at present, its reliability and validity have been verified only in studies conducted on older adults [9]. OSA-SF is an important tool for promoting client-centered practice for clients and research participants, for whom OSA has been difficult to implement because it was more time-consuming, thus it is expected that its implementation will continue in Japan. Therefore, the purpose of this study was to examine the reliability and validity of the OSA-SF by applying the Rasch model.

2. Methods

2-1. Participants

Participants were recruited from occupational therapy students attending three occupational therapist training colleges in Japan. MOHO is a theory that focuses on occupational adaptation rather than specific diseases, and the OSA-SF developed based on MOHO is the same. Additionally, we decided to use a sample of occupational therapy students as a relatively more homogeneous group than diverse subjects to avoid the possibility of item bias due to sub-population. The sample size calculations were based on Rasch analysis. Approximately 150 participants were needed to have at least 95% confidence that item calibrations were within ± 0.5 logits [10].

2-2. Measures (Assessment tool)

The Japanese version of the OSA-SF is a self-report assessment consisting of 12 questions that address the components of MOHO [6, 8]. Occupational competence is rated on a 4-point scale ("1: I have a lot of problem doing this," "2: I have some difficulty doing this," "3: I do this well," "4: I do this extremely well") in step 1, and value on a 3-point scale ("1: This is important to me," "2: This is more important to me," "3: This is extremely important to me") where items that the subject judges not to be applicable can be excluded in step 2. The items are prioritized in step 3, and the client and occupational therapist work together to identify priority areas for occupational therapy goals. As Step 3 is not scored, this study analyzed only the Competence scale from Step 1 and the Value scale from Step 2.

2-3. Rasch analysis

The Rasch model was applied to analyze the scale properties of the OSA-SF. The Rasch model is a mathematical model for converting raw score data from questionnaire responses to interval scale levels based on item response theory. The Consensus-based Standards for the selection of health Measurement Instruments (COSMIN) emphasizes the importance of using item response theory (IRT) in the study of measurement [11]. Rasch analysis, a type of IRT, provides various evidence of internal construct validity and reliability, such as unidimensionality, category function, item and person separation, and differential item functioning (DIF). When items fit the Rasch model, their measurement properties are assumed to be independent of the study population [12]. The study was conducted according to the framework of the Rasch Reporting Guidelines in Rehabilitation Research (RULER) [13, 14]. Data were analyzed using WINSTEPS software ver. 5.6.2 [15], and a partial credit model was applied to each item in the OSA-SF. Rasch analysis was performed using the following procedure.

- *Rating scale structure*: Verifies whether the rating scale structure of each item is appropriately adapted. The following criteria from the RULER guidelines [13, 14] and Linacre [16] were considered. (1) There are at least 10 observations in each category, (2) the mean measures increase monotonically, (3) the outfit mean square (MnSq) < 2.0 (4) the step calibration (threshold) increases monotonically and is 1.4 logit or greater, but 5.0 logit or less.
- *Unidimensionality*: Verified in order to examine the objectivity of the measurement. To evaluate dimensionality, a principal component analysis (PCA) of standardized Rasch residuals was performed. If the OSA-SF is unidimensional, then all items in the OSA-SF can be interpreted as conforming to the constructs of occupational competence and value. To confirm the unidimensionality of the measure, the eigenvalue and the percent variance explained by the first contrast is less than 2.0 and less than 10%, respectively [13, 14].
- *Local independence of the items*: Correlations of standardized residuals were calculated to confirm local independence of items. High correlation of residuals between each item (> 0.3) indicate latent local dependence [14].
- *Item fit*: The structural validity of the scale was assessed using fit statistics. The goodness of fit is

mainly calculated using infit MnSq and outfit MnSq and standardized as a z-score (Zstd). In the case of a Likert scale, fit outside the ranges of $0.60 \leq \text{MnSq} \leq 1.4$ and $-2.0 \leq \text{Zstd} \leq +2.0$ are considered problematic [17]. If MnSq are acceptable, then Zstd can be ignored [15].

- *Person fit*: As with item fit, fit statistics were calculated and examined for the person fit. The person's infit MnSq < 2.0 is desirable [18]. The criterion was that the percentage of person with an infit MnSq values greater than 2.0 should be less than 15% [13, 14].
- *Reliability*: There are two types of reliability in Rasch analysis: item separation reliability, which indicates the accuracy of estimates of item difficulty that comprise the test, and person separation reliability, which indicates the reproducibility of the relative ranking of the person in the study. Item separation reliability and person separation reliability of 0.7 and above indicate high reliability [17]. The sensitivity of the scale is also evaluated by transforming the item separation reliability and person separation reliability into strata using the following formula:

  [4 (separation index) + 1] / 3 [19]

  The strata indicate the number of distinct levels of items and people evaluated by the assessment. It was expected that the instrument could separate items and people into at least two separate levels of difficulty and competence, respectively [8].
- *Item Hierarchies*: Item difficulty was estimated by Rasch analysis; the hierarchy of item difficulty in this study would be comparable to that of previous studies of OSA [20].
- *Targeting*: An item-person map was examined to identify whether item difficulty and person ability were hierarchically aligned. Ideal item difficulty and person ability should be observed on the same interval continuum of logits [21]. The standard error of the person measure was used to examine targeting. The cutoff points were defined as follows: 1–2 errors for fair targeting, less than 1 error for good targeting, and less than 0.5 errors for very good targeting [22]. The floor and ceiling effects were calculated by calculating the percentage of participants who obtained the minimum and maximum total scores on each scale, with a criterion of less than 15% [13, 14].
- *Differential Item Function (DIF)*: DIF analysis was performed to investigate the stability of the scale across gender subgroups. Mantel-Haenszel p-value < 0.05, DIF contrast > 0.64 indicate items with statistically meaningful DIF and moderate to large effect sizes [15, 23]. The Mantel-Haenszel Chi-square tests the null hypothesis of no uniform DIF. It is important to consider DIF contrasts because significant Mantel-Haenszel p-values alone are insufficient to determine whether the differences are meaningful [24]. The presence of a significant and meaningful DIF indicates the presence of bias in the sense that the interpretation of the scale/item varies across groups.

2-4. Research ethics

This study was conducted with the approval of the Ethical Review Committee of the University of Tokyo Health Sciences (approval number: 21-23H) in compliance with the Declaration of Helsinki Guidelines for Research Involving Human Subjects. The survey was conducted after explaining in writing and orally that the purpose and methods of the research, the survey would be conducted anonymously, participation in the research would be voluntary, that there would be no disadvantages for non-participation in the research or for discontinuation or withdrawal during the research, and that consent would be deemed obtained by filling out and submitting the survey form.

3. Results

3-1. Participants

A total of 302 students participated in this study, of whom 106 (35.10%) were male. The number of females was 180 (59.60%), and 16 (5.30%) did not respond to the question about gender. The average age was 19.45 ± 1.23 years, with a range of 18 to 21 years.

3-2. Rating scale structure

The rating scales of both the Competence and Value scales of the OSA-SF met the criteria. Each evaluation category included 10 or more observations, and the mean measures increased monotonically. Step calibration (threshold) increased in each category, with a difference of 1.75–2.5 for the Competence scale, and 3.7 on the Value scale. Outfit MnSq values was 0.91–1.11 on the Competence scale, and 0.98–1.16 on the Value scale. All of them met the criteria (Table 1).

3-3. Unidimensionality

The results of PCA of the standardized residuals showed that the Competence scale had an observed raw variance explained by measure of 37.7%, and the eigenvalue of the first residual factor is 1.89 (9.8%). For the Value scale, the observed raw variance explained by measure is 40.2%, and the eigenvalue of the first residual factor is 1.62 (8.1%). The eigenvalues of the first contrast all met the criteria. Various values are found for the criterion of raw variance measured by the scale, but the scale is considered unidimensional when it is 30% or higher [25, 26]. These results confirm the unidimension-

Table 1 Summary of category structure statistics

scale	category (response)	observed count	average measure	Infit Mnsq	Outfit Mnsq	threshold
Competence	1 I have a lot of problem doing this	142	−0.46	1.11	1.16	NONE
	2 I have some difficulty doing this	769	0.12	0.96	0.96	−2.00
	3 I do this well	1766	1.03	0.92	0.91	−0.25
	4 I do this extremely well	943	2.26	1.02	1.01	2.25
	missing	4	1.42			
Value	1 This is not so important to me	235	−0.93	1.08	1.16	NONE
	2 This is important to me	1624	0.94	0.96	0.98	−1.85
	3 This is more important to me	1723	2.57	0.97	0.98	1.85
	missing	30	−0.06			

MnSq: mean square

Table 2 Dimensionality analysis

	Competence			Value		
	Empirical		Modeled	Empirical		Modeled
	Eigen	%	%	Eigen	%	%
Total raw variance	19.27	100.0	100.0	20.06	100.0	100.0
Raw variance explained by measures	7.27	37.7	38.3	8.06	40.2	39.8
Raw variance explained by persons	5.29	27.4	27.9	6.02	30.0	29.7
Raw variance explained by items	1.98	10.3	10.5	2.05	10.2	10.1
Raw unexplained variance (in 1st contrast)	1.89	9.8	15.7	1.62	8.1	13.5
Raw unexplained variance (in 2nd contrast)	1.46	7.6	12.1	1.40	7.0	11.6

ality, a basic requirement of the Rasch model, for both the Competence and Value scales of the OSA-SF (Table 2).

3-4. Local independence of the items

For all combinations of OSA-SF items, the correlations of standardized residuals did not exceed 0.3, confirming local independence.

3-5. Item fit

The infit MnSq of the Competence scale was 0.86–1.21, Zstd was −2.63–2.57; all items showed appropriate infit MnSq. The infit MnSq of the Value scale was 0.82–1.17, Zstd was −2.41–2.02; all items showed appropriate infit MnSq (Table 3).

3-6. Person fit

There were 27 participants (8.94%) with an infit MnSq > 2.0 on the Competence scale, and 17 participants (5.65%) on the Value scale. Thus, the percentage of participants who were misfit was within the acceptable range.

3-7. Reliability

Person separation reliability and item separation reliability for the Competence scale were 0.77 and 0.97, respectively, which were within the acceptable range. The person separation index and item separation index were 1.85 and 5.73, respectively, indicating that the items of the Competence scale can separate the participants into two strata and the items into seven strata. Person separation reliability and item separation reliability for the Value scale were 0.78 and 0.96, respectively, which were also within the acceptable range. The person separation index and item separation index were 1.89 and 4.93, respectively, indicating that the items of the Value scale can separate the participants into two strata and the items into six strata.

3-8. Item Hierarchies

Compared to a previous study [20], the items related to basic tasks of living (items 1, 2, and 4) tended to be less difficult than those related to satisfaction, enjoyment, actualization (items 6, 7, and 10), as shown in the previous study, although they were not identical on either the Competence and Value scales (Table 3).

3-9. Targeting

Figure 1 shows an item-person map. Although the distribution of item difficulty was narrower than the distribution of person ability for both the Competence and Value scales, the measurement error of person abil-

Table 3 Item fit statistics and differential item functioning (DIF) by gender

Competence									
Item	Difficulty	SE	Infit		Outfit		DIF CONTRAST	MH	
			MnSq[a]	Zstd	MnSq[a]	Zstd		Chi-sq	p
1. Taking care of myself	0.34	0.08	1.04	0.58	1.04	0.58	−0.12	0.63	0.43
2. Getting where I need to go	−1.08	0.10	0.98	−0.21	0.98	−0.21	−0.47	3.10	0.08
3. Managing my finances	0.26	0.09	1.21	2.57	1.21	2.57	−0.07	0.01	0.93
4. Managing my basic needs (food, medicine)	−0.97	0.10	1.04	0.45	1.04	0.45	−0.12	0.00	0.99
5. Identifying and solving problems	0.35	0.10	1.00	0.07	1.00	0.07	0.29	0.77	0.38
6. Getting done what I need to do	0.44	0.09	0.97	−0.31	0.97	−0.31	0.32	4.16	0.04
7. Having a satisfying routine	0.37	0.09	1.17	2.02	1.17	2.02	0.14	0.45	0.50
8. Handling my responsibilities	−0.08	0.11	0.86	−1.44	0.86	−1.44	−0.03	0.00	0.96
9. Being involved as a student, worker, volunteer, and/or family member	−0.57	0.10	0.97	−0.29	0.97	−0.29	−0.32	2.24	0.13
10. Working toward my goals	0.30	0.09	0.80	−2.63	0.80	−2.63	0.04	0.12	0.73
11. Making decisions based on what I think is important	−0.15	0.10	0.94	−0.72	0.94	−0.72	−0.04	0.43	0.51
12. Effectively using my abilities	0.79	0.10	1.00	−0.01	1.00	−0.01	0.14	0.19	0.67
Value									
Item	Difficulty	SE	Infit		Outfit		DIF CONTRAST	MH	
			MnSq[a]	Zstd	MnSq[a]	Zstd		Chi-sq	p
1. Taking care of myself	−0.49	0.13	1.01	0.17	1.04	0.58	0.42	2.15	0.14
2. Getting where I need to go	0.04	0.13	1.02	0.29	0.98	−0.21	−0.35	2.22	0.14
3. Managing my finances	−0.95	0.14	1.15	1.54	1.21	2.57	−0.15	0.07	0.79
4. Managing my basic needs (food, medicine)	−0.43	0.13	0.96	−0.39	1.04	0.45	−0.15	0.06	0.81
5. Identifying and solving problems	0.32	0.13	1.00	−0.01	1.00	0.07	0.14	0.56	0.45
6. Getting done what I need to do	−1.01	0.14	0.94	−0.90	0.97	−0.31	−0.02	0.02	0.89
7. Having a satisfying routine	0.84	0.12	1.17	2.02	1.17	2.02	0.56	2.98	0.08
8. Handling my responsibilities	−0.10	0.13	0.82	−2.41	0.86	−1.44	−0.05	0.36	0.55
9. Being involved as a student, worker, volunteer, and/or family member	0.94	0.12	0.89	−1.45	0.97	−0.29	−0.22	0.34	0.56
10. Working toward my goals	−0.39	0.13	0.84	−2.27	0.80	−2.63	−0.01	0.26	0.61
11. Making decisions based on what I think is important	0.34	0.13	1.09	1.13	0.94	−0.72	−0.15	1.07	0.30
12. Effectively using my abilities	0.87	0.12	1.03	0.36	1.00	−0.01	−0.02	0.02	0.88

MnSq: mean square; Zstd: standardized as a z-score; MH: Mantel-Haenszel
a: Values in the range of 0.6–1.4 indicate a good fit.

ity was 0.48 for the Competence scale, and 0.64 for the Value scale, showing good targeting. The highest and lowest scores occurred in less than 15% of participants in both the Competence and Value scales, showing no evidence of a floor or ceiling effect (Competence scale: maximum score in 2 participants (0.7%), minimum score in 1 participant (0.3%); Value scale: maximum score in 21 participants (7%), minimum score in 0 participants (0%)).

3-10. Differential Item Function (DIF)

When examining the DIF related to gender, significant differences were found in the Mantel-Haenszel values for item 5 of the Competence scale and item 6 of the Value scale, but the DIF contrasts were both less than 0.64. Thus no DIF was observed (Table 3).

4. Discussion

4-1. Validity of OSA-SF

Structural validity was examined through analyses of rating scale functioning, item fit, person fit, unidimensionality, and item hierarchies, and all items met the criteria, confirming the content and structural validity of the OSA-SF. Although unidimensionality did not meet the 50% criterion set by Popova [8] for the percentage of variance explained by the measures of Competence and Value scales, it did meet the criterion for ensuring unidimensionality of 30% or more, with no items indicating misfit. A low percentage of misfit items is considered an indicator of unidimensionality [17]. The eigenvalue of the first contrast is less than 2, so the possibility of a second dimension is also low, confirming the unidimensionality of the scale. Popova also mentioned that the

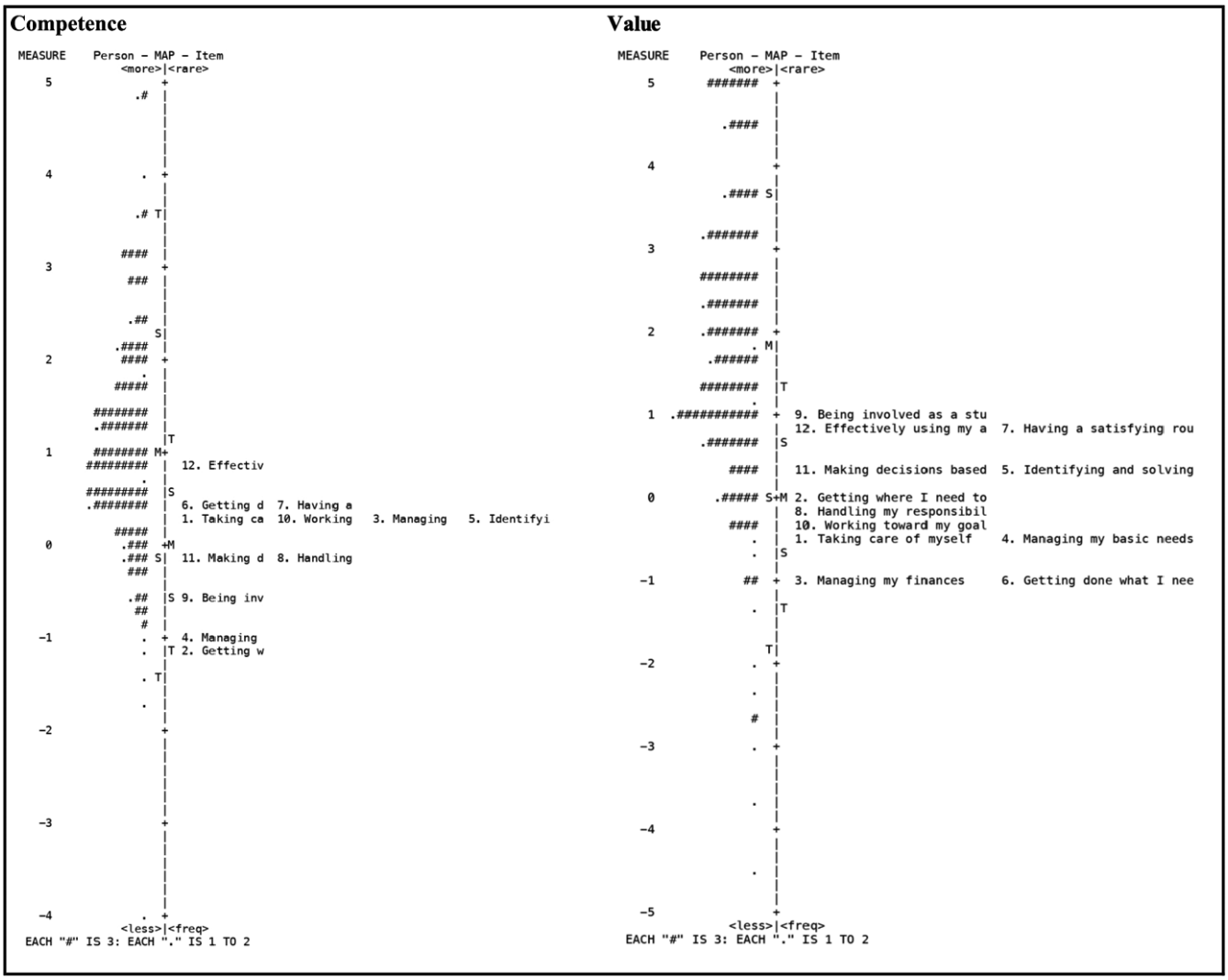

Fig. 1. Item-person map for Occupational Self Assessment Short-Form.

three-level rating scale of Value scale may have affected validity [8], but in this study, the rating scale of Value scale met the criteria from the Rasch analysis, indicating that it is valid and functioning appropriately.

4-2. Reliability of the OSA-SF

Reliability was examined using person and item separation reliability, local independence, item targeting, and DIF. Both person and item separation reliability met the criteria, and the results of correlations of standardized residuals for each item showed that there was no local item dependence, indicating that the OSA-SF is a scale that meets the criteria for reliability. In addition, the examination of DIF by gender revealed that although significant differences were found in item 5 of the Competence scale and item 6 of the Value scale, the DIF contrast met the criteria, confirming that each item of the OSA-SF was equivalent regardless of gender and that it was a scale capable of stable measurement. Comparing the distribution of person ability with the distribution of item difficulty on the item targeting, the distribution of person ability on the occupational competence scale is wide (−4.0–5.0), but within the range of −1.0–2.0, the item difficulty distribution was further concentrated in the range of −1.0–1.0, which was narrower than the ability distribution. On the Value scale, the distribution of person ability was also wide (−5.0–5.0), but within the range of −1.0–3.0, the item difficulty distribution was further concentrated in the range of −1.0–1.0, which was narrower than the ability distribution. Thus, OSA-SF was found to be capable of effectively differentiating the subjects with occupational competence and value in the range of −1.0–1.0. On the other hand, it is clear that lack of items is observed at higher ability level estimates, suggesting that the difficulty may be lower for healthy adults. This property of the scale was also observed in a previous study [8], and this result may explain the person separation index (PSI). The PSI is said to be in-

fluenced by factors such as the match between the items and the person ability (targeting) [15]. The separation index presented in this study is 1.85 on the Competence scale, and 1.89 on the Value scale, which was sufficient to discriminate between the two strata of person, but a higher index would be desirable for greater sensitivity and improved discrimination of person ability levels [24]. In particular, for the Value scale, the large difference between the person ability and the item difficulty level of 1.51 logit suggests that there is a need to consider adding more difficult items in order to adequately capture the self-perception of value of healthy adults. In other words, the Japanese version of the OSA-SF differs from the original version in that there is room for reconsideration of the items to be adopted in the shortened version. On the other hand, the results of this study based on the measurement error of person ability showed good targeting, and also met criteria for the ceiling effect, suggesting that the OSA-SF is a scale that can be used adequately for healthy adults.

4-3. Application of OSA-SF

Japanese studies using OSA have often used it with students, including studies of educational effectiveness [27–29]. It has also been used to investigate occupational dysfunction in healthy workers in general companies [30] and to assess the health status of caregivers [31]. The use of OSA has been extended not only to people with disabilities but also to healthy people may experience problems with occupational adaptation. In this regard, the reliability and validity of the OSA-SF for healthy adults demonstrated in this study are meaningful for future research. The number of items was reduced and the time required for the assessment was shortened, which decreases the burden on clients or study participants and enables more rapid assessment of occupational adaptation problems. It is hoped that OSA-SF will be widely used in the future.

4-4. Limitations of the study and implications for future research

The present study examined the psychometric properties of the OSA-SF in healthy adults aged 18–21 years in occupational therapy training colleges. This is the main limitation and relates to the narrow scope of the demographic criteria. The sample size of 302 is considered sufficient for conducting Rasch analysis. As a result of the analysis, the items of the OSA-SF fit the Rasch model, allowing for the estimation of item characteristics independent of the person abilities. However, as indicated by the item-person map, some items in the OSA-SF are relatively easy for occupational therapy students, which may be influenced by demographic characteristics such as age and student status. It is uncertain how the OSA-SF would adapt to other populations with different demographic characteristics than those in this study. In order to apply the instrument to a wider range of occupational therapy clients, it is necessary to evaluate the validity and reliability of the instrument for a more diverse group of clients with different levels of ability and characteristics. Future research is also needed to verify the low item difficulty of the Value scale revealed in this study and the retest reliability, which was not examined in this study.

5. Conclusion

The scale characteristics of the Japanese version of the OSA-SF were examined by applying the Rasch model. As a result, the rating scale of the Value scale was modified from a 4-point to 3-point scale in the process of creating the shortened version, and functioned properly. The Value scale had a low level of difficulty for healthy adults, suggesting the need to consider adding items of higher difficulty, but the other criteria were met, indicating that both the Competence and the Value scales of OSA-SF are unidimensional and have sufficient reliability and validity to be used on healthy adults.

Declaration of conflicting interests

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A Scoping Review of E-Learning in Occupational Therapy

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Abstract: Objective: This study summarizes the characteristics and evidence of E-learning in occupational therapy and highlights areas needing further research.
Methods: A scoping review was conducted using the Arksey and O'Malley framework. We accessed the electronic databases PubMed, CINAHL, Web of Science, SCOPUS, and Education Research Complete to collect literature on E-learning in occupational therapy. Two reviewers independently selected studies according to set inclusion and exclusion criteria. The following data points were collected: Article title, Journal of publication, Study design, Resource utilization, Country of origin, Teaching methodology, Educational contents, Educator, Targeted learners, Outcome, and Research question.
Results: A total of 29 papers met the criteria. This scoping review of E-learning in occupational therapy revealed that a significant number of studies focused on learner outcomes. However, education on occupational therapy expertise was lacking. There was also a paucity of research on international development, cultural exchange, leadership, and management. The methods of education vary from synchronous, asynchronous, face-to-face/non-face-to-face, to blended methods, and it remains unclear which methods are most effective.
Conclusion: For the advancement of E-learning in occupational therapy, it became clear that education related to the expertise of occupational therapy, promotion of international exchange, leadership, and management, and research on pedagogy and educational content according to the target learner's characteristics are imperative.

Keywords: electronic learning, occupational therapy education, distance learning, online learning, blended learning

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Introduction

"Electronic learning (E-learning)" refers to the provision of education or training through digital technology [1]. This term is used interchangeably with other terms, such as "online learning," "web-based learning," and "computer-assisted learning" [1, 2]. E-learning has been utilized in childhood education [3], higher education [4], and professional education [1].

The COVID-19 pandemic triggered the rapid spread of E-learning, which is not restricted by time or place [2]. E-learning protects learners from the risk of infection while ensuring the continuity of learning [5]. Even now that COVID-19 is converging, E-learning is still an becoming an integral part of the education process [6]. E-learning is expected to become even more popular in the future due to advances in digital technology and users' understanding [5, 6].

E-learning is also utilized by healthcare professionals [1]. Healthcare professionals are expected to learn the latest findings from medical advances [1, 7].

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As such, E-learning has become a tool to help busy healthcare professionals improve their skills. A recent scholarly inquiry conducted by Florence et al. [8] has identified twelve distinct research themes associated with E-learning for health professionals, through rigorous qualitative analysis. These themes comprehensively encapsulate the entire gamut of findings on E-learning for healthcare professionals.

E-learning is of growing significance in the realm of occupational therapy [9]. Particularly, it is progressively employed in both undergraduate and postgraduate education, facilitating the provision of educational opportunities independent of temporal or residential constraints [10]. Furthermore, there exist accounts of professional postgraduate education concerning evidence-based practices and ethical conduct [9, 11]. Many of these accounts indicate that E-learningg is held in high regard by occupational therapists [12].

However, learners and educators engaged in E-learning for occupational therapy encounter significant barriers, including issues with self-regulation skills like time management and motivation, ineffective teaching models, insufficient empirical evidence supporting E-learning, and inadequate knowledge of E-learning, which collectively impede the implementation of educational programs [13–16]. Research that facilitates overcoming these challenges is still lacking.

Here, in order to set the stage for future specific empirical and practical research, this study summarizes the characteristics and evidence of E-learning in occupational therapy and highlights research areas in need. It maps the basic themes of E-learning in occupational therapy, the target learners and the outcomes and methods utilized to identify these research gaps. The study aims to guide future research and the dissemination of E-learning practice in occupational therapy and ultimately improve the quality of occupational therapy practice and education.

Methods

The scoping review's methodology was guided by the framework proposed by Arksey and O'Malley [17]. The scoping review was conducted in accordance with five sequential steps outlined by Arksey and O'Malley: (Step 1) Identifying research questions, (Step 2) Identifying studies, (Step 3) Selecting studies, (Step 4) Data extraction, and (Step 5) Summarizing the results [17].

Step 1: Identifying the research question

We specified our research questions as follows:

(1) What themes have been explored in the study of E-learning in occupational therapy?
(2) What are the educational characteristics (target learners, outcomes, methods) of E-learning in occupational therapy?
(3) What are the gaps in evidence for E-learning in occupational therapy and what future research is needed?

Step 2: Identifying relevant studies

We conducted an extensive literature search by accessing electronic databases such as PubMed, CINAHL, Web of Science, SCOPUS, and Education Research Complete. To conduct the search, we utilized the terms "Occupational Therap*" AND ("E-learning" OR "distancE-learning" OR "distance education" OR "electronic learning" OR "electronic education" OR "online learning" OR "online education" OR "blended learning" OR "remotE-learning" OR "remote education") to retrieve full-text articles. We only included articles written in English. The selection of search terms for the databases was determined in consultation with all authors, who possess extensive experience in scoping and systematic reviews. The search period was unrestricted to ensure a comprehensive collection of research articles. The literature search was conducted on March 30, 2021.

Step 3: Study selection

Prior to the screening, duplicate articles were eliminated. During the primary screening, two independent authors examined the title and abstract to determine their choices. During the secondary screening, two independent authors carefully reviewed the full text to determine their choices. In the event of discrepancies between the authors, the first and last authors (TH and YO) discussed and determined the selection of papers.

The inclusion criteria were (1) that the article was published in English and (2) that the study was specifically on E-learning for occupational therapists. The exclusion criteria were (1) review articles, (2) books, (3) conference abstracts, and (4) theses for degrees.

The exclusion of grey literature from this review was due to the study's objective of promoting academic advancement by providing guidelines for future research. It was essential to adopt findings from papers that ensured the validity of the research process.

Step 4: Charting the data

Data extraction for the paper was executed by two authors, whereby one author performed the extraction, and the other author ensured its accuracy. In case of any discrepancies between their assessments, all authors engaged in discussions to achieve a consensus. The following data points were collected: Article title, Jour-

Table 1 Education contents and Teaching methods in E-learning (Florence et al. 2020)

Research theme	Description
	Organization
Learner Characteristics	Focuses on understanding the learner characteristics and how online learning can be designed and delivered to meet their needs. Online learner characteristics can be broadly categorized into demographic characteristics, academic characteristics, cognitive characteristics, affective, self-regulation, and motivational characteristics.
Learner Outcomes	Learner outcomes are statements that specify what the learner will achieve at the end of the course or program. Examining learner outcomes such as success, retention, and dropouts are critical in online courses.
Engagement	Engaging the learner in the online course is vitally important as they are separated from the instructor and peers in the online setting. Engagement is examined through the lens of interaction, participation, community, collaboration, communication, involvement and presence.
	Course and Instructor
Course or Program Design and Development	Course design and development is critical in online learning as it engages and assists the students in achieving the learner outcomes. Several models and processes are used to develop the online course, employing different design elements to meet student needs.
Course Facilitation	The delivery or facilitation of the course is as important as course design. Facilitation strategies used in delivery of the course such as in communication and modeling practices are examined in course facilitation. Course Assessments are adapted and delivered in an online setting. Formative assessments, peer assessments, differentiated assessments, learner choice in assessments, feedback system, online proctoring, plagiarism in online learning, and alternate assessments such as portfolios are examined.
Course Assessment	Evaluation is making a judgment either on the process, the product or a program either during or at the end. There is a need for research on evaluation and quality in the online courses. This has been examined through course evaluations, surveys, analytics, social networks, and pedagogical assessments. Quality assessment rubrics such as Quality Matters have also been researched.
Evaluation and Quality Assurance	A number of online course technologies such as learning management systems, online textbooks, online audio and video tools, collaborative tools, social networks to build online community have been the focus of research. With the increase in online courses, there has also been an increase in the number of instructors teaching online courses. Instructor characteristics can be examined through their experience, satisfaction, and roles in online teaching.
Course Technologies	A number of online course technologies such as learning management systems, online textbooks, online audio and video tools, collaborative tools, social networks to build online community have been the focus of research.
Instructor Characteristics	With the increase in online courses, there has also been an increase in the number of instructors teaching online courses. Instructor characteristics can be examined through their experience, satisfaction, and roles in online teaching.
	Organization
Institutional Support	The support for online learning is examined both as learner support and instructor support. Online students need support to be successful online learners and this could include social, academic, and cognitive forms of support. Online instructors need support in terms of pedagogy and technology to be successful online instructors.
Access, Culture, Equity, Inclusion, and Ethics	Cross-cultural online learning is gaining importance along with access in global settings. In addition, providing inclusive opportunities for all learners and in ethical ways is being examined.
Leadership, Policy and Management	Leadership support is essential for success of online learning. Leaders perspectives, challenges and strategies used are examined. Policies and governance related research are also being studied.

nal of publication, Study design, Resource utilization, Country of origin, Teaching methodology, Educational contents, Educator(s), Targeted learners, Outcome, and Research question.

Step 5: Collating, summarizing and reporting the results

We have employed Florence et al.'s [8] classification of research topics to synthesize our findings. This taxonomy is based on a number of systematic reviews and incorporates recent insights on E-learning and covers a broad range of research themes, namely 1) Learner Characteristics: 2) Learner Outcomes: 3) Engagement: 4) Course or Program Design and Development: 5) Course Facilitation: 6) Course Assessment: 7) Evaluation and Quality Assurance: 8) Course Technologies: 9) Instructor Characteristics: 10) Institutional Support: 11) Access, Culture, Equity, Inclusion, and Ethics, 12) Leadership, Policy, and Management [18]. The descriptions of each category are displayed in Table 1. If an article

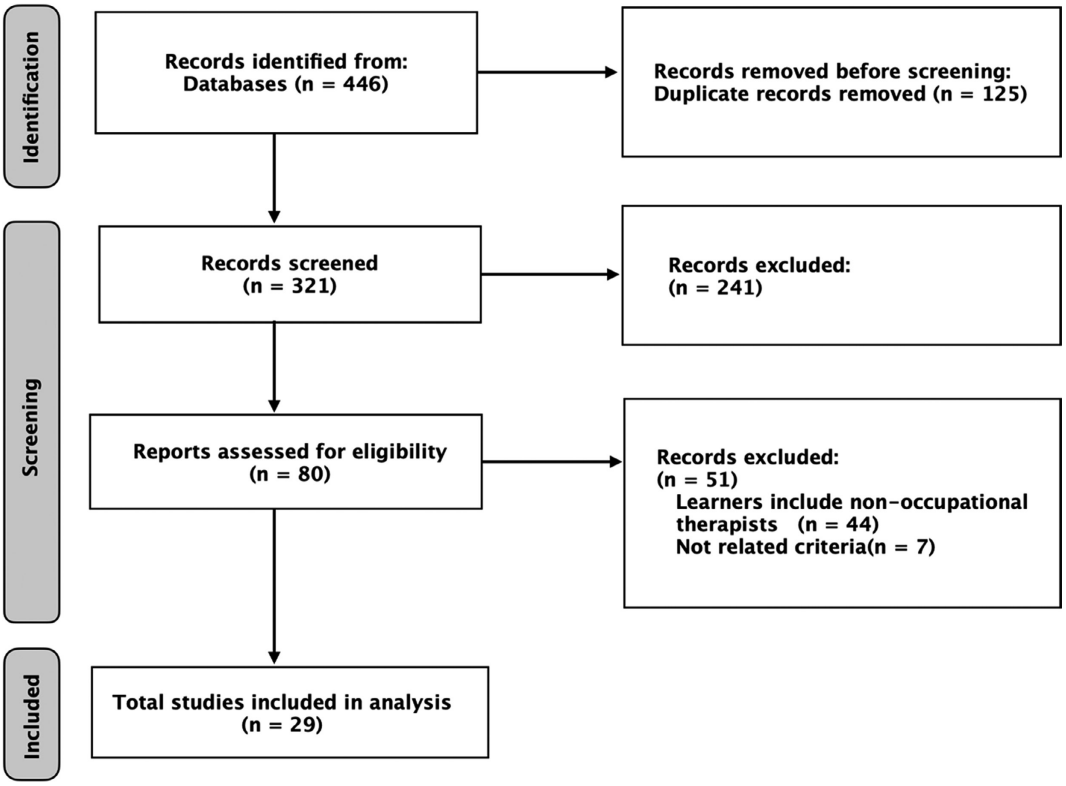

Fig. 1. PRISMA flow diagram representing literature search process (Tetzlaf J et al. 2020).

falls into multiple categories, we classify it under all relevant categories. The categorization was conducted by author pairs, and in the case of divergent assessments, the first and last authors (TH and YO) deliberated and arrived at a consensus.

Results

Our review yielded a total of 29 papers that conformed to the predetermined criteria. The review process was carried out in accordance with the PRISMA guidelines [19] (Fig. 1).

Investigations on E-learning in the field of occupational therapy have witnessed an upsurge in recent years (Table 2). The majority of the studies were executed in America, Australia, and Canada, with America contributing 18 studies, Australia 4, and Canada 4 (Table 2).

Mixed-method studies were the most frequently employed research design (n = 8) (Table 2). The subsequent most prevalent research design was the "Qualitative study" (n = 7). The remaining publications utilized Non-randomized controlled trial (n = 4), Case study (n = 3), Pre-post design (n = 3), Descriptive study (n = 2), Cohort study (n = 1), or Cross-sectional study (n = 1) (Table 2).

Research themes

The predominant area of research pertained to "Learner Outcomes (n = 14)", followed by "Course or Program Design and Development (n = 4)" and "Course Technologies (n = 4)". Conversely, studies on "Access, Culture, Equity, Inclusion" and "Leadership, Policy, and Management" are lacking. This indicates that there are few studies on leadership and management, which are necessary to facilitate international exchange, cultural exchange, and E-learning (Table 2).

This is followed by an overview of the literature categorized into the top three themes. Among the studies encompassed under "Learner Outcomes," only one pertained to occupational therapy expertise [20] (Table 3). The study concentrated on acquiring knowledge regarding the theory of occupational therapy [20]. Occupational therapy expertise here refers to occupational therapy's own theories and knowledge. In contrast, the other studies mainly focused on the attainment of general professional knowledge and skills, such as Neuroscience [21], aphasia communication [22], and Low Vision Education [23].

There was no unified outcome to measure educational effectiveness. The Watson-Glaser Critical Thinking Assessment (WGCTA) [20], Kolb Learning Inventory (LSI) [24], Adapted Fresno Test (AFT) [9], Aphasia Attitudes, Strategies and Knowledge (AASK) [22], and

Table 2 Characteristics of the 29 studies included in the scoping review (% of 29)

Publication year	
2000–2005	8 (27.6%)
2006–2010	5 (17.2%)
2011–2015	5 (17.2%)
2016–2021	11 (37.9%)
Origin	
America	18 (62.1%)
Canada	4 (13.8%)
Australia	4 (13.8%)
United Kingdom	1 (3.4%)
South Africa	1 (3.4%)
Ireland	1 (3.4%)
Target learner	
College student	15 (48.3%)
Graduate student	9 (31.0%)
Occupational therapist	5 (17.2%)
Study Design	
Mixed method study	8 (27.6%)
Qualitative study	7 (24.1%)
Non-randomized controlled trial	4 (13.8%)
Case study	3 (10.3%)
Pre-post design	3 (10.3%)
Descriptive study	2 (6.9%)
Cohort study	1 (3.4%)
Cross-sectional study	1 (3.4%)

Organization	
Learner Characteristics	2
Learner Outcomes	14
Engagement	2
Course and Instructor	
Course or Program Design and Development	4
Course Facilitation	1
Course Assessment	1
Evaluation and Quality Assurance	3
Course Technologies	4
Instructor Characteristics	2
Organization	
Institutional Support	1
Access, Culture, Equity, Inclusion, and Ethics	0
Leadership, Policy and Management	0

Note. Research themes are categorized into several themes depending on the literature.

Interactions with Disabled Persons Scale (IDP) [22] were some of the quantitative outcomes utilized for assessing "Learner Outcomes" (Table 3). In addition, original questionnaires provided quantitative data, while interviews provided qualitative data.

"Course or Program Design and Development" focused mainly on research pertaining to the introduction and development of E-learning. Various reports examined the validity and usefulness of program design, employing quantitative and qualitative data [25, 26]. To ensure that students have equivalent learning opportunities as on-campus during clinical practice and other placements, the development of learning programs that can be accessed remotely was underway [27]. In one study, the development of an online course in critical thinking was investigated, and students' critical thinking was assessed through questionnaires, while focus group interviews identified the course design that facilitated changes [26].

Regarding "Course Technologies" most of the research concentrated on the technologies utilized for E-learning. Studies investigated the utility of technologies and devices, such as video, audio, and chat, for E-learning [12, 28]. Additionally, an exploratory study examined an online module-based learning management system [29].

Educational Characteristics

Most pupils were comprised of college students (n = 15) and graduate students (n = 11) (Table 2). E-learning tailored for clinically engaged occupational therapists was the least frequently occurring type of education (n = 5) (Table 2). These three components encompassed instruction on employment support for occupational therapists [30], evidence-based practice education [9], and education on ethics [11].

In terms of synchronous or asynchronous styles, the most common approach to education was combined (n = 24) (Table 4). Most of these studies employed an amalgamation of asynchronous learning through video lectures and teaching materials with synchronous learning, including face-to-face lectures and online discussions. Only the online discussion program was exclusively conducted online and synchronously [31].

Table 3 Learner outcomes research details

No	Tittle	Target learner	Education contents	Outcome
4	An online learning course in Ergonomics	College student	Ergonomics for Health-care Professional	Mean mark in all courses studied in the same year. frequency of usage of the materials and interactive tools
7	Student development in an online post-professional Master's program	Occupational therapist	Learning knowledge and skills in occupational therapy practice	Qualitative data reflecting both the process and outcomes of the educational experience
10	Student outcomes in a postpro-fessional online master's-degree program	Occupational therapist	Lectures and practical training on research methodology, education, and cultural diversity	(1) Four open-ended questions (2) Question evaluating level of satisfaction with 23 professional skills and 5 indicators of professional status (3) Professional involvement since graduation
11	A study of critical reasoning in online learning: Application of the Occupational Performance Process Model	Graduate student	Learning about the Occupational Performance Process Model (OPPM)	Watson-Glaser Critical Thinking Assessment (WGCTA) was used to identify patterns of critical reasoning
15	Effectiveness of interactive, online games in learning neuroscience and students' perception of the games as learning tools: A pre-experimental study	College student	Learning about neuroscience concepts	Test results on neurological aspects such as ascending and descending nerve tracts, anatomy of the nervous system, cranial nerves, and neurotransmission
16	Online course design for teaching critical thinking	Graduate student	Learning about critical thinking	Rubric assessment to measure proficiency in critical thinking
17	Accommodating student learning styles and preferences in an online occupational therapy course	College student	Graduate program	Kolb Learning Style Inventory (LSI), Visual, Aural, Read/Write, and Kinesthetic (VARK)
18	The influence of blended learning on student performance in an undergraduate occupational therapy curriculum	College student	Theory of assessment and treatment in occupational therapy	Student performance was measured through retrieval of two types of records: practical competency test marks (1) and end-of-module knowledge test marks (2). The overall module performance (3) of the students was then calculated combining (1) and (2) into one score
21	The Use of an Online Module to Increase Occupational Therapy Practitioners' Evidence-based Practice Knowledge and Skills	Occupational therapist	Knowledge of evidence-based practice	Adapted Fresno Test (AFT)
24	Use of online training modules for professional development with school-based therapists: Outcome project	Occupational therapist	Knowledge of evidence-based practice	Questionnaire on opinions, perceived limitations, and knowledge of evidence-based practices
25	The development of a web-based simulated learning resource for occupational therapy students.	College student	Learning through simu-lations (e.g., people with various health conditions, mock graduate interviews)	Questionnaire on developing empathy, evaluation, and information gathering skills
26	On-line ethics education for occupa-tional therapy clinician-educators: a single-group pre-/post-test study	Occupational therapist	Ethics in occupational therapy practice and education	Questionnaires with three parts: Part A (General Information), Part B (Self-Assessment of Knowl-edge and Skill), Part C (Role as Tutor/Preceptor/ Facilitator)
27	A pilot randomized controlled trial comparing online versus face-to-face delivery of an aphasia commu-nication partner training program for student healthcare professionals	College student	The aphasia CPT program ('Communicating with People with Aphasia in Healthcare Contexts')	(1) Aphasia Attitudes, Strategies and Knowledge (AASK) survey. (2) Interactions with Disabled Persons Scale (IDP)
29	Comparing Learning Platform Impact on Low Vision Education for Occupational Therapists.	Occupational therapist	Education on low vision after acquired brain injury	A 25-question survey about demographic infor-mation. satisfaction, confidence, and knowledge application

Table 4 The corpus of 29 studies forming the scoping review

No	Year	Author	Tittle	Synchronous, Asynchronous, Combined	Online, Blended
1	2000	Rodger	Enhancing graduate supervision in occupational therapy education through alternative delivery	Asynchronous	Online
2	2002	Jedlicka	A comparison of distance education instructional methods in occupational therapy	Combined	Online
3	2002	Simons	Online learning: perspectives of students and faculty in two disciplines – occupational therapy and teacher education	Combined	Blended
4	2004	Weiss	An online learning course in Ergonomics	Combined	Online
5	2004	Wooster	An exploratory study of Web-based supports for occupational therapy students during Level II fieldwork	Combined	Online
6	2004	Gallew	The benefits of on-line learning in occupational therapy	Combined	Online
7	2004	Richardson	Student development in an online post-professional Master's program	Combined	Blended
8	2005	Beer	Collaboration and teamwork: Immersion and presence in an online learning environment	Combined	Online
9	2007	Boerema	Educators' perspective of online course design and delivery	Combined	Online
10	2008	Richardson	Student outcomes in a post professional online master's-degree program	Combined	Blended
11	2009	Mitchell	A study of critical reasoning in online learning: Application of the Occupational Performance Process Model	Combined	Online
12	2010	Perlman	Enabling meaningful learning through Web-based instruction with occupational therapy students	Combined	Blended
13	2010	Schaber	Designing Learning Environments to Foster Affective Learning: Comparison of Classroom to Blended Learning	Combined	Blended
14	2011	Rogers	From all perspectives: Opinions of students and teaching staff regarding occupational therapy distance education	Combined	Online
15	2011	Thompson	Effectiveness of interactive, online games in learning neuroscience and students' perception of the games as learning tools: A pre-experimental study	Combined	Online
16	2012	Schaber	Online course design for teaching critical thinking	Combined	Blended
17	2013	Doyle	Accommodating student learning styles and preferences in an online occupational therapy course	Combined	Online
18	2014	Barnard-Ashton	The influence of blended learning on student performance in an undergraduate occupational therapy curriculum	Combined	Blended
19	2016	Doyle	Faculty Mentors' Perspectives on E-Mentoring Post-Professional Occupational Therapy Doctoral Students	Synchronous	Online
20	2016	Abbott	Changing occupational therapists' knowledge of their role in secondary transition planning	Combined	Online
21	2016	Egan	The Use of an Online Module to Increase Occupational Therapy Practitioners' Evidence-based Practice Knowledge and Skills	Combined	Blended
22	2017	Rudman	Biomechanics for first year occupational therapy students: enriching learning using an E-learning resource	Combined	Online
23	2017	Gee	Exploring the influence of an E-learning sensory processing-based module for graduate level occupational therapy students on clinical reasoning: A pilot study	Combined	Online
24	2017	Lawdis	Use of online training modules for professional development with school-based therapists: Outcome project	Combined	Online
25	2018	Nicola-Richmond	The development of a web-based simulated learning resource for occupational therapy students	Asynchronous	Online
26	2019	VanderKaay	On-line ethics education for occupational therapy clinician-educators: a single-group pre-/post-test study	Asynchronous	Online
27	2020	Power	A pilot randomized controlled trial comparing online versus face-to-face delivery of an aphasia communication partner training program for student healthcare professionals	Asynchronous	Online
28	2020	Walsh	Seeing the bigger picture': a post-graduate online learning community facilitates political competence for occupational therapists	Combined	Online
29	2020	Perea	Comparing Learning Platform Impact on Low Vision Education for Occupational Therapists	Combined	Blended

This study employed e-mentoring, a teaching method centered around student-faculty meetings, thus not encompassing asynchronous learning. Regarding online and face-to-face educational methods, the most common form of education was limited to online (n = 20) (Table 4). Additionally, blended education (face-to-face and online) was also administered (n = 9) (Table 4).

Discussion

This scoping review of E-learning in occupational therapy reveals that a substantial body of research has focused on "Learner Outcomes". Although general professional knowledge and skills were the focus of many existing studies, education on occupational therapy's own expertise was lacking. There was also a limited amount of research on international development, cultural exchange, leadership, and management.

It was discovered that outcomes for measuring educational effectiveness have not been developed. The methods of education vary from synchronous, asynchronous, face-to-face/non-face-to-face, and blended methods, and it remains unclear which methods are most effective.

Regarding the development of E-learning in occupational therapy, it has become apparent that education pertaining to the specialty of occupational therapy, the promotion of international exchange, leadership, and management, the establishment of outcomes to measure educational effectiveness and research on educational methods and content that caters to the characteristics of the target population are essential.

Research themes

The prevalent theme among E-learning studies pertains to "Learner Outcomes". However, most of these studies revolve around the acquisition of specialized knowledge, skills, and attitudes outside the realm of occupational therapy. Egan et al. [9] suggest that E-learning is regarded as a supplementary modality of instruction in the field of occupational therapy education. These findings substantiate the outcomes presented within this investigation.

In contrast, according to Hollis and Madill [10], developing E-learning programs based on the occupational therapy expertise is crucial since occupational therapy, being highly specialized, necessitates learning content founded on expertise. Furthermore, as occupational therapy practice employs various evidence and reasoning reflective of its specialty, education reliant on this specialty is imperative [32]. The exploration of efficacious pedagogical approaches for occupational therapists represents a pivotal subject matter in showcasing the distinctiveness of the occupational therapy discipline to the broader community [33]. Given its educational attributes, E-learning can serve as a valuable modality for acquiring knowledge in the field of occupational therapy, as it offers adaptable educational opportunities both before and after graduation [12]. Nevertheless, this investigation has unveiled a dearth of specialized education pertaining to occupational therapy and the ongoing professional development of practicing occupational therapists. These findings underscore the imperative to develop an E-learning curriculum that specifically caters to the intricacies of occupational therapy specialties, while simultaneously substantiating its pedagogical efficacy.

Research on E-learning has lacked international and cultural exchange. Moreover, the geographic scope of E-learning research endeavours has been confined primarily to the United States, Canada, and Australia. One of the benefits of E-learning is that students can learn regardless of their place of residence [1]. Moreover, occupational therapy is influenced by national and regional factors, and capturing the cultural aspects of occupation is an integral component of occupational therapy practice [34]. International knowledge sharing could contribute to the academic progress of occupational therapy. Nevertheless, lack of infrastructure and technology in various countries have impeded E-learning implementation [7], leading to measures aimed at promoting cross-cultural exchange among healthcare professionals [35]. The study results underscore the necessity for research on implementation strategies and international deployment of E-learning in occupational therapy.

Additionally, there was a dearth of research on the leadership and management required to facilitate E-learning. Generally, in other domains of E-learning, it is recognized that educator leadership and organizational reforms to incorporate new technologies and knowledge about E-learning are significant [8]. This is also applicable to E-learning in occupational therapy, where organizational management for implementing E-learning is crucial to maximize the educational benefits for learners [14]. To foster the development and dissemination of E-learning in occupational therapy, it is necessary to generate evidence focusing on the management of organizations, including aspects such as leadership and administration.

Despite its significant role in providing educational content and fostering "Learner Outcomes", E-learning in the field of occupational therapy has yet to establish specific metrics for gauging its educational effectiveness. Previous research endeavours have highlighted the absence of consensus regarding learning effectiveness

measures in the realm of E-learning [36]. In line with these findings, our present study similarly identified a prevailing trend. While the sole utilization of the Watson-Glaser Critical Thinking Assessment (WGCTA) has been observed in E-learning endeavours targeting the acquisition of professional theories in occupational therapy [20], it fails to comprehensively encompass the professional intricacies inherent to the field. However, recent advancements have seen the development of assessments tailored to the distinctive nature of occupational therapy [37], and the integration of such outcomes within E-learning initiatives holds the potential to foster the scholarly advancement of the occupational therapy domain.

E-learning research features

In the occupational therapy field, it was evident that the themes "Course or Program Design and Development" and "Course Technologies" were the most common approaches to designing educational programs and examining digital technology. The predominant approach entailed the utilization of a hybridized format encompassing synchronous and asynchronous online instructional modalities. Specifically, methodologies integrating online discussions [26] and asynchronous chat platforms [21] were implemented. These findings hold paramount significance, as they offer a compelling demonstration of an effective amalgamation of synchronous and asynchronous pedagogical approaches, duly considering the temporal and environmental constraints faced by learners. Furthermore, a blended educational model combining face-to-face and online components was employed to deliver educational content [26, 38]. These strategies, known for their emphasis on interaction, are deemed essential within the realm of E-learning [10].

Conversely, a dearth of research exists pertaining to the efficacious amalgamation of digital devices employed in E-learning and investigations involving healthcare practitioners. Additionally, a majority of research designs in the field of occupational therapy E-learning have been predominantly exploratory in nature, encompassing mixed-methods and qualitative studies, while the execution of high-quality empirical studies, such as randomized controlled trials (RCTs), has been limited.

The utilization of a diverse range of digital technologies to cater to specific objectives holds paramount importance in facilitating the dissemination of E-learning of exceptional quality [10]. Moreover, E-learning inherently serves as an apt educational approach for busy clinicians [39]. In terms of future advancements in E-learning within the occupational therapy domain, the study indicates the presence of various educational modalities, including synchronous, asynchronous, face-to-face/non-face-to-face, and blended methods, thereby necessitating an examination to determine the most effective approaches. Furthermore, the development of E-learning content tailored to the needs of occupational therapy clinicians assumes significance.

Limitations

The limitations of this study include the possibility that additional articles could have been obtained from other databases, despite our use of the major ones. Additionally, we did not appraise the scientific rigor of the reviewed articles, as scoping reviews typically do not entail a critical evaluation of the evidence. Lastly, some data may have been omitted because review articles or grey literature were excluded.

Conclusion

For the advancement of E-learning in occupational therapy, it became clear that education related to occupational therapy expertise, promotion of international exchange, leadership, and management, and research on pedagogy and educational content according to the target learner's characteristics are imperative.

Conflict of interest

The authors have no conflict of interest to declare.

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■ORIGINAL ARTICLE

Experience of Living Space for Older Adults with Disabilities During the Transition from Hospital to Home-Based Care

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Abstract: Objectives: This study aimed to clarify positively how perceptions of living space affect the restructuring of life during the transition to home.
Methods: We conducted fieldwork on nine older adults with disabilities living in urban areas and suburbs who were discharged from the hospital after receiving rehabilitation, and analyzed their subjective experiences regarding "housing and ways of living."
Results: Initially, they felt a sense of openness, but experienced a transformation into an obstructive system due to a sense of insufficiency in daily activities, rationalization by care, and internalized social norms. On the other hand, when the involvement or event of the open system acts on the person, the aspect of introspection and active involvement in the unique living needs and living environment as well as the promotion of the reconstruction of the meaningful living space.
Conclusions: This study found that older adults with disabilities struggle with feeling at home after transitioning to home-based care due to physical challenges and shifting caregiver relationships. Interventions based on everyday activities can help to redefine these space and relationships. Continuous support is crucial for the adaptation process.

Keywords: older adults with disabilities, community-based integrated care system, transition to home, reconstruction of the living space, qualitative study

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Introduction

Japan is grappling with the dual challenges of a declining birth rate and an aging population. As a result, a community-based integrated care system is being developed. This system is founded on the principle that every individual, regardless of the presence or severity of disabilities, can continue living in their familiar surroundings. Consequently, more older adults with disabilities are staying at home after hospital discharge [1]. This shift has led to a significant societal demand for improved and cohesive rehabilitation services [2]. Occupational therapists are expected to play a crucial role in "housing and ways of living," not only by modifying the physical living environment but also by supporting the daily lives of these individuals.

Discussions about "housing and ways of living" in Japan often assume that older adults will transition to assisted living facilities [3, 4]. While some research focuses on older adults who continue to live at home, much of it aims to reduce the burden on caregivers [5, 6]. Studies specifically targeting older adults with disabilities are limited.

Older adults with disabilities reportedly experience stress due to changes in their environment and face various challenges after transitioning to home care [7, 8]. Furthermore, there is a positive correlation between an older adult's perception of their living environment and their ability to reside at home for > 6 months after

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discharge [9]. Thus, addressing these perceptions can significantly impact the continued residence of older adults with disabilities at home.

While existing studies focus on subjective perceptions, they typically rely on single interviews or surveys conducted several months after the transition. This approach captures the perceptions at only specific time points and does not consider temporal changes that are required to understand the continuous needs of older adults with disabilities during their transition from medical institutions to home care.

Given this background, there is social significance in longitudinally evaluating how older adults adapt to temporal changes in their living environment and examining the support for continued residence, considering the impact and changes of a community-based integrated care system.

This study aims to clarify the process of reconstructing living space by examining changes in the perceptions of older adults with disabilities during the transition from medical institutions to home. Within the framework of a community-based integrated care system, which aims for a smooth transition between home, hospital, and institution, it is crucial to capture the subjective experiences of older adults with disabilities during this transition. This approach will enable occupational therapists to evaluate effective environmental support measures to facilitate continued residence at home.

Methodology

Research collaborators

We recruited elderly patients who were discharged home after receiving rehabilitation at three medical facilities in urban and suburban areas of the Kanto region. The inclusion criteria were (1) patients discharged to their previous home address, (2) patients with a Mini-Mental State Examination score of 24 or higher at admission and the ability to communicate, and (3) patients aged 65 or older using the long-term care insurance system. To reflect the principles of the community-based integrated care system, we did not limit patients according to family composition, disability type, or severity beyond the necessary cognitive function. Maximum variation sampling [10] was employed to ensure a diverse range of experiences and perspectives among participants.

The study aimed to elucidate living space perception processes, which require detailed qualitative data. Extended engagement, follow-up interviews, and fieldwork were essential to achieve this. The sample size was determined using the steps for coding and theorization (SCAT) [11], which is characterized by the derivation of potential meanings, internal realities, processes, and hidden structures from small samples. Accordingly, we selected nine participants.

Contents of the survey

Through a series of interviews, we examined the impact of participants' experiences on the present and future, collecting data to capture the nuances of time. We built trust with the participants and conducted interviews at a relaxed pace [12]. Interviews were conducted at home 1, 3, and 6 months after discharge, with the participants' consent. Each interview lasted between 40 and 90 minutes and was recorded. The semistructured interview protocol was based on previous research [9].

The questionnaire focused on the sequence of events leading to home discharge, involvement at home after discharge, transition to family life, current difficulties, and steps taken or planned for improvement. Verifiable episodes related to these real-life situations were documented, and subjective interpretation was sought. We worked with architects to create a floor plan, identify and assess living requirements, and discuss changes in living environments with participants. The survey period was from April 2019 to March 2020.

Analytical methods

This study employed SCAT, which entails a four-stage coding process as follows: cataloging segmented text data within a matrix and bestowing codes, recontextualizing of the extracted codes into a storyline, and delineation of a theory. The codes are bestowed in the following order: notable phrases in the data, expressions external to the text for rewording, phrases for explanation, and emerging themes and integral concepts [11]. SCAT is suitable for analysis by several individuals as it facilitates clear documentation of the analytical procedure, ensuring reflectiveness and the possibility of disproof, which enhances analytical legitimacy. SCAT analysis is typically performed once for compact data. However, because of the extensive interview durations and significant quantity of data per person collected in our study, individual narratives were described as new segments, and we used a method to analyze them by theme [11, 13].

The derived theoretical descriptions were categorized based on their similarities and commonalities. The relationships among these were examined based on the theoretical descriptions, codes that constituted them, and text. Finally, we created an outline for reconstructing living space for older adults with disabilities during their transition to home-based care. The analysis was conducted by the lead author and two occupational ther-

Table 1 Summary of research collaborators

Participant	Age	Gender	Disease	MMSE	BI	House	Area of residence	Family members living together	Long-term care services used
A	80	Female	Subarachnoid hemorrhage	26	100	Owning/ Detached housing	Urban	none	Welfare equipment rental
B	71	Female	Lumbar compression fracture	30	95	Owning/ Detached housing	Urban	none	Home help service/Day services/ Welfare equipment rental
C	69	Male	Intestinal obstruction	30	65	Owning/ Collective housing	Suburbs	wife/son	Day services/Home-visit nursing/ Welfare equipment rental
D	83	Male	Stroke	28	90	Owning/ Detached housing	Suburbs	wife	Day services/Home-visit rehabilitation/Welfare equipment rental
E	74	Female	Lumbar compression fracture	27	75	Owning/ Detached housing	Urban	husband →daughter/son-in-law	Home help service/Home-visit nursing/Home-visit rehabilitation/ Welfare equipment rental
F	83	Male	Lumbar compression fracture	27	70	Owning/ Detached housing	Urban	wife/daughter	Day services/Home-visit rehabilitation/Welfare equipment rental
G	75	Female	Myelopathy	28	70	Owning/ Detached housing	Suburbs	none →son/daughter-in-law/grandchild	Day services/Home-visit nursing/ Home-visit rehabilitation/Welfare equipment rental
H	78	Male	Stroke	27	90	Owning/ Detached housing	Suburbs	wife/son	Day services/Welfare equipment rental
I	90	Male	Lumbar compression fracture	28	80	Owning/ Detached housing	Urban	wife/grandchild	Home-visit rehabilitation/Welfare equipment rental

Ms. E's husband died three months after being discharged from the hospital, and her daughter and her husband moved in together.
Ms. G originally lived alone, but his son's family came to live with him around the same time he was discharged home.

apists with > 15 years of clinical experience. They were supervised by researchers experienced in qualitative research in the fields of social medicine and architecture.

Ethical considerations

The participants were verbally informed by the author about the purpose of the study, methods, risks, responses to physical and mental burdens, maintenance of anonymity, and the possibility of withdrawal at any stage, and their consent was obtained. The procedures followed the ethical standards of the Declaration of Helsinki. This study was approved by the Kenwakai Ethics Committee (No: 2017005) and the Research Safety and Ethics Committee of Tokyo Metropolitan University (No: 18017).

Results

Basic characteristics

Table 1 presents the demographic and clinical characteristics of the nine study participants. The study included five men and four women aged 65–90 years. The Barthel Index score ranged from 65 to 100. Five participants resided in urban areas, while four participants lived in suburban areas. All participants were homeowners. Eight participants lived in detached houses, and one lived in a collective housing. Six participants lived with their families, and three participants lived alone. Two participants experienced changes in their cohabitation status with family members during the 6-month follow-up period.

Living space experiences of older adults with disabilities during the transition period

Although the cognitive changes in each participant followed a similar trajectory, they were not necessarily synchronized. Based on the chronological order and uniqueness of each individual's experience, the codes derived from the participants' narratives were organized into the following four stages: "hospital space during discharge preparation," "living space after discharge," "reconstruction of the living space," and "stabilization

of the living space." These provided a theoretical description. Finally, 10 categories were extracted based on the similarity of content. Table 2 provides an overview of this process. The letters A–I refer to individual participants, with each letter representing a unique individual.

Theme 1: Ward space before discharge.

This theme included the following two categories:

1. Striving to be a patient in the ward space

Striving to be a patient in the ward space encompassed two subcategories: conflict with patient role and relationship-based spaceelection.

Older adults with disabilities who embraced "the behavior of a system beneficiary (D)" and "expected behavior within the ward space (B, H)," while "self-marginalizing as a resident (I)" by distancing from everyday life, exemplified conflict with patient role.

Within the ward, "spaceelection according to relationships (E)" varied, including finding a "sense of solidarity among ward patients (G)" or a "safe zone for oneself (A)," and consciously making "space choice to maintain oneself (E)."

Desire to be an active participant in everyday life practice manifested as "the desire for a unique family life that is different from the uniform ward life (F)" and "the desire to be involved in daily life (A)," evolving into "a longing for a familiar home (G)." The "concrete prospect of returning home (C, G, H)" fostered "increased motivation for rehabilitation (C, G)," reflecting the desire for active participation in everyday practice.

Theme 2: Living space after discharge

This theme included the following four categories:

1. Liberation from constraints

Discharge home was perceived as "liberation from constraints (A, B, C, D, E, F, G, H, and I)."

2. Sense of incompleteness in life

Sense of incompleteness in life encompassed two subcategories: environmental gaps in hospital-home transition and movement-related social isolation.

"Restriction of activity range due to temperature differences (A, B, I)" and "gaps in practice within the living space (C)" led to "stress due to the inability to adapt to environmental changes (E)" and a "sense of incompleteness due to an uncooperative body (C)" postdischarge, exemplifying environmental gaps in the hospital-home transition.

"Impaired movement due to architectural inaccessibility (I)," "difficulty in going out due to surrounding environmental barriers (A, C, G)," and "stress of relying on family members for every trip (C)" exacerbated "difficulties in mobility due to the environment (E)." This heightened "the decline of the local living community (B, F)," "loss of neighbors due to death (B, E, F, H)," "absence of caregivers (E)," and "individualization of the community (B, E, F, H)."

"Necessary movements for life (H)" became challenging due to "community vacancy caused by the suburban transfer of life functions (B, H)" and "systems optimized for the able-bodied (H)." "Transportation inaccessibility issues (F)" resulted in "difficulty in accessing lifelines (B, H)," creating "shopping refugees (B, H)." These factors collectively deepened social isolation stemming from movement inconvenience.

3. Loss of place

Loss of place encompassed two subcategories: displacement due to rationalized care and erosion of existence-affirming space.

Space and time "optimized for patient care (E, F, G)" and "relationships filtered for care purposes (B, E)" led to "dismantling of the personal space (E)." "Nonself-contained environments (C, E)" like "caregiver-centric space (E)" or "institutionalized living space (E)" eliminated "choices involving risk (C, F)." The resulting "publicization of private zones (E, F)," founded on "asymmetrical relationships (E, F)" and "refamiliarization of care (E, G)," threatened participants' sense of self, leading to "abandonment of roles (C, F)" and "disconnection from household chores as a part of lifestyle (E, G)." These experiences exemplified displacement through rationalized care.

"Lifestyle deviations due to disabilities (C, F)" challenged "social norms regarding housing (D, F)" and the "obviousness of one's home (C, F)." Living an "unscripted retirement life (C, D, F)" in an "uncertain and uncontrollable realm (C, F)," accompanied by a "rootless feeling (C, F)," characterized the erosion of existence-affirming space.

4. Self-regulation in living

Self-regulation in living encompassed three subcategories: norms avoiding reliance on others, remorse for lack of productivity, and resignation to current living conditions.

The "reversal of the role of dependence (E)" and beliefs in "obsession with independence (A, C, E)" and that "incapacity are the end (A, C, D)" fostered "negative views on dependence on assistive devices (I)" and "deterioration of the environment due to self-restraint (C)." The "pursuit of functional independence for the sake of autonomy (A, G)" was seen as "the only path to freedom (A, C)," reflecting norms avoiding reliance on others.

Table 2 Categories generated from theoretical descriptions for each theme

Theme 1: Ward life toward discharge.

Category	Subcategory	Theoretical description
Striving to be a patient in the ward space	Conflict with patient role	Older adult individuals with disabilities during their hospital stay, embrace social norms such as "the behavior of a system beneficiary (D)" and "expected behavior within the ward space (B, H)," and "self-marginalized as a resident (I)" by distancing themselves from everyday life.
	Space selection according to relationships	Even within the same ward, the "space selection according to relationships (E)" differ.
		They find a "sense of solidarity among ward patients (G)" or a "safe zone for oneself (A)" and consciously make "space choice to maintain oneself (E)."
Desire to be an active participant in everyday life practice		"The desire for a unique family life that is different from the uniform ward life (F)" and "the desire to be involved in daily life (A)" develop into "a longing for a familiar home (G).
		The "concrete prospect of returning home (C, G, H)" leads to "increased motivation for rehabilitation (C, G)."

Theme 2: Living space after discharge.

Category	Subcategory	Theoretical description
Liberation from constraints		Discharge home is perceived as "liberation from constraints (A, B, C, D, E, F, G, H, and I)."
Sense of incompleteness in life	Environmental gaps in the hospital–home transition	The "restriction of activity range due to temperature differences (A, B, I)" and "gaps in practice within the living space (C)" that differe from the ward environment produced "stress due to the inability to adapt to environmental changes (E)" and a "sense of incompleteness due to an uncooperative body (C)" after returning home.
	Social isolation deepened by the inconvenience of movement.	The effects of "impaired movement due to architectural inaccessibility (I)", "difficulty in going out due to surrounding environmental barriers (A, C, G)," and "stress of relying on family members for every trip (C)" is significant.
		"Difficulties in mobility due to the environment (E)" make "the decline of the local living community (B, F)," "loss of neighbors due to death (B, E, F, H)," "absence of caregivers (E)," and "individualization of the community (B, E, F, H)" more prominent.
		The "necessary movements for life (H)" were perceived as severe challenges by the participants due to the "community vacancy caused by the suburban transfer of life functions (B, H)" and use of "systems optimized for the able-bodied (H)" such as public services.
		The "transportation inaccessibility issues (F)" lead to "difficulty in accessing lifelines (B, H)," including becoming "shopping refugees (B, H)."
Loss of place	Displacement due to rationalized care	The use of space and time "optimized for patient care (E, F, G)" and "relationships filtered for care purposes (B, E)" are considered "dismantling of the personal space (E)."
		"Choices involving risk (C, F)" were eliminat by "non-self-contained environments (C, E)" such as "caregiver-centric space (E)" or "institutionalized living space (E)."
		"Publicization of private zones (E, F)," based on "asymmetrical relationships (E, F)" and "refamiliarization of care (E, G)," are perceived as threats leading to "abandonment of roles (C, F)" and "disconnection from household chores as a part of lifestyle (E, G)."

Table 2 Categories generated from theoretical descriptions for each theme (Continued)

Category	Subcategory	Theoretical description
	Erosion of space that affirms existence	"Social norms regarding housing (D, F)," such as the housing ladder, and the "obviousness of one's home (C, F)" are in crisis due to "lifestyle deviations due to disabilities (C, F)."
		"Unscripted retirement life (C, D, F)" and an "uncertain and uncontrollable realm (C, F)" lead to a "rootless feeling (C, F)."
Self-regulation in living	Norms that do not rely on others	The confusion caused by the "reversal of the role of dependence (E)" and the belief that "obsession with independence (A, C, E)" and "incapacity are the end (A, C, D)" led to "negative views on dependence on assistive devices (I)" and "deterioration of the environment due to self-restraint (C)."
		The "pursuit of functional independence for the sake of autonomy (A,G)" was "the only path to freedom (A, C)" and meant norms that do not rely on others.
	Remorse for lack of productivity	Based on "past experience as caregivers (A, B, E)," there is an "attitude of not putting one's own burden on the child (A, B)."
		They feel "guilty for imposing themselves on the family (A, B, C)," which resulted in a "desire not to be a burden on the family (A, G)" and an attitude of "aloofness (C)."
		They perceive themselves a "costly existence (A, B, C)" and are in a psychological state of guilt for "nonproductivity (C)."
	Resignation to living in the current habitat	The struggle to not be functionally independent and productive lead to "countdown to institutionalization (A, B)," "resignation of support (B)," and "neglect of home maintenance (A, B, G)," which result in "restrained dispositions toward one's environment (B)."
		The "abandonment of living areas (B)" and "minimization of activities (C, E, F)" accelerat the "vicious cycle of deterioration of living space (C, E, F)."

Theme 3: Reconstruction of the living space

Category	Subcategory	Theoretical description
Reevaluation of relationships via engagement in activities	Life needs induced by external factors	"Daily needs that change with seasons (A, B, E)" is a catalyst for "reinitiating home activities (D)," such as "activity adjustments in response to the climate (A, B)."
	Advocates for activity engagement	"Hesitation to engage in activities (B, E)," "struggles due to limitations (C, E)," support for "making environmental adjustments according to living needs (G)," and companions who "assist with outings (A, B, G)" as empathetic or cooperative entities foster the "restoration of activity space (C, E, G)."
		Informal support, such as "assistance from neighboring families who do not interfere too much (I)" and the "presence of someone reliable (G)" encourage activities.
	New connections arising from activity engagement interactions	"Engagement with everyday life (C, H, E)" lead to "regaining roles within the family (C, H, E)" and relationships of "mutual care (B, C)."
		Engagement with activities causes "variability in established relationships (C, E)," "desensitization to dependence on others (E)," and the "relativization of connections (B, C)."
		The "redefinition of relationships (C, E)" because of the discovery of potential between individuals and their helpers lead to the "mobilization of resources according to one's lifestyle (B, D, G)."
		"Relativization of barriers (G)" symbolize a "shift from being a protected individual to reclaiming one's role as an active participant in life (C, E)."

Table 2 Categories generated from theoretical descriptions for each theme (Continued)

Category	Subcategory	Theoretical description
	Broadening of the space via activity engagement	"Rhythms of life arising from gardening or neighborhood interactions (D)," "organization of time and space by resuming activities (A)," and "expanding the space based on past experiences and relationships (B)" contribute to a "feeling of being an active participant in life (C, E)" and "realization of successful home discharge (F)."
Reorganization of space where activities are generated	Rediscovery of activity space	Semioutdoor space like Engawa is reaffirmed as enabling "diverse self-expression (A, B)" and "connection with society (A, B)."
		"Space where the presence of others can be subtly felt (D, E)" and "layouts and geographical conditions that enable mutual care (A, E, G)" facilitate use as "communal areas (E, G)" and foster "acknowledgment of roles (E, F, H)."
	Pioneering the third space	By "adjusting the environment by utilizing familiar resources (B, G)" such as "securing private space through digital devices (B, G)," "places of connection (B, G)" such as personal space are created in the "urban gap (B)," such as drinking tea at convenience stores.

Theme 4: Stabilization of the living space

Category	Subcategory	Theoretical description
Constant redefinition of space	Space consistently given significance	Each aspect of "home arrangement (I)" becomes a "symbol of life (D, F, I)" and are "space imbued with meaning (D, F, I)."
		By "inhabiting it (D, E, F, I)," the home serve as an "assurance of continued existence (D)" and a "space inseparable from self (F)."
	Embodiment of space through dwelling	The "reality of dwelling (D, E)" is associated with tangible "bodily experiences of the environment through activities (B, C, E)."
		The "reorganization of everyday practices (E)" includ the constant "use of assistive devices as tools (C, E)," and "adjustment of the environment and body through activities (D, G, H)."
Coexistence with others	Collaborative creation of living space	"Mutual understanding in actual care scenarios (C, E)," the "joy of going out with ease (C)," "expressions and realizations of hopes (B, E, G)" and "successful living activities (C, E)" allowe the "rebuilding of one's unique space with supporters (B, C, E, G)."
		"Mutual recognition in places and activities that affirm the self (D)" foster a new "symbiotic relationship (A, B, C, E, G, H)."
	Coexisting with uncertainty	For older adults with disabilities, living space is easily disrupt by the absence or presence of "supporters who optimize the environment (C, H)," "fluctuations between routine and emergencies (G)."
		Maintaining "agency in living (F)" involve "struggles over space (A)," "tensions (G)," and coexisting with "Uncertainty due to relationships (H)" external factors.

The letters A through I used in this study refer to individual participants, with each letter representing a unique participant.

Participants' "past experience as caregivers (A, B, E)" motivated an "attitude of not putting one's own burden on the child (A, B)." Feelings of "guilty for imposing themselves on the family (A, B, C)" led to a "desire not to be a burden on the family (A, G)" and "aloofness (C)." Self-perception as a "costly existence (A, B, C)" and guilt for "nonproductivity (C)" exemplified remorse for lack of productivity.

Struggles with independence and productivity resulted in a "countdown to institutionalization (A, B)," "resignation of support (B)," and "neglect of home maintenance (A, B, G)," leading to "restrained dispositions toward one's environment (B)." "Abandonment of living areas (B)" and "minimization of activities (C, E, F)" exacerbated the "vicious cycle of deterioration of living space (C, E, F)," indicating resignation to current living conditions.

Theme 3: Reconstruction of the living space

This theme included the following two categories:

1. Reevaluation of relationships via engagement in activities

Reevaluation of relationships via activity engagement encompassed four subcategories: externally-induced life needs, activity engagement advocates, new connections from interactions, and space broadening through engagement.

"Daily needs that change with seasons (A, B, E)" catalyzed "reinitiating home activities (D)" and "activity adjustments in response to the climate (A, B)," exemplifying externally-induced life needs.

"Hesitation to engage in activities (B, E)" and "struggles due to limitations (C, E)" were countered by support for "making environmental adjustments according to living needs (G)" and companions who "assist with outings (A, B, G)." "Assistance from neighboring families who do not interfere too much (I)" and the "presence of someone reliable (G)" served as activity engagement advocates.

"Engagement with everyday life (C, H, E)" led to "regaining roles within the family (C, H, E)" and "mutual care (B, C)," resulting in "variability in established relationships (C, E)," "desensitization to dependence on others (E)," and "relativization of connections (B, C)." "Redefinition of relationships (C, E)" facilitated "mobilization of resources according to one's lifestyle (B, D, G)" and "relativization of barriers (G)," symbolizing a "shift from being a protected individual to reclaiming one's role as an active participant in life (C, E)."

"Rhythms of life arising from gardening or neighborhood interactions (D)," "organization of time and space by resuming activities (A)," and "expanding the space based on past experiences and relationships (B)" fostered a "feeling of being an active participant in life (C, E)" and "realization of successful home discharge (F)," illustrating space broadening via activity engagement.

2. Reorganization of space where activities are generated

Reorganization of activity-generating space encompassed two categories: rediscovery of activity space and pioneering the third space.

Semioutdoor space like Engawa was reaffirmed as enabling "diverse self-expression (A, B)" and "connection with society (A, B)." "Space where the presence of others can be subtly felt (D, E)" and "layouts and geographical conditions that enable mutual care (A, E, G)" facilitated use as "communal areas (E, G)" and fostered "acknowledgment of roles (E, F, H)." This complementary reorganization exemplified rediscovery of activity space.

"Adjusting the environment by utilizing familiar resources (B, G)" and "securing private space through digital devices (B, G)" created "places of connection (B, G)" in the "urban gap (B)," such as convenience stores. These active attitudes, transcending virtual and real space boundaries, represented pioneering the third space.

Theme 4: Stabilization of the living space

This theme included the following two categories:

1. Constant redefinition of space

Constant redefinition of space encompassed two subcategories: space consistently given significance and embodiment of space through dwelling.

"Home arrangement (I)" becomes a "symbol of life (D, F, I)" and creates "space imbued with meaning (D, F, I)." "Inhabiting it (D, E, F, I)" transforms the home into an "assurance of continued existence (D)" and a "space inseparable from self (F)," exemplifying space consistently given significance.

The "reality of dwelling (D, E)" manifests through "bodily experiences of the environment through activities (B, C, E)." "Reorganization of everyday practices (E)" involves "use of assistive devices as tools (C, E)" and "adjustment of the environment and body through activities (D, G, H)," illustrating embodiment of space through dwelling.

2. Coexistence with others

Coexistence with others encompassed two subcategories: collaborative creation of living space and coexisting with uncertainty.

"Mutual understanding in actual care scenarios (C, E)," "joy of going out with ease (C)," "expressions and

realizations of hopes (B, E, G),” and “successful living activities (C, E)” facilitated “rebuilding of one’s unique space with supporters (B, C, E, G).” “Mutual recognition in places and activities that affirm the self (D)” fostered new “symbiotic relationships (A, B, C, E, G, H),” exemplifying collaborative creation of living space.

For older adults with disabilities, living space was vulnerable to disruption by “supporters who optimize the environment (C, H)” and “fluctuations between routine and emergencies (G).” Maintaining “agency in living (F)” involved “struggles over space (A),” “tensions (G),” and coexisting with “Uncertainty due to relationships (H)” and external factors, characterizing coexistence with uncertainty.

Discussion

Living space experiences of older adults with disabilities during the transition from hospital to home care

This study aimed to elucidate the process of living space reconstruction for older adults with disabilities during the transition from medical institutions to home. Concerning the community-based integrated care system, we sought to gain insights that can contribute to the development of effective environmental support measures by examining subjective experiences and perceptual changes. This complex transition process was analyzed based on four primary themes. The following discussion addresses implications for occupational therapy practice and how can the sustainable home-based support can be realize for older adults with disabilities.

1. Ward space before discharge

During discharge preparation, participants’ experiences largely aligned with Goffman’s theory of total institutions [14], revealing varied responses based on individual characteristics.

Participants with higher levels of independence (B, D, H, I) exhibited a strong desire for an active life post-discharge, which manifested as “conflicts with the patient role.” This can be interpreted as effort to maintain self-identity in anticipation of life after hospitalization.

The “spaceelection according to relationships,” which were only extracted from female participants (particularly A, E), suggests an important aspect of discharge preparation. Securing “safe zones” within the ward and forming a sense of solidarity with other patients may provide opportunities for mutual encouragement and information sharing, potentially enhancing motivation for recovery as the discharge date approaches.

Notably, “concrete prospects of returning home” were crucial for all participants, regardless of independence level or gender. These prospects promoted active participation in rehabilitation (G, C, H) and contributed to the recovery of self-identity in preparation for rebuilding life after discharge. This indicates a psychological preparation process specific to the transition from institution to community.

These findings suggest that discharge support should comprehensively consider individual independence levels, needs for social interaction, and future life prospects.

2. Living space after discharge

Although participants initially felt a sense of “liberation” from hospital constraints after discharge, they soon faced significant environmental challenges. The elderly struggled with inadequate home modifications and temperature control issues, particularly during seasonal changes (A, B, I). These challenges restricted their mobility and increased feelings of social isolation, especially in older homes lacking proper accessibility.

The adaptation process was greatly influenced by participants’ level of independence, residential area, and social background. Participants with higher BI scores (A, B, D, H) adapted more smoothly, whereas those with lower BI scores (C, F, G) required more support and reported stronger feelings of “incompleteness in life.”

Clear differences were observed by residential area. Urban participants (A, E, F, H, I) had easier access to services; however, experienced difficulties adapting to environmental complexities. Suburban participants (B, C, D, G) tended to have larger living space, but reported difficulties in accessing services.

For some participants, the introduction of new caregivers intensified feelings of psychological alienation (E, C). Moreover, the transformation of homes into care-optimized space often increased feelings of dependency and reduced autonomy. This process, though less overt than hospital-based institutionalization, reflected a recreation of the “total institution” concept [14] in a domestic setting.

Furthermore, family composition was crucial. Participants living alone (A, B) struggled to maintain independence and faced higher risks of social isolation. Participants living with family had easier access to daily support but faced challenges in redefining roles. Changes in family composition (E, G) substantially impacted redefinition of living space.

3. Reconstruction of the living space

This theme represented a complex and individualized process of re-establishing identity, life continuity, and social connections, transcending mere physical adaptation. This aligns with the concept of creating meaningful places in old age [15], recognizing the intricate

interplay of personal attributes, environmental factors, and evolving needs.

Participants' experiences revealed that reconstruction of living space is not determined by a single attribute but complex interactions. For instance, resuming seasonal activities (A, B) and household chores (D) reflected participants' attempts to reaffirm self-identity and imbue their homes with personal meaning. These approaches even varied among participants with similar characteristics, with further influences by urban/suburban environments and living situations.

Environmental adjustments, which were particularly evident in participants experiencing life changes (E, G), demonstrated attempts to harmonize individual needs with one's surroundings. Ongoing adjustments emphasized the fluid nature of space reconstruction, in which meaning and use are constantly renegotiated.

The creative use of urban space (B) illustrated how older adults can reimagine their environments, and the diversity of reconstruction experiences highlighted the need for individualized, life-centered support.

These findings underscore the importance of supporting older adults with disabilities in building meaningful relationships within new environments postdischarge, rather than solely focusing on functional independence. Support systems should comprehend individual histories, values, and changing circumstances, facilitating the creation of personalized, meaningful living space.

This approach advocates for flexible, comprehensive support with the consideration of functional independence and the establishment of environments reflecting personal significance. Recognizing living space reconstruction as a dynamic, individualized process reflects the potential for effective and sustainable home living arrangements for older adults with disabilities.

4. Stabilization of the living space

Our analysis under "Stabilization of the living space" revealed how older adults with disabilities navigate the challenges of transitioning from hospital to home care. This process aligns with Rowles and Bernard's [15] "meaning and significance of place in old age." Our study revealed two main categories in this process: "constant redefinition of space" and "coexistence with others."

By redefining space, participants viewed their homes as "symbols of life" (D, F, I) and created "space imbued with meaning" (D, F, I), implying a deep psychological journey beyond physical adaptation and involving reconstruction of personal identity and life meaning. The "reality of dwelling" (D, E) was embodied through the activities (B, C, E), use of assistive devices (C, E), and environmental adjustments (D, G, H). These findings are in line with Iwarsson et al.'s [16] emphasis on the role of the environment healthy aging and highlight the dynamic nature of interactions between individuals and their living space.

Coexistence with others facilitated the rebuilding of unique space (B, C, E, G) through mutual understanding and shared activities (C, E), indicating that social relationships play an essential role in the meaning-making and reconstruction of living space beyond support provision. However, this process involved managing uncertainties, including potential disruptions from supporters (C, H), and maintaining agency amid changing circumstances (F, A, G). This finding indicates that stabilization of living space is an ongoing process requiring continuous adjustment and negotiation.

These insights highlight the need for holistic support approaches that consider individual histories, values, and social relationships, going beyond the traditional focus on functional independence and physical adaptations. Such strategies could involve narrative approaches to support meaning-making in space, designing environments that promote social connections, and developing adaptive support systems that flexibly respond to changes.

Limitations and future studies

This study has several limitations. Postdischarge interviews may be biased by memories that could influence narratives about the hospital. This study focused on urban and suburban populations. Detailed data by region and disability could enhance support for home care. Further epidemiological research is needed to understand how perceptions of the living environment after discharge affect future health.

Conclusion

This study qualitatively and longitudinally examined how older adults with disabilities reconstructed their living space during the transition to home care. After returning home, these individuals began to perceive their once-familiar home as alien due to physical limitations and challenging relationships with caregivers. The necessity of arranging the living environment during the transition period is often overlooked, resulting in care dependence and psychological distress amid confusion and a sense of unproductivity.

The dynamic nature of daily activities, space, and interactions led to unpredictability, enabling activity-based interventions. These activities prompted reevaluation of relationships between individuals and caregivers, fostering the reconstruction of "home" with new mean-

ings. The process of interaction and relationship-building around living space is complex and nonlinear, evolving dynamically amid conflicts and hesitations, with equilibrium easily disrupted by external factors. The study's results underscore the effectiveness of activity-oriented approaches within these dynamics and highlight the need for consistent supportive assistance for older adults with disabilities transitioning to home care.

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Conflict of interest

The authors declare no competing interests.

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■ORIGINAL ARTICLE

Validity and Reliability Study of a Line Bisection Task on Tablet Personal Computer

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Abstract: Objective: Recently, we developed a line bisection task (LBT) that could be performed on a tablet personal computer (PC) by recording the results and automatically calculating the lateral deviation from the true center for each trial. The present study aimed to verify the validity and reliability of the LBT on a tablet PC. Additionally, we examined whether there were any differences between the results of the tablet and paper LBTs.
Methods: The LBT was performed both on paper and tablet PC by 26 right-handed healthy adult volunteers (mean age 21.2 ± 2.1 years). Lines of three different lengths (200, 100, and 50 mm) were presented five-times in a pseudorandom order in each task condition. The participants were asked to mark a subjective midpoint with a pencil or a dedicated pen. Additionally, eight participants performed the LBT on the tablet twice to evaluate reliability.
Results: Data analysis revealed a significant and "strong" to "very strong" correlation between the results of paper and tablet LBTs for each line length. Additionally, "good" test-retest reliability was confirmed by the results of the tablet LBT. There was no difference in the LBT results for each line length between the two task conditions.
Conclusions: The validity and reliability of the newly developed tablet LBT were confirmed. Additionally, the LBT performed on the tablet PC yielded results equivalent to those obtained when performed on paper.

Keywords: line bisection task, tablet personal computer, spatial attention, healthy participants

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1. Introduction

Unilateral spatial neglect is a symptom where patients show difficulty in paying attention to contralesional space [1]. It is likely to occur after right-hemisphere injury [2]. As this symptom is often accompanied by a decline or lack of awareness [3], it hinders the improvement of the ability to perform activities of daily living [4–6]. Therefore, we believe that detecting symptoms and understanding their extent and characteristics will help clinicians prioritize and select appropriate therapeutic intervention programs.

A common test for assessing unilateral spatial neglect is the line bisection task (LBT). Some of the well-known LBTs include the line bisection test in the Japanese version of the behavioral inattention test [7] and that reported by Schenkenberg et al. [8]. In these tests, as multiple lines are printed on one sheet of paper, it is possible to evaluate simultaneous attention allocation to them. However, the drawn subjective midpoints may impact the judgment of the subjective midpoint of the next line. Additionally, a few patients may ignore the existence of the line on Schenkenberg's LBT [9].

Therefore, to appropriately evaluate the attention allocation to each presented line, it is necessary to show the lines individually. Additionally, by presenting lines of different lengths, we can examine the deviation of the subjective midpoint based on line length [10]. Furthermore, by changing the presentation position of the line, we can examine the effect of position on determining the subjective midpoint [11, 12]. In the LBT, the partic-

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ipants are asked to mark the subjective midpoint of the presented line. Owing to the simplicity of instructions and implementation, this test can be applied to many patients.

However, in clinical situations, evaluation using the LBT with a one-line presentation is not common. As one-line printed LBT sheets are not commercially available, examiners must prepare test sheets with adjusted line lengths and presentation positions. Additionally, the results for each trial must be measured in millimeters. Performing LBTs on a personal computer (PC) could eliminate these time-consuming processes, and previous studies have reported the use of touchscreen displays connected to PCs [13–17]. However, the space required to conduct the examination using such devices is limited to the rehabilitation room. Therefore, we developed a new LBT that could be performed on a tablet PC, which could be used not only in the rehabilitation room but also at the bedside.

To the best of our knowledge, no previous study has as yet developed a tablet LBT and reported its reliability and validity. Therefore, this study aimed to verify the criterion-related validity based on the results of the newly developed tablet version of the LBT and those of the paper LBT, and the test-retest reliability of the results of the tablet LBT. Furthermore, upon verifying its validity, we examined whether there was any difference in the performance of the LBT, even when the implementation conditions (tablet and paper) were different.

2. Materials and Methods

2.1 Participants

The study included 26 young healthy right-handed participants (13 females and 13 males, age 21.2 ± 2.1 years). All participants had +8 or more on the FLENDERS handedness test [18] and met the right-handedness criterion of +5 or more.

The inclusion criteria were as follows: (1) Age at the commencement of the experiment, 18–40 years, (2) Write only with the right hand, and (3) Possess sufficient eyesight to complete the LBT, regardless of whether they wear glasses or contact lenses. Exclusion criteria included: (1) Have a decline or disorder in physical and/or cognitive functions that will impact the implementation of this study, (2) Currently have, or have a past history of, neurological and/or neuropsychiatric symptoms, (3) Have visual field defect, and (4) Have an orthopedic or skin disease that could interfere with the implementation of the LBT.

To ascertain the required sample size, G*power 3.1.9.7 [19] was used for the correlation analysis of the LBT between the two conditions, with effect size 0.5, α 0.05, and power 0.8, which yielded a sample size of 26. Additionally, the R ver. 4.0.3 [20] operated by Windows 10 was used to ascertain the number of participants required for intraclass correlation (ICC) (1,1) to examine test-retest reliability; it showed eight participants. The sample size required to verify that there was no difference in the performance of the LBT depending on the implementation conditions was determined using G*power 3.1.9.7 [19], selecting repeated-measures analysis of variance, effect size 0.25, α 0.05, power 0.8, number of groups 1, number of measurements 6, correlation among repeated measures 0.5, and nonsphericity correction 1. Accordingly, the sample size was 19.

2.2 Procedure and experimental environment

This study adopted a crossover design. To eliminate the order effect of the LBT, half of the randomly selected participants first performed the LBT on paper, followed by the LBT on a tablet; the remaining participants performed the tasks in reverse order. Additionally, to verify test-retest reliability, after completing the LBT for the two conditions, eight participants were randomly selected—four from each implementation order, and asked to repeat the LBT on the tablet.

A room with no noise from inside or nearby was used for this study. To control the amount of light in the room, the experiments were implemented with curtains drawn in front of the windows and doors and the ceiling lights switched on.

2.3 Line bisection task on paper

An A4 landscape sheet (210 × 297 mm) was printed with a single horizontal line. Lines of lengths 50, 100, and 200 mm with a thickness of 0.5 mm were used to evaluate the effect of the line length. Each line was arranged to coincide with its midpoint at the center of the sheet.

Each participant sat in front of a 70 cm-high desk. The test sheets were presented individually in front of the participant, such that the midline of the sheet coincided with the midsagittal plane of the participant's trunk. The distance from the participant's abdomen to the midpoint of the line was approximately 20 cm. Participants were instructed to mark the subjective midpoint of the presented line using a pencil (weight: approximately 4 g) held in their right hand, and no corrections were allowed. The thickness of the pencil lines was approximately 0.5 mm. As the prolonged presentation of the marked test sheets could influence the outcome of each trial, the sheets were replaced as soon as the participants marked them.

The order of the line presentation was pseudo-random, but the same line length was not presented

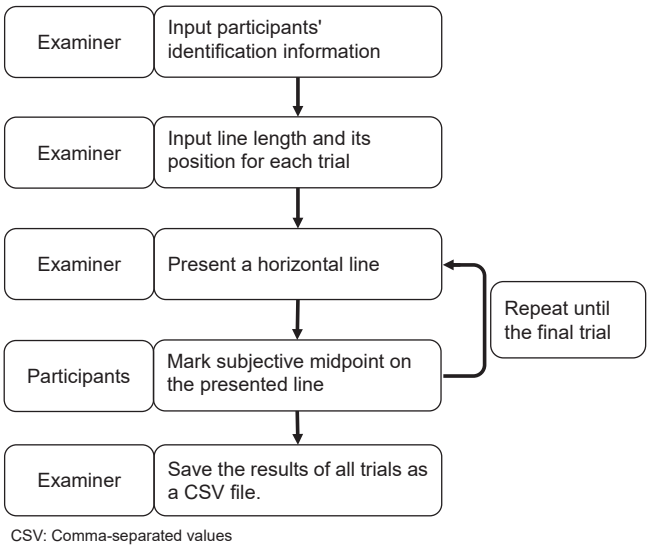


Fig. 1. The process of the line bisection task using a tablet personal computer with the developed app.

repeatedly. Each line length was presented five-times and each participant performed a total of 15 trials. The results obtained in each trial were measured in millimeters of lateral displacement from the true center to the subjective midpoint, with a positive value for rightward deviation and a negative value for leftward deviation. For each participant's results, the average value for each line length was calculated, and each was regarded as an individual result.

2.4 Line bisection task on a tablet personal computer

A tablet PC (Microsoft Surface Pro 7, Processor: Intel® Core™ i5-7300U, PC size: 201 × 292 × 8.5 mm, monitor size: 173 × 260 mm, resolution: 1824 × 2736 pixels) equipped with a newly developed application for LBT was used. The sampling frequency was set to 100 Hz.

An application software for an LBT was newly developed by co-authors HS and MT on a PC (Microsoft Surface Pro 7, Processor: Intel® Core™ i5-7300U, OS: Windows 10), using a programming language of Python (version 3.9.1) with Graphical User Interface library Tkinter (version 8.6) as a toolkit. These are open-source software. There are two functions of this software. First, the length of the horizontal line and its presentation position on the monitor could be set for each trial. Second, to obtain the results from each trial, the position of the participant's subjective midpoint was automatically measured as a lateral displacement from the true center of the presented line in millimeters, and rightward and leftward displacements were recorded as positive and negative values, respectively. When the test is completed, a comma-separated values file containing the results of each trial is created. By saving it, the results could be obtained. The process of the LBT on a tablet PC is illustrated in Fig. 1.

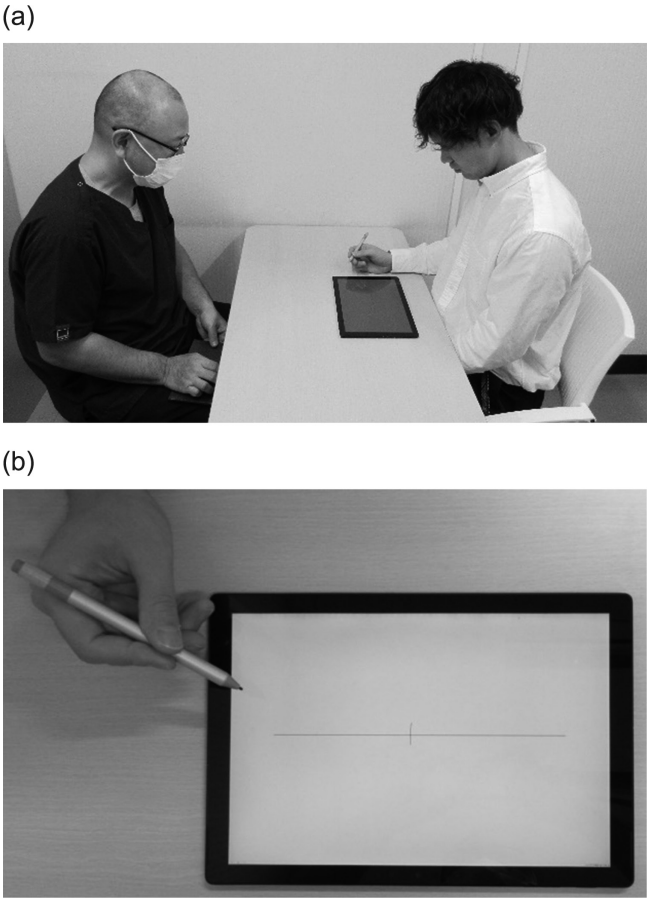


Fig. 2. (a) The experimental setup: The examiner and the participant sat facing each other across a table, with the tablet personal computer positioned in front of the participant. The distance from the center of the screen to the participant's torso was about 200 mm. (b) The tablet screen as viewed from the examiner's side: The displayed line was 200 mm long, with a small vertical line marking the subjective midpoint, drawn by a dedicated pen held in the participant's right hand.

Each participant sat in front of a 70 cm-high desk and was instructed to mark the subjective midpoint of a line displayed on the screen with a dedicated pen (Microsoft Surface Pen: model 1776, weight: approximately 20 g) held in their right hand (Fig. 2). The tip of this pen was 0.5 mm in width and the thickness of the pencil lines was approximately 0.5 mm. No corrections were allowed. The midpoint of the presented line was aligned with the center of the screen. The length and width of the line, the distance from the participant to the line, and the order of presentation of the line were matched with those of the paper LBT.

The examiner presented the line on the screen using a mouse. The order of line presentation and the total number of trials were the same as those of the paper-based LBT. As the participants had to place their right hand outside the task sheet after marking the subjective midpoint to change the test sheets in the paper-based LBT, they were similarly instructed to place their right hand outside the screen after each trial.

The results obtained from each trial were recorded by the application program in pixel units of lateral deviation from the true center to the subjective midpoint and then converted to mm units (1 pixel = 0.095 mm); the right and left of the true center were displayed as positive and negative values, respectively. For each participant, the mean value of each line length was regarded as the individual result.

2.5 Statistical analysis

To clarify the results for each line length obtained in each task condition, we calculated the mean and standard deviation of the subjective midpoint for each line length. Additionally, the Shapiro-Wilk normality test was conducted to examine the normality of each data point. Based on the result, appropriate statistical methods were selected for the following analyses.

To examine criterion-related validity, a correlation analysis was performed for the results of the paper and tablet LBTs, obtained from each participant for each line length.

To examine test-retest reliability, a correlation analysis was performed for each line length based on the results of the eight participants who performed the LBT on the tablet task twice.

If there was a correlation between the results of the LBT in the two conditions, a two-factor analysis of variance was performed to investigate the effect of the task conditions and line lengths using the collected data from all participants.

EZR (ver. 1.54) [21] operated by Windows 10 was used for all statistical analyses, and the significance level was set at 0.05.

3. Results

Data from all 26 participants, including the test-retest reliability results, were analyzed as no trials were missing or incorrectly marked. Table 1 presents the results of the LBT under the two task conditions for each line length. The Shapiro-Wilk normality test was performed to examine the normality of the results for each line length obtained in each condition. Normality was confirmed for the entire dataset (all the results obtained from each line length in two task conditions were $W > 0.95$ and p-value > 0.05).

Table 1 Line bisection task results for each line length under the two conditions

Task condition	Line length		
	50 mm	100 mm	200 mm
LBT on paper [mm]	−0.07 ± 0.73	0.38 ± 1.86	0.05 ± 3.13
LBT on the tablet [mm]	0.11 ± 0.82	1.12 ± 1.55	1.46 ± 2.91

LBT: line bisection task

Each data point expresses the lateral deviation from the true midpoint of each line as the mean ± SD with a positive value for rightward deviation and a negative value for leftward deviation. A two-factor analysis of variance with the task conditions (on the tablet, on paper) and line lengths (50 mm, 100 mm, 200 mm) revealed that no main effects or interactions were observed between them.

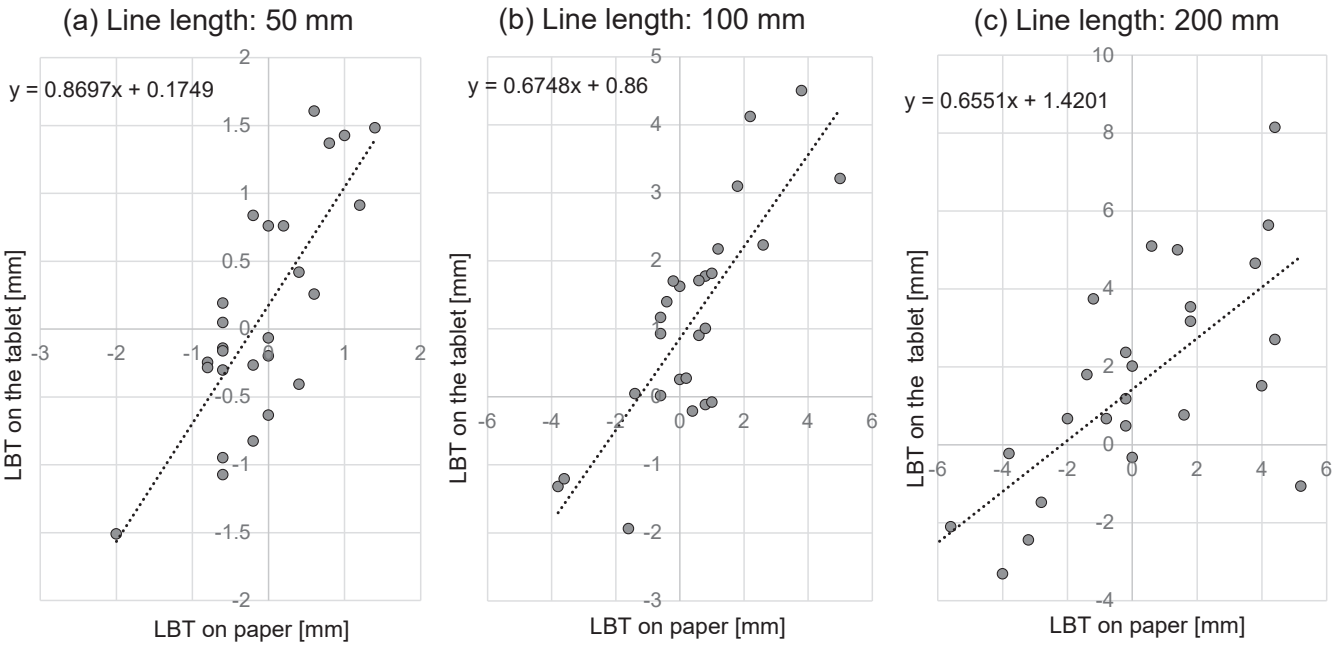
Figure 3 illustrates the correlation between the results of the two task conditions for each line length. The results of the Pearson's product-moment correlation analysis for criterion-related validity, represented as (correlation coefficient [95% confidence interval], p-value) were: 50 mm line (Fig. 3a) (0.78 [0.56–0.90], $p < 0.001$); 100 mm line (Fig. 3b) (0.81 [0.62–0.91], $p < 0.001$); 200 mm line (Fig. 3c) (0.70 [0.43–0.86], $p < 0.001$). The correlation coefficients between the tablet and paper LBT results were significant and > 0.7 at all lengths.

The results of ICC (1,1) for the test-retest reliability for each line length, represented as correlation coefficient [95% confidence interval], were: 50 mm line, 0.78 [0.29–0.95]; 100 mm line, 0.85 [0.46–0.97]; 200 mm line, 0.82 [0.46–0.97]. All results showed an ICC (1,1) ≥ 0.75.

The correlations in the results of the LBT between the two conditions for each line length were significant. Therefore, a two-factor analysis of variance with the task conditions (on the tablet, on paper) and line lengths (50 mm, 100 mm, 200 mm) was performed to determine if there were differences in task conditions and an interaction between task conditions and line lengths. No main effects or interactions were observed between the task conditions and line lengths (line length: $F_{1.33}$, 66.58 = 3.57, $p > 0.05$; task conditions: $F_{1, 50} = 2.96$, $p > 0.05$; interaction: $F_{2, 100} = 1.88$, $p > 0.05$).

4. Discussion

The present study examined the validity and reliability of the LBT on a tablet PC, which was developed based on results obtained from healthy young people. First, for each of the three line lengths, criterion-related validity was verified based on the results of the paper and tablet LBTs. A correlation coefficient ≥ 0.7 was ob-



LBT: Line bisection task

Fig. 3. The correlation of results between the two task conditions for each line length.
Graphs (a), (b), and (c) show the correlation between the results of the line bisection tasks on the tablet and on paper of line lengths of 50 mm, 100 mm, and 200 mm, respectively.

tained from the results between the two task conditions for each line length, confirming the validity. Second, the test-retest reliability was verified for each line length based on the results of two repeated trials of the LBT performed on a tablet PC. An ICC ≥ 0.75 was obtained for each line length, and retest reliability was confirmed. Furthermore, there was no difference between the results of the LBT performed on the tablet and that on paper. Additionally, no interactions were observed between the test conditions and line lengths. We identified that the LBT on the tablet has good reliability and validity and yields the same extent of results as the LBT on paper.

In this experiment, the results of the LBT on paper and that on the tablet showed a significant correlation, with a correlation coefficient of 0.7 to 0.8, regardless of the line length. These could be interpreted as results showing correlations from "strong" to "very strong" [22]. When comparing the LBTs under the two conditions, there were differences in the size of the A4 sheet and the display size of the tablet, the weight of the dedicated pen and pencil used, and the frictional resistance during drawing, which could not be measured. However, in both task conditions, the test paper and tablet were placed horizontally on a desk, a writing instrument with a sharp tip was used, and the relative position of the presented lines from the participants were kept the same. These commonalities resulted in strong correlations.

Katsuyama et al. [23] developed an LBT that could be performed on a touch panel using a PC and examined the relationship between the results of the LBT performed on the touch panel and that on paper. Their study revealed no significant correlation between the results of the two task conditions even though the presented line length was 203 mm—approximately the same as the 200 mm line length we adopted. In that study, the participants responded to the subjective midpoint with the right index finger. When pointing at the subjective midpoint with the fingertip, the recorded position differed depending on the part of the finger that touched the screen first. Therefore, this may have led to results that did not correlate with those derived after the test on paper.

Our results showed that the variability in the results of the subjective midpoint increased as the length of the presented line was longer, regardless of the task conditions as shown in Table 1. These results are similar to those of Yamashita et al.'s LBT in healthy young participants [24]. Both Yamashita et al.'s and our study adopted different lengths of lines for the LBT, which may have led to fluctuations in the determination of the subjective midpoint for longer lines. Therefore, even if there was a significant correlation, we interpreted that the results of longer lines indicated greater variability between the two conditions, as illustrated in Fig. 3.

Additionally, the analysis of the test-retest reliability revealed an ICC ≥ 0.75 for all line lengths. According

to Koo et al. [25], an ICC of 0.75 to 0.9 is considered as good reliability; therefore, our study showed that the tablet LBT yields highly reproducible results regardless of the line length. The LBT was simple for young, healthy participants, and the presentation order of the three line lengths was the same for the first and second trials. These factors may have contributed to the results of the present study.

Furthermore, the results of the analysis of variance, with task conditions and line length of the LBT as factors, revealed no main effects of task conditions or interaction of these two factors. The screen size of the tablet PC for this experiment was approximately 4 cm smaller in length and width than the A4 size sheet utilized in the paper LBT. The thickness of the tablet PC was 8.5 mm. However, in both conditions, lines of the same length and thickness were presented at the same distance from and in front of the participants on the same table. Therefore, we believe that these commonalities resulted in no differences in the LBT results between the two conditions or no interaction between the two factors.

The results of the above three analyses confirmed the high reliability and validity of the LBT performed on tablets and that the tablet LBT yields results similar to those obtained on paper. These results suggest that the tablet LBT could be used in the same manner as paper LBT. Even if multiple trials are performed, lateral deviation results could be obtained immediately after completion; therefore, it is considered highly practical in a clinical setting. Additionally, because the test does not use paper, the data could be conveniently stored and managed. Furthermore, because we can implement LBTs on a tablet anywhere, the use of a tablet PC is allowed. Moreover, as the LBT is utilized to assess spatial attention during awake surgery in patients with brain tumors [26], we believe that it is useful for intraoperative evaluation, as the LBT could be repeated. Collecting data from healthy participants of different ages and setting an average value and normal range for each age group will facilitate assessing the pathological symptoms of spatial attention disorders.

Limitations of the study

This study has a few limitations. First, we targeted healthy young individuals. It remains vague whether the same reliability and validity could be obtained in elderly individuals and patients with brain damage, especially those who are unfamiliar with pen operations on tablet PC. Depending on the results, it may be necessary to verify the operability of the dedicated pen in advance by asking the participants to write letters or draw pictures.

Second, the maximum length of the line that could be shown on the tablet PC is, theoretically, 260 mm. Therefore, it is impossible to perform LBTs using longer lines. This would necessitate performing the test on paper.

Finally, the results of this study were obtained from a task condition in which three lines of different lengths were presented in a pseudo-random manner. Therefore, it remains vague whether the same results could be obtained for each line length, even if a single length were repeatedly presented.

5. Conclusions

The reliability and validity of the LBT developed on a tablet PC were confirmed. Furthermore, there was no difference between the test results of the tablet and paper LBTs.

Ethical considerations

This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ethics Committee of Sapporo Medical University (approval number: 4-1-20). All participants provided written informed consent before participation.

Declaration of conflicting interests

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

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■ORIGINAL ARTICLE

Quantitative and Qualitative Analysis of a Japanese Road Sign Recognition Task

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Abstract: Occupational therapists use the Road Sign Recognition task (RSR) to assess driving capabilities. The Japanese Version of the Stroke Drivers' Screening Assessment (JSDSA), frequently used to specifically evaluate Japanese individuals' driving ability post-stroke, includes the RSR. However, the RSR in the J-SDSA utilizes signs and illustrations of overseas, making it less suitable for Japan. Therefore, this study developed an RSR using Japanese signs and actual driving photographs to investigate the relation of age, driving experience, and history of safe driving education on task difficulty. The RSR, consisting of 10 questions, was administered to 167 participants, including 62 older adults, 69 young adults, and 36 driving instructors with a driver's license. The results showed that the correct answers in the RSR were the highest in the order of instructors, young adults, and older adults. Similarly, the time required for the RSR was the shortest for instructors followed by young and older adults. The Rasch analysis indicated that the top three most difficult and easiest questions for older adults and young adults were the same. However, the questions deemed difficult or easy for instructors differed from the other two groups. This study indicated that age, driving experience, and safe driving education play important roles in RSR. The findings also highlight the necessity of understanding the examinee's background when applying the RSR to assess driving ability.

Keywords: driving, elderly, road sign recognition test

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Introduction

Occupational therapists often assess driving capabilities in medical institutions as part of their role in supporting automobile driving and community mobility. Neuropsychological testing is the foundation of driving capability assessments conducted in medical settings. Examples of such tests include the Trail Making Test (TMT), Block Design, and Raven's Progressive Matrices. These tests are useful predictors of on-road driving ability [1]. While these assessments excel in measuring cognitive functions, from the examinees' perspectives, they often do not directly measure driving capabilities, which is a drawback. This disadvantage can negatively affect occupational therapists' explanations of the test results to participants and the description of their anticipated risky driving behaviors. The Japanese version of the Stroke Drivers Screening Assessment (J-SDSA) was released in Japan in 2015 [2]. It is used to evaluate cognitive functions related to automobile driving and primarily targets stroke patients. Originally developed in the UK, it has been shown to predict on-road driving abilities with a certain degree of accuracy [3–5]. It has been translated into several languages and is used clinically in various countries [6–8]. One of the tests included in the SDSA is the Road Sign Recognition test (RSR). In general, it is the driver's duty to understand road situations while driving, detect road signs appropriately, and practice safe driving. The RSR involves a task in which the examinee selects an appropriate road sign for a location hidden within an illustration depicting a driving situation from multiple illustrated signs available. The RSR requires the knowledge of signs, ability to

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grasp road situations, executive function, and nonverbal reasoning abilities. Performance on the RSR was found to correlate with on-road driving ability [5, 6, 9, 10].

Unfortunately, the RSR task included in the J-SDSA uses signs and illustrations from overseas, making it difficult to determine whether it is suited for Japan. Therefore, the authors previously developed an RSR using traffic situations in Japan and examined its characteristics among older adults and young people [11]. The results showed no difference in performance between older adults and young people [12, 13]. This outcome contradicts the findings that age, driving experience, and history of safe driving education [14–16] influence tests measuring driving-related cognitive functions. One possible reason for this contradiction is that the difficulty level of the developed RSR was inappropriate. Therefore, this study aims to investigate the relations of age, driving experience, and safety driving education on RSR.

Methods

Ethical consideration

This study was conducted with the approval of the Medical Research Ethics Committee of Hokkaido Chitose College of Rehabilitation (approval number 2081). The procedures of this study followed the ethical standards of the Declaration of Helsinki.

Participants

This study comprised 167 participants, including older adults, young adults, and instructors, who provided their consent orally and in writing. To investigate the relations of age, driving experience, and safety driving education on RSR, we established three groups based on age, and the instructors were designated as the group with a high level of proficiency in safe driving education. The inclusion and exclusion criteria for each group were as follows.

Older adults were recruited by distributing flyers to participants in community health classes and salons with which the first author is involved. The inclusion criteria for older adults were aged 60 years or older and holding a valid standard driving license. Individuals who did not meet the vision and hearing requirements defined by the Road Traffic Law, or those with cognitive and physical impairments or requiring assistance in daily life, were excluded. The older adults group consisted of 62 participants (39 men and 23 women) with an average age of 75.4 ± 5.9 years (median 74 years, range 65–89 years). All the older adults had been driving for more than 10 years and regularly drove, with 52 of them driving daily, 8 driving 2–3 days a week, and 2 driving once a week. Cognitive function in older adults was assessed using the Mini-Mental State Examination (MMSE) [17]. The MMSE is a widely used cognitive function test for screening dementia and is scored out of 30 points, with higher scores indicating better cognitive function. The cutoff score for dementia screening was 24 points. The older adults' average score was 27.8 ± 1.8 (median 28, range 23–30 points). Younger adults were recruited by distributing flyers to students at the university to which the first author belongs. The inclusion criteria for young adults were enrollment in the first to fourth year of university and holding a valid standard driving license. Those who did not meet the vision and hearing requirements as defined by the Road Traffic Law were excluded. The young group consisted of 69 participants (24 men and 45 women) with an average age of 21.3 ± 1.7 years (median 21 years, range 19–29 years). The number of years since obtaining a license among the young participants was less than one year for 25 individuals, 1–5 years for 41 individuals, and 6–10 years for 3 individuals. The frequency of driving among the young participants was daily for 3 individuals, once every 2–3 days for 4 individuals, once a week for 6 individuals, a few times a year for 26 individuals, and almost never for 30 individuals. Driving instructors were recruited by distributing flyers to four driving schools associated with the coauthors. The inclusion criterion for driving instructors was holding a valid driving instructor license. Those not conducting classroom teaching or on-road training and testing as part of their daily work were excluded. The instructor group consisted of 36 participants (33 men and 3 women) with an average age of 45.0 ± 13.0 years (median age 43 years, range 24–66 years). The years of experience as an instructor averaged 15.7 ± 13.9 years (ranging from 2 months to 41 years, with a median of 10 years). Details of the participants are presented in Table 1.

Tasks and procedures

The participants performed the RSR task using a touch panel notebook computer (PC) (CF-C1B 12.1, Panasonic Corporation, Japan). The screen size was equivalent to that of A4. In the RSR task, participants choose the most appropriate road sign for a given road situation. The signs in the photos of the actual road conditions were hidden through editing. The participants were required to judge the road situation and select the most appropriate road sign from four options by physically touching their choices on the screen. There were ten questions in total, with each correct answer awarded one point. The PC recorded the number of correct answers (ranging from 0 to 10 points) and the time taken from the presentation of question 1 to answering ques-

Table 1 Characteristics of participants.

	N (M/F)	Age		MMSE		Driving experience (years)			
		Ave. ± SD (median)	Min-max	Ave. ± SD (median)	Min-max	< 1	1–5	6–10	> 10
Older	62 (39/23)	75.4 ± 5.9 (74)	65–89	27.8 ± 1.8 (28)	23–30	0	0	0	62
Young	69 (24/45)	21.3 ± 1.7 (21)	19–29			25	41	3	0
Instructor	36 (33/ 3)	45.0 ± 13.0 (43)	24–66			0	1	5	30

tion 10 (seconds). Subsequently, as an indicator of visual information processing speed, the TMT was conducted using the same PC. The TMT was used as a reference to indicate that elements other than the visual information processing speed were included in the time required for the RSR. The TMT comprises two tasks. In the TMT-A, participants were required to touch numbers 1–25 displayed on the screen in order. In TMT-B, participants are required to alternately touch a total of 25 items displayed on the screen, numbers (1 to 13) and Hiragana characters (あ to し) (Japanese script), in sequence. The PC recorded the time taken to complete both tasks and the number of incorrect responses. A time limit of 300 seconds was set for the TMT; if a participant reached this limit, their time was recorded as 300 seconds.

Analysis

First, the total scores and time required for the RSR as well as the time required for the TMT were compared between the groups. A one-way analysis of variance (ANOVA) was applied, and the Tukey method was used for multiple comparisons. The significance level for all analyses was set at 5%. Cohen's d [18] was used to measure the effect size. Subsequently, structural analysis of the RSR was conducted for each participant group. The statistical method applied was Rasch analysis. The difficulty level of each question was expressed in logits, with 0 indicating a standard level of difficulty for the participants, and higher values indicating higher difficulty. Infit and outfit values indicate the fit of the data to the Rasch model, with a range of 0.5 to 1.5 considered an appropriate fit. Questions showing more than 1.5 (underfit) were interpreted as having participant response patterns that were more erratic than those predicted by the Rasch model. If such questions were identified, it was necessary to discuss the reasons for them. Questions showing less than 0.5 (overfit) were interpreted as having participant response patterns that match the Rasch model predictions closely, potentially not providing useful information as indicators of the abilities measured by the RSR. The statistical software used was R 4.2.3, with the TAM package 4.1-4 for Rasch analysis.

Results

1. RSR and TMT

The ANOVA results showed statistically significant differences in the total RSR scores among the three groups ($p < 0.01$). Based on the Tukey post-hoc comparison, the older adults group scored lower than both the young adults and instructor groups, with significant effect sizes (older adults vs. young; 6.2 ± 1.7 vs. 7.7 ± 1.6, $p < 0.01$, $d = 0.91$, older adults vs. instructors; 6.2 ± 1.7 vs. 8.4 ± 1.4, $p < 0.01$, $d = 1.38$). Although there was no statistically significant difference in the total scores between the young and instructor groups, instructors scored higher than the young adults, showing a moderate effect size (young vs. instructors; 7.7 ± 1.6 vs. 8.4 ± 1.4, $p = 0.16$, $d = 0.46$) (Fig. 1-1). The ANOVA results also indicated statistically significant differences in the time required to complete the RSR among the three groups ($p < 0.01$). The Tukey post-hoc comparison showed that older adults required more time than both the young adults and instructors, with significant effect sizes (older adults vs. young; 190.9 ± 83.1 vs. 121.0 ± 39.6, $p < 0.01$, $d = 1.1$, older adults vs. instructors; 190.9 ± 83.1 vs. 99.8 ± 24.6, $p < 0.01$, $d = 1.35$). While instructors required less time than the young adults, showing a moderate effect size, this difference was not statistically significant (young adults vs. instructors; 121.0 ± 39.6 vs. 99.8 ± 24.6, $p = 0.23$, $d = 0.61$) (Fig. 1-2).

Regarding the time required to complete the TMT-A, statistically significant differences were observed among the three groups ($p < 0.01$). The Tukey post-hoc comparison showed that older adults took significantly longer than young adults and instructors, with large effect sizes (older adults vs. young adults; 78.6 ± 19.6 vs. 48.1 ± 9.3, $p < 0.01$, $d = 2.04$, older adults vs. instructors; 78.6 ± 19.6 vs. 53.6 ± 14.0, $p < 0.01$, $d = 1.42$). Although there was no statistically significant difference in completion time between the young adults and instructors, the young completed TMT-A faster than instructors, showing a moderate effect size (young vs. instructors; 48.1 ± 9.3 vs. 53.6 ± 14.0, $p = 0.17$, $d = 0.5$) (Fig. 2-1). The Tukey post-hoc comparison for the time required to complete TMT-B revealed that older adults took significantly longer than both young adults and instructors,

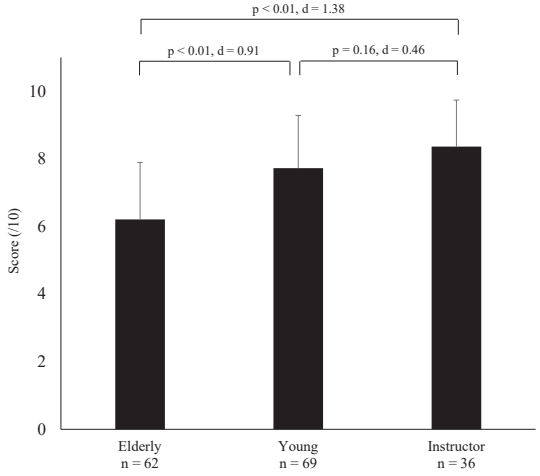

Fig. 1-1. Comparison of the total score of the RSR among groups. Direct comparison was performed by Tukey's method.

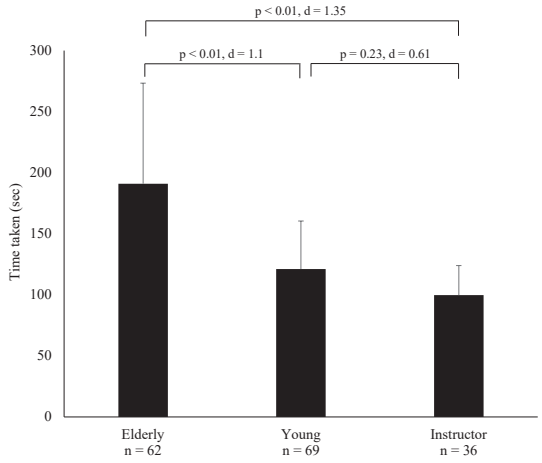

Fig. 1-2. Comparison of the time taken of the RSR among groups. Direct comparison was performed by Tukey's method.

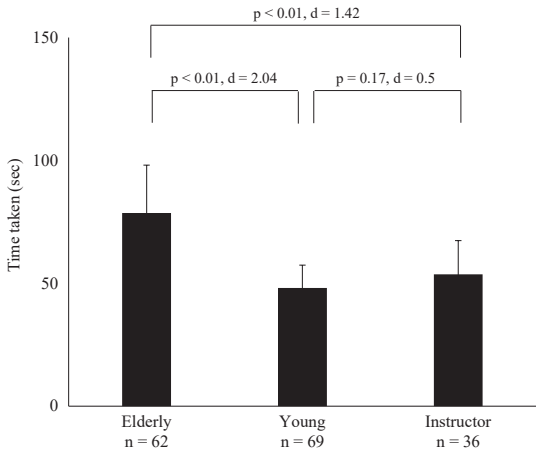

Fig. 2-1. Comparison of the time taken of the TMT-A among groups. Direct comparison was performed by Tukey's method.

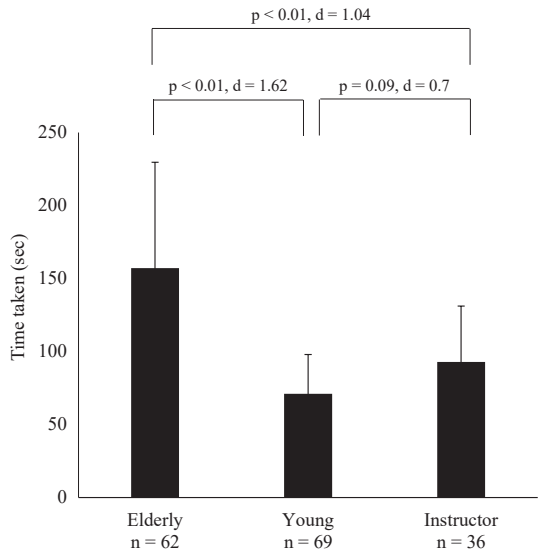

Fig. 2-2. Comparison of the time taken of the TMT-B among groups. Direct comparison was performed by Tukey's method.

with large effect sizes (older adults vs. young; 155.8 ± 73.2 vs. 71.0 ± 27.2, $p < 0.01$, $d = 1.62$, older adults vs. instructors; 155.8 ± 73.2 vs. 92.9 ± 38.8, $p < 0.01$, $d = 1.04$). While there was no statistically significant difference in completion time between the young adults and instructors, the young completed the TMT-B faster than the instructors, with a moderate effect size (young adults vs. instructors; 71.0 ± 27.2 vs. 92.9 ± 38.8, $p = 0.09$, $d = 0.7$) (Fig. 2-2).

2. Rasch analysis

For all questions except questions 5 and 9 in the instructor group, the infit and outfit values ranged from 0.1 to 1.5 across all groups. Question 5 in the instructor group showed an overfit (infit = 0, outfit = 0), and question 9 showed an underfit (infit = 1.13, outfit = 1.95) (Table 2). Based on the logit values, the difficulty of questions for each group was organized as follows: for the older and young adults groups, questions 1, 3, and 7 were the most difficult, in that order, while for the instructor group, questions 10, 1, and 6 were the most difficult (Fig. 3). Conversely, the easiest questions were questions 8 and 5 for the older and younger groups, respectively, and questions 5, 9, and 2 for the instructor group (Fig. 4).

Table 2 Item Difficulty and Fit by Question Category in groups. The top three most difficult questions are underlined, while the bottom three easiest questions are indicated with a dotted line.

Item	Older (n = 62)			Young (n = 69)			Instructor (n = 36)		
	logits	infit	outfit	logits	infit	outfit	logits	infit	outfit
Q 1	1.35	1.02	1.10	−0.17	0.94	0.93	−0.92	0.96	0.95
Q 2	−0.99	1.00	0.97	−3.37	1.04	1.08	−3.08	0.99	0.67
Q 3	1.35	1.00	1.00	−0.10	1.01	1.02	−2.02	0.97	0.79
Q 4	−1.68	1.06	1.10	−1.65	1.13	1.27	−2.63	1.08	1.33
Q 5	−2.41	0.94	0.74	−3.37	1.00	1.00	−37.17	0*	0*
Q 6	−0.29	0.99	0.98	−0.65	0.97	0.98	−1.23	0.98	0.91
Q 7	0.21	1.00	1.01	−0.51	0.94	0.93	−2.63	1.00	0.93
Q 8	−2.87	0.98	0.81	−4.53	1.03	1.23	−1.23	1.06	1.07
Q 9	−1.16	1.00	0.99	−2.26	0.98	0.99	−3.08	1.13	1.95**
Q10	−0.59	1.01	1.03	−1.75	0.99	0.95	−0.25	0.98	0.98

* underfit ** overfit

Discussions

1. RSR Total Score and Time Required

The total RSR scores were the highest for instructors, followed by young and then older adults. The high scores for instructors indicate high proficiency in safe driving education. If age and driving experience were to affect RSR scores, instructors would be expected to perform worse than older adults. Regarding young and older adults, if driving experience influenced RSR scores, older adults should score higher than the young adults; however, this study did not show such results. It appears that nonverbal reasoning abilities and knowledge of road signs, rather than driving experience, influence RSR performance [5, 6, 9, 10]. In Japan, there is no opportunity to relearn road signs during license renewal courses, which might explain why younger participants who have recently obtained their licenses could more easily recall the meaning of road signs. This finding is also consistent with the finding that nonverbal reasoning abilities tend to decline with age [19]. However, the fact that instructors who were older than the young participants scored higher suggests that proficiency in safety driving education has a stronger impact than a decline in nonverbal reasoning abilities. Additionally, considering the time required for the RSR and TMT, it appears that cognitive processing speeds that differ from visual information processing speeds are involved in the RSR. If only the visual information processing speed influenced the time required for the RSR, then the time for the RSR and TMT should show the same order across all three groups. The fact that older adults took longer for both the RSR and TMT reflects a decrease in their information processing speed, while the reversal in time required for the RSR and TMT between instructors and young participants suggests a strong influence of proficiency in safe driving.

In summary, it is presumed that proficiency in safe driving education, rather than age or driving experience, influences RSR. This aligns with previous research showing that individuals who have received professional safety driving education have higher driving capabilities [14–16] and that RSR is useful for predicting driving ability [20]. A direct demonstration of the impact of proficiency in safe driving education on RSR performance is the novelty of this study.

2. Structural analysis

The results of the RSR demonstrated the relative performance of the older adults, young adults, and instructors. The logit values for each group indicated that the RSR was the most challenging for older adults and easiest for instructors, consistent with the total RSR scores. Focusing on the differences between groups, the structural analysis of the RSR through Rasch analysis provided new insights. The most significant finding was that the difficulty ranking of each question differed between the young and older adults and the instructor group. As shown in Figs. 3 and 4, while the difficult and easy questions were the same for young and older adults, they were different for the instructors. This can be considered a reflection of the instructors' proficiency in safe driving education. The questions were speculative; for example, among the top three difficult questions, Question 10 required the participants to recognize the width of the roadside strip, bicycles in motion, a bus positioned to the right, the number of lanes, and the size and signals at the intersections. For Question 6, the participants had to recognize the one-way sign to the right, the width of the road ahead, cars parked in front of houses, pedestrians far ahead, and the river beside the road. It is essential to match each detail with the mean-

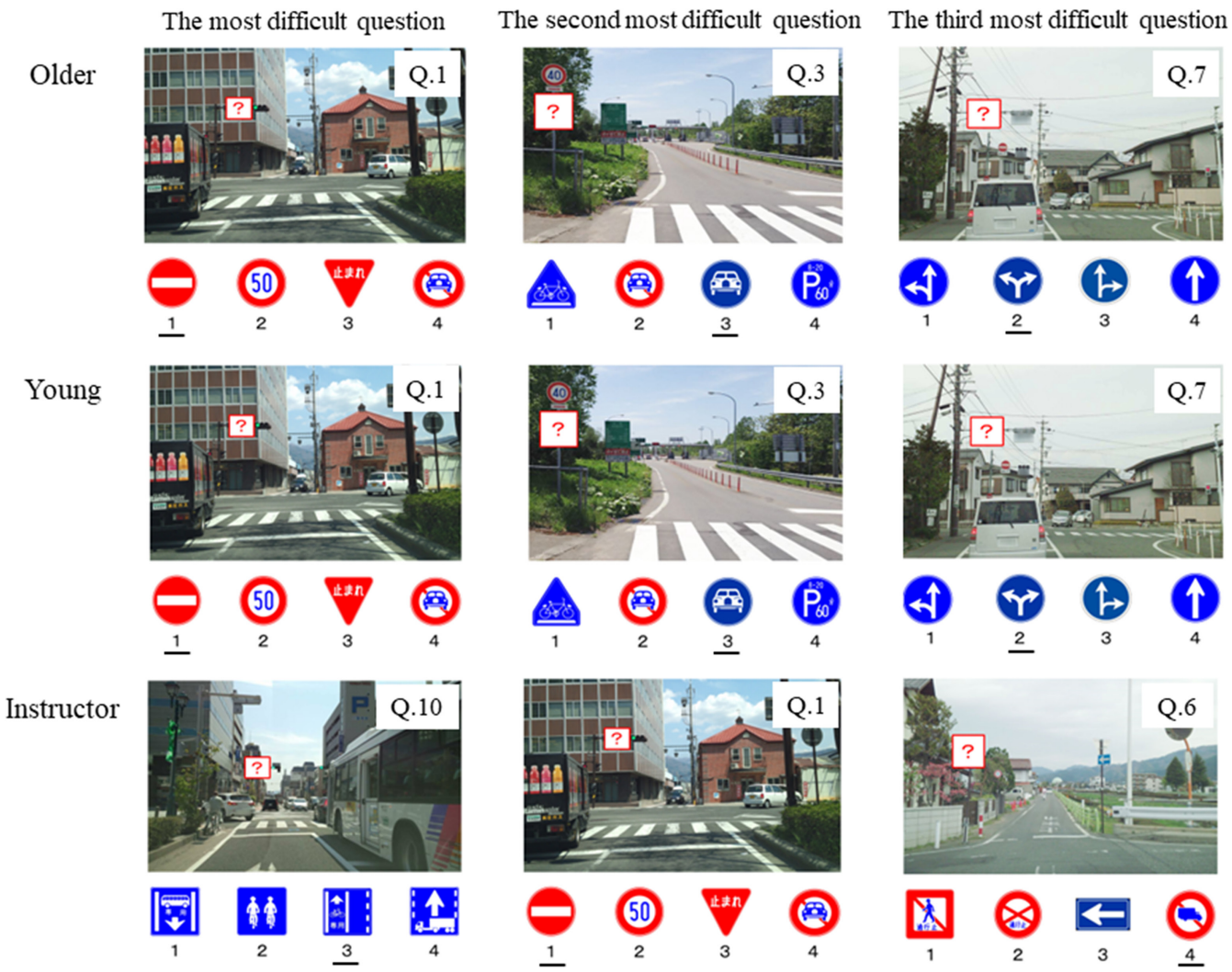

Fig. 3. The top three questions with high difficulty levels. The correct answer is underlined.

ings of the signs among the given choices and to decide which signs are inappropriate or appropriate. It seems that extensive knowledge of signs due to high proficiency in safe driving education made answering questions more challenging [21].

The infit and outfit values indicate that the RSR used in this study measures driving ability consistently. However, attention should be paid to the fact that the outfit value for Question 9 for instructors exceeded 1.5, indicating an underfit. For individuals with high proficiency in safe driving education, such as instructors, this question may be inappropriate. Determining the reason for this based on the data obtained in this study is challenging, and a qualitative analysis, such as listening to the thought processes of instructors to arrive at an answer, may be necessary. It has long been known that the thought processes involved in solving cognitive tasks can differ [22].

This study suggests that proficiency in safety driving education influences the RSR tasks more than age or driving experience. Occupational therapists work with individuals of various ages and conditions in medical institutions who wish to resume driving. This study has several clinical implications. For older adults, it is crucial to present the latest traffic rules, including knowledge of road signs and understanding road situations, and build a foundation that maximizes driving abilities through experience by enhancing information processing speed. For young people, it is important to utilize their ability to process information swiftly, while enhancing the certainty of recognizing road signs and understanding driving situations. Furthermore, for individuals with a high level of proficiency in safe driving education, such as instructors, or those with a professional history of high safe driving awareness, such as professional drivers, it is necessary to fully understand their professional backgrounds when conducting driving ability evaluations.

Fig. 4. The bottom three questions with low difficulty levels. The correct answer is underlined.

3. Limitations and future challenges

This study did not assess the cognitive functions of the participants. As discussed, cognitive functions may influence the RSR results. Future research should include detailed assessments of cognitive functions and on-road driving abilities to investigate their relationship with RSR.

4. Conclusions

In conclusion, the results showed driving instructors had the highest correct answers and shortest RSR time, followed by young adults, then older adults. Rasch analysis revealed similar question difficulties for young and older adults but differences for instructors. Age, driving experience, and safe driving education should consider when administer the RSR in our clinical practice.

Conflict of interest

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

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■ORIGINAL ARTICLE

Relationship between Muscle Oxygen Dynamics in the Tibialis Anterior Muscle and Tapping Intervals during the Preparatory, Execution, and Recovery Phases of Foot-Tapping

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Abstract: Objectives: This study aimed to examine differences in tibialis anterior muscle oxygen dynamics during the preparatory, execution, and recovery phases of foot-tapping exercise and clarify the relationship among the speed of foot-tapping, deviation from the index sound stimulus, and ankle joint position sense.
Methods: We measured oxygen dynamics in the tibialis anterior muscle during the preparatory, execution, and recovery phases of foot-tapping in 15 healthy young adult men. Participants imagined the movement in sync with 0.5-Hz and 1-Hz sound stimuli during the preparatory phase. During the execution phase, measurements were taken under sound synchronization and recall conditions.
Results: The results revealed that sound intervals, synchronization, and recall conditions affected the oxygen dynamics of the tibialis anterior muscle. In particular, the synchronization and recall conditions at 0.5-Hz and 1-Hz sound intervals had different effects on muscle oxygen dynamics and motor control. However, no relationship was observed among muscle oxygen dynamics, foot-tapping interval deviation, and ankle joint positional sense.
Conclusion: The sound intervals and conditions of synchronization and recall during the preparatory, execution, and recovery phases of foot-tapping affected oxygen dynamics in the tibialis anterior muscle. In particular, the results suggested that the synchronization and recall conditions at 0.5-Hz and 1-Hz intervals had different effects on muscle oxygen dynamics and motor control. These results are important for understanding the effects of exercise intervals and cognitive loads on muscle oxygen supply and consumption.

Keywords: foot-tapping, tapping intervals, tibialis anterior muscle, muscle oxygen dynamics, ankle joint position sense

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I. Introduction

During exercise, aerobic metabolism plays an important role in supplying energy to skeletal muscles, except for short periods of intense exercise. In particular, the ability to supply oxygen to active muscles and the ability to utilize oxygen are important factors that determine the sustainability of exercise in the target muscle [1, 2].

In this regard, although methods for directly measuring local skeletal muscle oxygen metabolism have been developed, such as arteriovenous oxygen gradient measurement [3] and thermodilution [4], these methods have limitations, including the necessity to observe blood flow and the inability to measure while the subject is standing. However, the recent development of near-infrared spectroscopy [5] (NIRS) has made it possible to noninvasively measure the balance between oxygen supply and consumption in muscle tissue. A study on muscle oxygen dynamics during and after exercise using NIRS has reported that during maximal isometric exercise, the concentration of oxyhemoglobin (oxyHb), an index of aerobic level, decreases rapidly immediately

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after the start of exercise, and the aerobic level gradually increases after the end of exercise, returning to normal. During repetitive exercise, the aerobic level tends to decrease, similar to that after the start of exercise. Thereafter, the aerobic level decreases and increases repeatedly in sync with the rhythm of contraction and relaxation, and the aerobic level gradually increases after the end of exercise, returning to normal. This indicates that muscle oxygen consumption increases with muscle contraction [6].

In addition, a previous study on exercise loading and muscle oxygen dynamics showed that the decrease in oxygen concentration increased with an increase in muscle loading [7]. Furthermore, research on fatigue tolerance and muscle oxygen dynamics [8] has demonstrated that healthy subjects undergoing endurance training, who possess higher local fatigue tolerance, exhibit a greater decrease in oxygen concentration (deoxygenation) during the early phase of the exercise and a faster increase in oxygen concentration (reoxygenation) after exercise.

In addition to the abovementioned studies on oxygen dynamics associated with exercise, other studies have indicated that similar circulatory responses occur during the preparatory phase of exercise when motion is imagined, contributing to a predictive increase in oxygen supply to the muscles without delay. In a study on muscle oxygen dynamics during the preparatory phase of exercise, when participants were asked to imagine motion during the preparatory phases of maximum grasping [9] and hand button pressing Stroop tasks [10], an increase in oxyHb, decrease in deoxyHb, and no change in totalHb were observed compared with conditions in which no exercise or task was performed. Thus, these studies have reported that oxygen supply can increase during the preparatory phase of exercise.

However, it is unclear how the increased oxygen supply during the preparatory phase of exercise influences exercise and movement, thereby the performance of daily life activities. In this study, we focused on the oxygen dynamics in the tibialis anterior muscle during ankle dorsiflexion (foot-tapping), which is a strategy to maintain balance in exercises that are fundamental to daily life activities, such as maintaining a standing posture and walking. The ankle strategy is a mechanism used to maintain the center of gravity within the limits of stability when the sway of the center of gravity is small during static standing. In other words, the ankle strategy is important for controlling a stable standing posture. This strategy functions as feedforward control and primarily involves movement in the sagittal plane, specifically plantarflexion and dorsiflexion of the ankle [11]. For these reasons, the ankle strategy may also contribute to controlling foot tapping over relatively short intervals. This study aimed to examine differences in tibialis anterior muscle oxygen dynamics during the preparatory, execution, and recovery phases of foot-tapping exercise and clarify the relationship among the speed of foot-tapping, deviation from the index sound stimulus, and ankle joint position sense.

II. Subjects and Methods

1. Subjects

G*Power 3.1.9.2 for mac [12] was used to determine the sample size. Statistical analysis by Friedman test was assumed, regarding previous studies [13], effect size (f) = .50, α error prob = .05, power (1-β error prob) = .95. As a result, the required sample size was 15 participants.

This study included 15 healthy young adult men with a mean age of 19.9 ± 0.9 years. Subjects who were unable to follow the instructions of the study procedures or who had neurological, orthopedic, ophthalmologic, or otolaryngologic problems that made it difficult to perform foot-tapping or ankle joint position sense tests were excluded from the study.

2. Methods

(1) Procedures

The subjects were informed orally and in writing about the purpose, methods, procedures, targets, anticipated risks, human rights, guarantees of rights in case of nonconsent, and guarantees of withdrawal of consent in accordance with the Declaration of Helsinki. After the explanation, the subjects who consented to participate in the study were asked to sign a consent form. After confirming that the subjects had no physical problems, the dominant leg was first evaluated using the Chapman dominant leg test [14] (Fig. 1). The subjects were then classified as right-handed if they scored 27 or lower out of 33 points and as left-handed if they scored 28 or higher points. Subsequently, oxygen dynamics of the tibialis anterior muscle, which is thought to reflect age-related decline in coordinated movement of the lower limbs, were measured during the preparatory, execution, and recovery phases of foot exercise [15]. In addition, ankle joint position sense, which has been reported as a factor that influences foot-tapping [16], was assessed.

(2) Measurement of oxygen dynamics in the tibialis anterior muscle during the preparatory, execution, and recovery phases of foot-tapping exercise

Each subject was seated in a chair with the hip and knee joints flexed at 90°. A NIRO-200NX monitor (Hamamatsu Photonics K.K.) was used to measure

	Use your left foot	Use both	Use your left foot
1．Kick a ball	3	2	1
2．Step on a stool	3	2	1
3．Push a golf ball through a maze	3	2	1
4．Write name in sand	3	2	1
5．Smooth sand	3	2	1
6．Arrange pebbles	3	2	1
7．Balance rod	3	2	1
8．Push a golf ball around a circle	3	2	1
9．Stand on one foot	3	2	1
10．Kick as high as possible	3	2	1
11．Stamp a tin	3	2	1
Total			

Fig. 1. Chapman dominant foot test.

muscle oxygen dynamics. The probe was attached to the anterior tibialis muscle on the lateral side of the tibia in the proximal third of the lower dominant leg, with an irradiation probe attached to the knee joint side and a light-receiving probe to the ankle joint side. The probe interval was 4 cm, and muscle oxygen dynamics [17] at a depth of 2 cm were measured at a sampling rate of 20 Hz. An electronic metronome was used to generate 0.5-Hz and 1-Hz sound stimuli, and each subject was asked to imagine foot-tapping movements on the dominant foot side synchronized with the sound stimuli for 2 minutes.

A Tablet Tracker (TTZ) (Library Corp.) was used to measure foot-tapping. Markers were affixed to the floor and the fifth metacarpal head on the dominant foot side, and the distance between the markers was measured with the TTZ at a sampling rate of 30 Hz over time (Fig. 2).

Fig. 2. Measurement of foot-tapping.

Foot-tapping was conducted under four conditions: a sound synchronization condition in which synchronized foot-tapping was performed to a constant sound stimulus after synchronized foot-tapping was imagined and a sound recall condition in which foot-tapping was performed at the same pace without any sound stimulus after synchronized foot-tapping was imagined. The foot stimuli were given at either 0.5 Hz or 1 Hz.

The order of the four conditions was randomized, with 5 minutes of rest between two conditions. In the 0.5-Hz sound synchronization condition, each participant rested for the first minute, imagined foot-tapping to the 0.5-Hz sound stimulus for the next 2 minutes, performed foot-tapping 15 times synchronized to the sound stimulus after a cue, and then rested until 4 minutes 30 seconds elapsed. In the 0.5-Hz sound recall condition, they rested for the first minute, imagined foot-tapping to the 0.5-Hz sound stimulus for the next 2 minutes, performed foot-tapping 15 times to the imagined sound stimulus without any actual sound stimulus after a cue, and then rested until 4 minutes and 30 seconds elapsed. In the 1-Hz sound synchronization condition, they rested for the first minute, imagined foot-tapping to the 1-Hz sound stimulus for the next 2 minutes, performed foot-tapping 15 times synchronized to the sound stimulus after a cue, and then rested until 4 minutes and 30 seconds elapsed. In the 1-Hz sound recall condition, they rested for the first minute, imagined foot-tapping to the 1-Hz sound stimulus for the next 2 minutes, performed foot-tapping 15 times to the imagined sound stimulus without any actual sound stimulus after a cue, and then rested until 4 minutes and 30 seconds elapsed (Fig. 3).

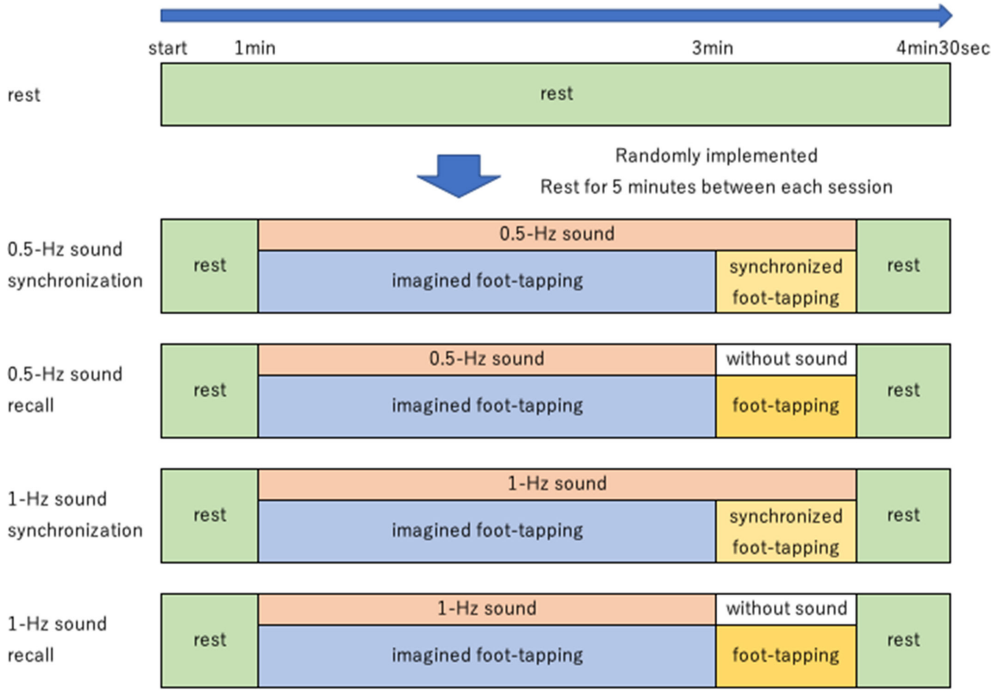

Fig. 3. Procedure for measuring muscle oxygen dynamics during foot-tapping.

Fig. 4. Ankle joint position sense test.

(3) Ankle joint position sense test

The subject was seated in a chair with the hip and knee joints flexed at 90°. A stretching board (LS-LJ300, Lysin Inc.) was used (Fig. 4). The examiner placed the subject's dominant leg on the table, which was set at an angle of 15 degrees, and then asked the subject to recognize the angle. The same procedure was followed for angles of 20 and 25 degrees. Subsequently, with the subject's eyes closed, the examiner placed the dominant foot on the platform at a random angle and asked the subject to answer the angle. The subject was then temporarily lowered, and the same procedure was repeated five times.

(4) Data analysis

During the preparatory phase of the exercise, based on the data on the change in oxyHb concentration (μmol/L) in the anterior tibialis muscle, the change in oxyHb concentration measured 1 minute after the start of measurement was used as the muscle oxygen dynamics at the start of measurement. In addition, the average oxyHb concentration over 5 seconds immediately before the start of foot-tapping was used as the muscle oxygen dynamics after exercise imaging.

During the execution and recovery phases, changes in aerobic capacity were analyzed using the method reported by Oka et al. [6]. The maximum rate of change (the ratio of the maximum rate of change to the minimum value of oxyHb concentration) was calculated from the minimum oxyHb concentration and the maximum value of the range of change during the execution phase. Changes in aerobic capacity during the recovery phase were calculated as the time taken for the oxyHb concentration to recover from its minimum value to one-half of the value at the start of the foot-tapping exercise on the recovery curve after the end of the foot-tapping exercise.

For foot-tapping, the point at which the distance between the markers was smallest was defined as the time of tapping, and the tapping interval (sec) was

calculated based on the number of samples taken up to the point at which the distance between the markers was smallest. The difference (sec) from 2 seconds for the data of 0.5-Hz sound stimulation and from 1 second for the data of 1-Hz sound stimulation was calculated, and the difference added for the first 10 taps was defined as the shift in the tapping interval, and this shift (sec) was the subject of analysis. For the ankle joint position sense test, the number of correct answers out of five attempts was the subject of analysis.

(5) Analysis method

To compare the changes in the average oxyHb concentration in the tibialis anterior muscle for 5 seconds immediately before the start of foot-tapping during the preparatory phase, maximum rate of change in oxyHb concentration during the execution phase, and recovery time of oxyHb concentration during the recovery phase among the 0.5-Hz sound synchronization condition, 0.5-Hz sound recall condition, 1-Hz sound synchronization condition, and 1-Hz sound recall condition, Friedman tests were performed. If significant results were obtained, Bonferroni multiple comparisons were performed. To compare the deviation in the foot-tapping interval and the accuracy rate of ankle joint position sense, Spearman's correlation coefficients were calculated along with the changes in the average oxyHb concentration in the tibialis anterior muscle for 5 seconds immediately before foot-tapping under the 0.5-Hz sound synchronization condition, 0.5-Hz sound recall condition, 1-Hz sound synchronization condition, and 1-Hz sound recall condition. Statistical analysis was performed using the statistical software EZR [18] version 1.61, with a risk rate of less than 5% considered significant.

This study was reviewed and approved by Sapporo Medical University Ethics Committee (Approval No. 5-1-89).

III. Results

1. Oxygen dynamics in the tibialis anterior muscle during the preparatory phase of foot-tapping

All subjects were right-footed according to the Chapman dominant foot test. The average oxyHb concentration in the tibialis anterior muscle during 5 seconds immediately before the start of foot-tapping in each of the four conditions is shown in Fig. 5. Although there was no significant difference between conditions ($P = 0.172$), the oxyHb concentration was higher in each condition than at the start of the preparatory phase. In addition, in the 0.5-Hz condition, the oxyHb concentration tended to be higher in the recall conditions than in the synchronous conditions.

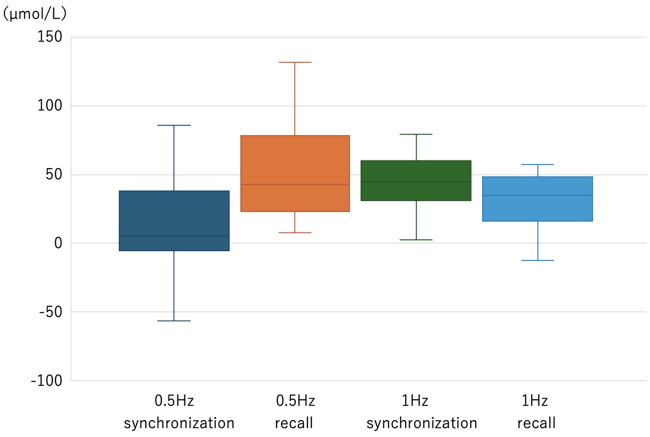

Fig. 5. Average oxyHb concentration in 5 seconds immediately before the start of foot-tapping.

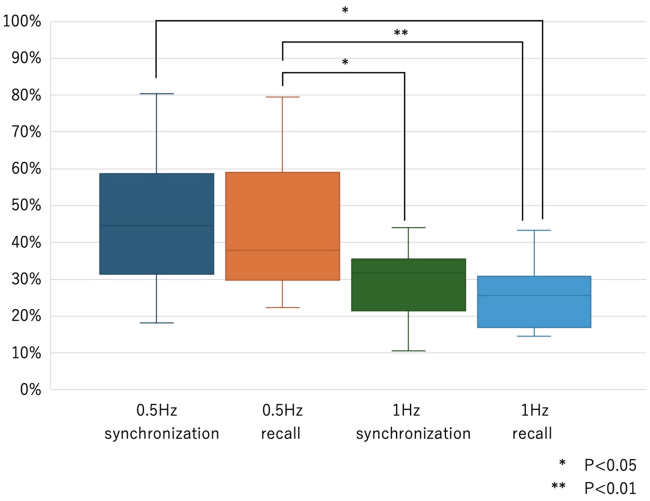

Fig. 6. Maximum variability of oxyHb concentration during the execution phase of foot-tapping exercise.

2. Oxygen dynamics in the tibialis anterior muscle during the execution phase of foot-tapping

The maximum variability of oxygen Hb concentration in the tibialis anterior muscle in each of the four conditions (Fig. 6) showed significant differences between conditions ($P = 0.0007$), and multiple comparisons revealed significant differences between the 0.5-Hz synchronization and 1-Hz recall conditions ($P = 0.0256$), between the 0.5-Hz recall and 1-Hz synchronization conditions ($P = 0.0403$), and between the 0.5-Hz and 1-Hz recall conditions ($P = 0.0092$). No significant difference was noted between the 0.5-Hz and 1-Hz synchronization conditions ($P = 0.0502$).

3. Oxygen dynamics in the tibialis anterior muscle during the recovery phase of foot-tapping

The recovery time of oxygen Hb concentration in

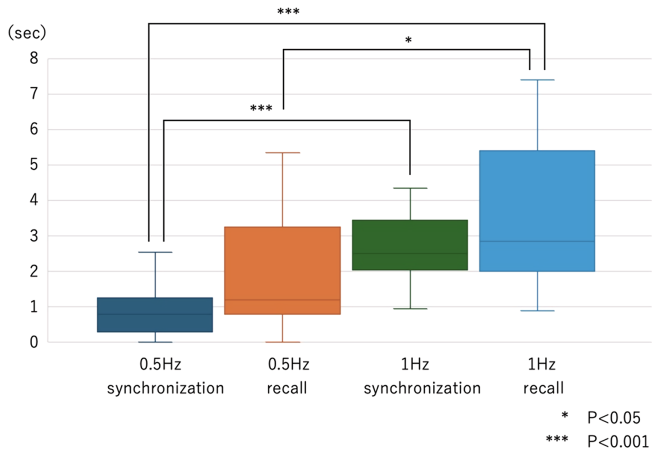

Fig. 7. Recovery time of oxyHb concentration during the recovery phase of foot-tapping exercise (Time to recover to 1/2 concentration at start of exercise).

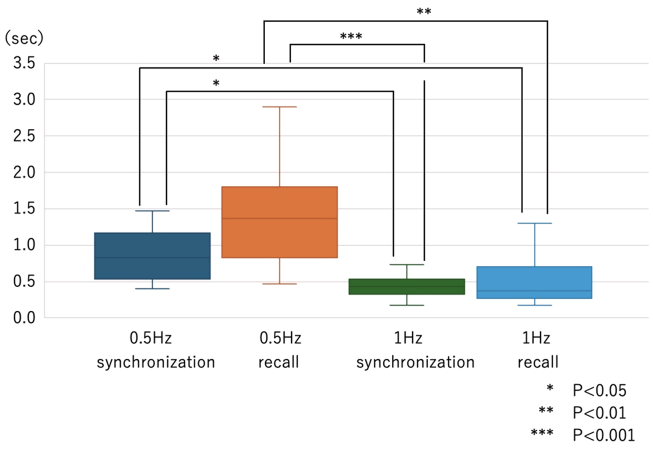

Fig. 8. Deviation of foot-tapping intervals.

the tibialis anterior muscle in each of the four conditions (Fig. 7) showed significant differences between conditions (P = 0.000082), and multiple comparisons revealed significant differences between the 0.5-Hz synchronization and 1-Hz synchronization conditions (P = 0.00037), between the 0.5-Hz synchronization and 1-Hz recall conditions (P = 0.00073), and between the 0.5-Hz and 1-Hz recall conditions (P = 0.03222). No significant difference was noted between the 0.5-Hz and 1-Hz recall conditions (P = 0.03222).

4. Foot-tapping interval deviation and oxygen dynamics in the tibialis anterior muscle during the preparatory phase of foot-tapping

Significant differences were observed between the four conditions in the foot-tapping interval gap (Fig. 8) (P = 0.000000884), and multiple comparisons revealed significant differences between the 0.5-Hz synchronization and 1-Hz synchronization conditions (P = 0.01008), between the 0.5-Hz synchronization and 1-Hz recall conditions (P = 0.02946), between the 0.5-Hz recall and 1-Hz synchronization conditions (P = 0.00037), and between the 0.5-Hz recall and 1-Hz recall conditions (P = 0.00591). However, no significant differences were observed between the 0.5-Hz and 1-Hz conditions.

No significant correlation was found between the average oxyHb concentration in the tibialis anterior muscle during 5 seconds immediately before the start of foot-tapping in each of the four conditions and the deviation in foot-tapping interval (Fig. 9).

5. Oxygen dynamics in the tibialis anterior muscle and ankle joint position sense during the preparatory phase of foot-tapping

No significant correlation was found between the average oxyHb concentration in the tibialis anterior muscle during 5 seconds immediately before the start of foot-tapping in each of the four conditions and the number of correct answers in the ankle joint position sense test (Fig. 10).

IV. Discussion

1. Oxygen dynamics in the tibialis anterior muscle during the preparatory phase of foot-tapping

In the oxygen dynamics of the tibialis anterior muscle during the preparatory phase of foot-tapping, there was a trend toward an increase in oxyHb concentration in each condition, indicating an increase in oxygen supply to the muscle as a result of motor imagery induced by sound stimulation. Such an increase in oxygen supply to muscles during the preparatory phase of exercise has only been reported in the forearm flexor muscle group during the preparatory phases of the maximal grasping exercise [9] and the hand button pressing Stroop task [10]. The fact that a similar increase in oxygen supply was observed during the preparatory phase of foot-tapping, a coordinated lower limb exercise, is considered an important finding because it may affect other relevant postural coordination abilities.

Feedforward control by an internal model, rather than feedback control, is necessary for the execution of high-speed, coordinated motion [19]. The sound intervals used in this study, 0.5 Hz and 1 Hz, were 2 s and 1 s, respectively. It is thought that the exercise was performed by feedback control at a relatively slow speed of 0.5 Hz. However, in the sound recall condition, as there was no sound stimulation during the exercise, it was impossible to perform the exercise by feedback control alone. Thus, the cognitive load may have increased during the preparatory period. This may be one of the

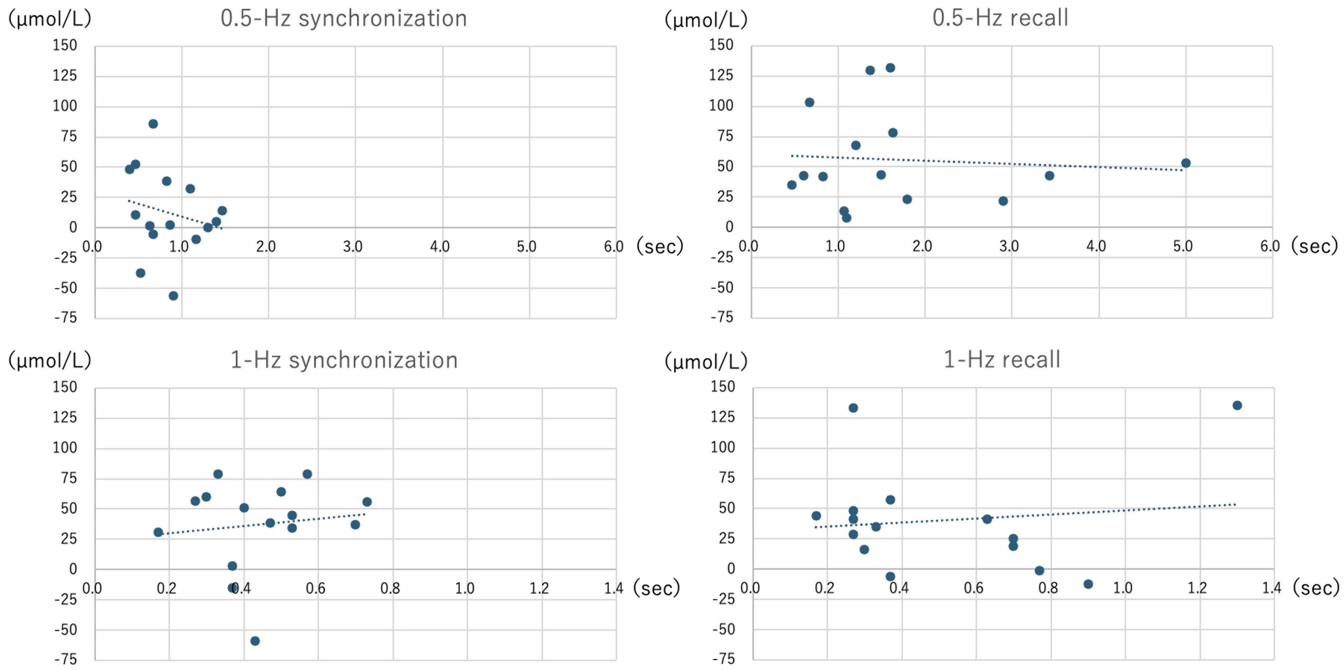

Fig. 9. Relationship between the average oxyHb concentration in the anterior tibialis muscle for 5 seconds immediately before the start of foot-tapping and the foot-tapping interval deviation

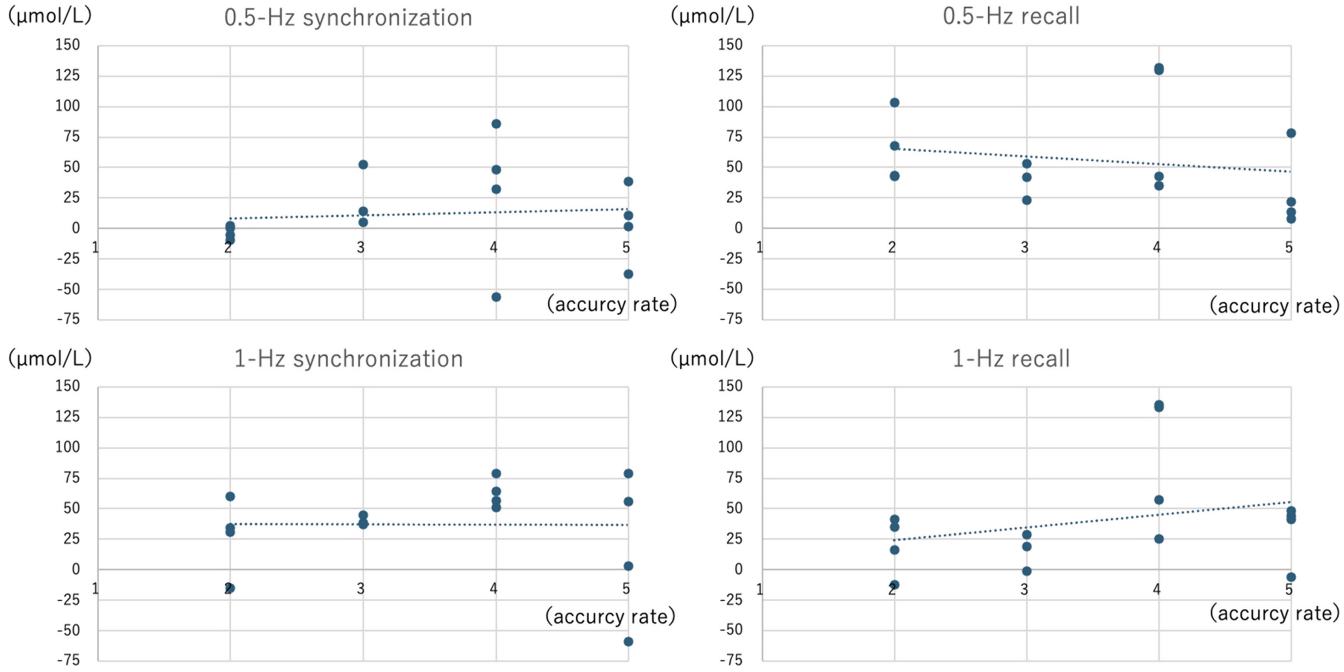

Fig. 10. Relationship between the average oxyHb concentration in the tibialis anterior muscle in 5 seconds immediately before the start of foot-tapping and the number of correct responses in the ankle joint position sense test

reasons why the oxygen supply to the tibialis anterior muscle increased during the preparatory phase in the 0.5-Hz sound recall condition.

2. Oxygen dynamics in the tibialis anterior muscle during the execution and recovery phases of foot-tapping

The maximum variability of oxyHb concentration in the tibialis anterior muscle during the execution phase of foot-tapping tended to be higher in the 0.5-Hz

sound recall condition than in the 1-Hz condition. The maximum variability indicates the ratio of the maximum variability of one foot-tapping to the minimum value of oxyHb concentration. With higher maximum variability indicating higher intramuscular oxygen metabolic capacity and adaptability of blood circulation, it is considered to be an index for judging aerobic recovery capacity [6]. The recovery time of oxyHb concentration in the anterior tibialis muscle during the recovery period tended to be higher at 0.5 Hz than at 1 Hz. In this study, foot-tapping was performed with different sound stimulus intervals in the tibialis anterior muscle, and compared with 1 Hz, a sound interval of 0.5 Hz is thought to result in less exercise load being placed and faster recovery from fatigue being achieved. This result indicates that indices such as maximal variability and recovery time are useful physiological indices for evaluating the ability of muscles to metabolize oxygen and recover from fatigue.

3. Foot-tapping interval deviation and oxygen dynamics in the tibialis anterior muscle during the preparatory phase of foot-tapping

Regarding the foot-tapping interval deviations, the accuracy of foot-tapping was affected by the sound intervals, with smaller deviations at the 1-Hz interval than at the 0.5-Hz interval. This result also indicates that foot-tapping at the 1-Hz interval is performed by an internal model of feedforward control. In addition, when relatively slow movements, such as those at 0.5-Hz intervals, are coordinated by the presentation of auditory rhythmic stimuli, it may be difficult to synchronize the movements to the rhythm due to the difficulty in predicting the next input stimulus [20]. This is consistent with the larger gaps in the intervals observed when tapping for synchronization and recall at a sound interval of 0.5 Hz.

On the other hand, no correlation was observed with muscle oxygen dynamics during the preparatory phase of exercise. Studies have suggested that during the preparatory phase, higher central nervous systems predict the amount of physical activity required at the start of exercise and generate an appropriate motor plan [21, 22]. Another study has proposed the existence of a central command [23], a signal that occurs in the brain to execute exercise and that triggers skeletal muscle contraction and changes in the autonomic nervous system in parallel. Furthermore, the latter study has suggested that circulatory regulation similar to that during exercise execution occurs during the preparatory phase of exercise [23]. The results of the present study suggest that the oxygen supply for exercise execution may differ from the oxygen consumption during exercise.

4. Oxygen dynamics in the tibialis anterior muscle and ankle joint positional memory during the preparatory phase of foot-tapping

There was no correlation between ankle joint position sense and muscle oxygen dynamics during the preparatory phase. The subjects in this experiment were healthy young adult men. Although there were differences in the number of correct answers in the position sense test, they did not have any diseases or disorders that would affect foot-tapping, which is why no correlation was found.

One limitation of this study is that the results were obtained from healthy young adult men, and future studies need to investigate differences due to sex, development, and aging. Moreover, since the study was conducted at the limited sound intervals of 0.5 Hz and 1 Hz, other intervals need to be investigated in the future.

V. Conclusion

The sound intervals and the conditions of synchronization and recall during the preparatory, execution, and recovery phases of foot-tapping affected oxygen dynamics in the tibialis anterior muscle. In particular, the results suggested that the synchronization and recall conditions at 0.5 Hz and 1 Hz intervals had different effects on muscle oxygen dynamics and motor control.

These results are considered important for understanding the effects of exercise intervals and cognitive loads on muscle oxygen supply and consumption.

Conflict of interest

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

Acknowledgements

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■ORIGINAL ARTICLE

A New Evaluation Method for Eye-Head Coordination: Usefulness of Coefficient of the Sharing Ratio Based on Pursuit Task's Sharing Ratio

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Abstract: Statement of the problem: Vision is crucial for obtaining information about the environment, and eye-head coordination plays a key role in visual processing. Previous studies have struggled to compare eye-head coordination across different tasks due to significant individual differences. This study addresses the challenge of relative comparisons by introducing a new evaluation method.
Methodology: We introduced the coefficient of the sharing ratio based on the pursuit task (CoSRP) to compare eye-head coordination across different tasks. Ten healthy individuals performed four tasks: pursuit, saccade, visual search, and classification. Eye and head movements were recorded using an eye tracker (TalkEye Lite) and an accelerometer. The sharing ratios were calculated, and the CoSRP was derived to assess differences between tasks.
Results: The results showed that the CoSRP was significantly smaller in the classification task than in the saccade and visual search tasks, indicating that the CoSRP may reflect the visual characteristics of each task.
Conclusion: The CoSRP provides a useful index for comparing eye-head coordination across different tasks and may offer insights into task-specific visual strategies. Future studies should include larger participant samples and explore CoSRP in populations with neurodegenerative diseases (e.g. Parkinson's Disease) and children with developmental disabilities to find their visual characteristics.

Keywords: eye-head coordination, sharing ratio, coefficient of the sharing ratio based on pursuit task (CoSRP)

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1. Introduction

Vision is among the most important aspects to obtain information on the details of surrounding objects, and individuals grasp the surrounding environment by changing their gaze [1]. The eyes are sensory organs for acquiring visual information, and individuals move their eyes to ensure that they can acquire information by vision reliably and easily [2]. Most eye movements observed in our daily lives are impulsive and usually accompanied by coordinated head movements [3]. Previous studies on eye gaze and body movements have shown that eye-head coordination that occurs during eye movements affects the sequential nature of segmental body movements, which appear in body parts closer to the eyes [4]. The results suggest that eye-head coordination significantly influences body movements and daily life.

Most previous studies on eye-head coordination have employed methods in which eye and head movements were measured and analyzed separately. Eye movements are often measured by spontaneous observation or recordings using a video tape recorder or the electrooculogram (EOG) method, which uses electrodes attached to the upper, lower, left, and right sides of the eye to detect the retina-corneal potential differences that change with eye movements and that between the cornea and retina during eye movements [5]. Head movements are observed and measured by attaching light to the frontal area and videotaping its trajectories [6] or using a lightweight helmet with a potentiometer [7]. However,

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the EOG has problems, such as being easily contaminated with noise, complicated analysis, and being prone to drift [8]. Additionally, it has been reported that there are participants' differences in ocular potential waveforms of ±100 μV and these differences depend not only individually but also on the participants' condition on the day and exact positions in which the electrodes were placed [9]. Therefore, there are many problems in calculating values regarding eye-head coordination and using them for relative comparisons among participants.

The tasks used to analyze eye-head coordination include pointing tasks, touching an LED target if it appears immediately, and pursuit tasks, following a target on a display [10, 11]. In these tasks, the number of gazing movements and patterns of coordinated movements are similar among participants [10]. Conversely, studies using indoor walking, ball-catching, visual search, and tea-making tasks have reported smaller amounts of pursuit during movements and differences in the patterns of eye-head coordination among participants [1]. Additionally, an analysis of the safety margin of participants who performed an index detection task and a numerical task in parallel while driving on an urban course for 10 min in a driving simulator reported that the useful field of view (UFoV) narrowed with increasing information processing load and the head preoccupancy rate was > 50% [12]. Various cognitive elements are included in the movements performed in daily life, such as tasks that require gazing at a pouring object (tea-making), tasks in which the object is moved (ball-catching), and tasks with a high cognitive load (multitasking during driving). Only a few studies have examined the relationship between these cognitive elements and eye-head coordination. However, the relationship between these tasks and eye-head coordination has yet to be investigated.

By clarifying the factors that influence eye-head movements in each task, including various cognitive loads, important knowledge on setting up tasks in rehabilitation and adjusting to the daily environment may be obtained. However, as mentioned, it is difficult to compare eye-head coordination between tasks because of the large individual differences in the analysis using EOG. In response, several previous studies have used an index called the sharing ratio, which indicates the ratio of head to gazing movements [13]. Morishima et al. used the sharing ratio to analyze the relationship between eye and head coordination and cognitive load and found that the sharing ratio increased as the cognitive load caused the UFoV to narrow and head movements to precede eye movements [14]. Moreover, Yamada reported that head and eye movements were almost synchronized in gazing at a target on a two-dimensional plane, and the variation in the sharing ratio became smaller in all participants as the distance between the optotypes was 30°, suggesting the existence of a control program corresponding to eye movemens [15]. Additionally, in the literature examining the angular difference between test targets, the head-sharing ratio increased by approximately 10% and was approximately 65% as the angular difference was ≥ 10°compared with 5°, and the head-sharing ratio increased as the angular difference between the following test targets increased, becoming almost constant for a difference of > 10 degrees [16].

For comparing inter-individual differences in eye-head coordination within a single task, the concept of the sharing ratio has been reported to be useful for comparing the same task as an index of individual eye-head coordination. However, a study by Takahashi et al. [17] revealed that the distribution of the sharing ratio of eye-head coordination significantly varied among individuals. Furthermore, daily life activities include various work processes, and eye-head coordination includes multiple tasks. Therefore, multiple tasks should be compared among individuals; however, the sharing ratio may not simply be used as an index because of the large individual differences in the sharing ratio distribution. Contrastingly, a study that evaluated eye-head coordination in a pursuit task using the sharing ratio reported a small within-individual error per trial [18].

Presently, intra-individual reproducibility was first confirmed using the sharing ratio of eye-head Coordination as an individual characteristic index based on the amount of eye and head movements in a pursuit task. Furthermore, after confirming the reproducibility, the ratio of the sharing ratio of the pursuit task to that of eye-head coordination in each task was operationally defined and termed as the coefficient of the sharing ratio based on the pursuit task (CoSRP), and whether this coefficient can be used as an indicator to compare the differences between tasks among individuals is examined.

2. Materials/Participants

Subjects

Ten healthy adults (seven men and three women, mean age; 27.1 ± 5.0 years) with no visual function problems were employed. Participants had no ophthalmological or orthopedic diseases that could interfere with their task performance. Whether the participants wore glasses or contact lenses did not matter. The experiment was conducted after approval by local ethical committee of University and written informed consent from all participants were obtained. And the procedures followed the ethical standards of the Declaration of Helsinki.

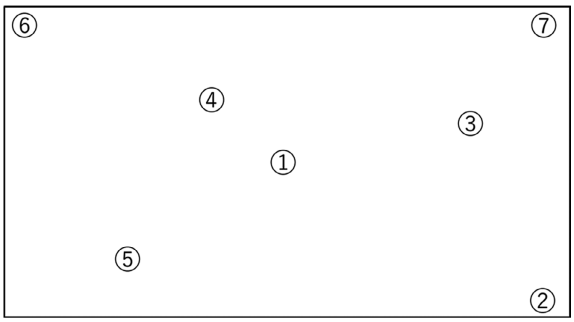

Fig. 1. Visual search task.
A visual search is performed in response to a voice call by an examiner.

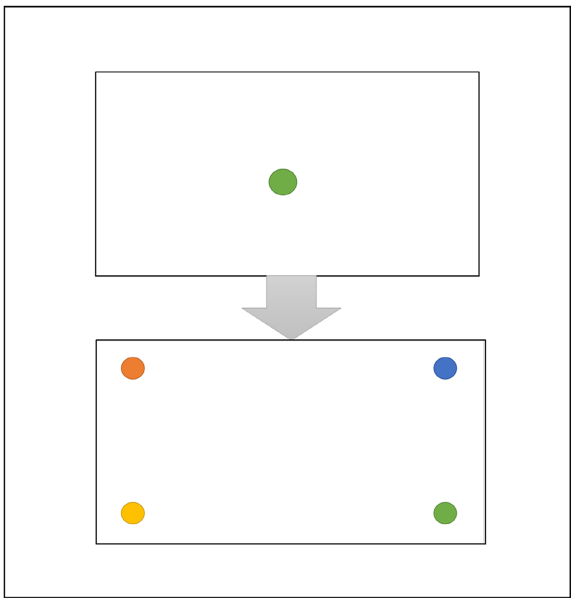

Fig. 2. Classification task.
Memorize the color shown in the above diagram and point immediately to the memorized color among the dots displayed in the following diagram.

Experimental setup

The experiment was conducted in a private room with a controlled temperature and humidity to ensure that the participants concentrated on the tasks. The participants were instructed to sit in front of a desk on an LCD-DF321XD (I-O Data, height: 40 cm, width: 70 cm) monitor. The refresh rate was set at 60 Hz. The participants wore TalkEye Lite (Takei Scientific Instruments), an eyeglass-type eye tracker, and a small three-axis acceleration sensor (AMA-A-5, KYOWA) attached to their heads. TalkEye Lite has a goggle-type frame structure and uses a camera in the eye detection unit to clearly photograph the eyeballs of the participant and obtain the line of sight through image processing. The right eye was examined. The detection angle range was 50°left and right, 20°up and 40°down, and the sampling rate was 30 Hz. The small three-axis accelerometer can measure in the range of ±5 G. The sampling rate was set to 30 Hz. The X (horizontal direction) and Y axes (anteroposterior direction) were measured and changes in waveforms were detected during neck rotation movements. The sampling rate was set at 100 Hz. An HD webcam (Logitech) was placed at the top of the task presentation monitor to capture images from the participant's viewpoint using TalkEye Lite during the movement. The HD webcam captured images at 30 fps.

Tasks

There were four experimental tasks; pursuit, saccades, visual search, and classification. All tasks were performed using a target displayed on a monitor at the participant's eye level, 45 cm in front of the participant (white background). To measure the participants' natural eye-head coordination, their head and eye movements were not specified upon conducting the tasks.

1) Pursuit task

A target (a 2-cm diameter blue circle) was displayed on the monitor and moved from the left to the right end. The participants were instructed to follow the target. Six trials were conducted.

2) Saccade task

The participants were instructed to look at a target, which suddenly appeared on the monitor, immediately. At the beginning of the task, the participant was presented with a fixation viewpoint, and subsequently instructed to fixate on the appeared point. Six trials were conducted.

3) Visual search task

Numbers from ①–⑦ were displayed on the monitor (Fig. 1). Each number was set to fit inside a 3-cm diameter circle. A visual search was performed as the examiner read the numbers. The reading speed was kept constant at 1 reading/s. The task was terminated as the number reached ⑦ and 1 s had elapsed.

4) Classification task

A colored target was displayed at the center of the monitor, and different colored dots were displayed at each of the four corners of the following screen (Fig. 2). The participants were asked to memorize the colored dots displayed on the previous screen and point at them immediately. After pointing, the finger returned to the center of the screen. The interval between the screen changes was 1 s, and six trials were conducted.

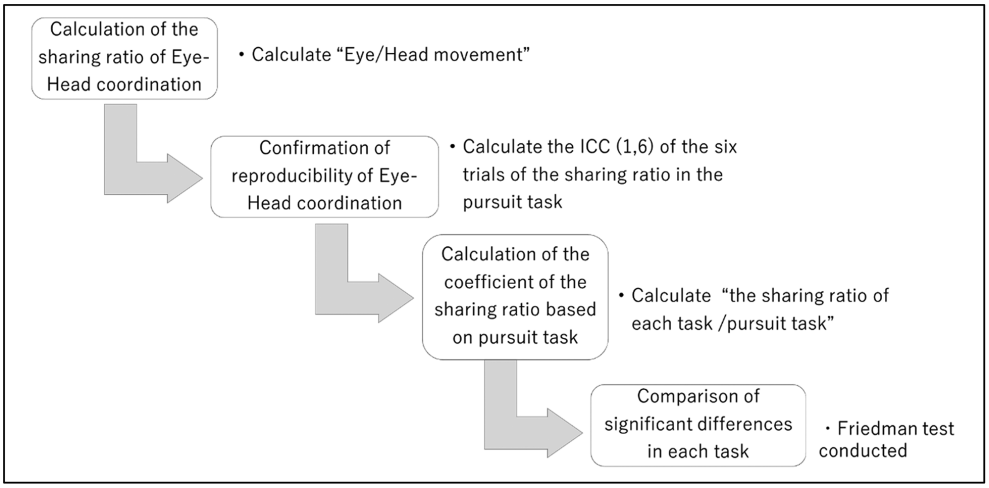

Fig. 3. Analysis procedure.
The analysis is performed according to the flow shown in the diagram.
The following steps are completed consecutively.

3. Methods

Procedure

The participants were asked to sit in front of the monitor and wore TalkEye Lite, and the three-axis acceleration sensor was attached to their head. TalkEye Lite was calibrated. Each participant first performed a pursuit task, randomly followed by the saccade, visual search, and classification tasks. The participants moved their heads freely during the task. The eye and head movements were recorded during the experiment, and the data were used in the analysis.

Data analysis

The displacement of eye and head movements were calculated from the horizontal viewing angle obtained from the TalkEye Lite data and three-axis accelerometer data, respectively. The displacement of the head movement in the area in which the amount of change from the task starting point was the largest was calculated using data from the three-axis accelerometer. It is difficult to determine the units for the 3-axis accelerometer because the values are unique to the device. Therefore, the focus of this study was to determine the amount of change. The displacement of the eye movements was divided by the displacement of the head movements to obtain the sharing ratio of eye-head coordination in the task. This is calculated by the following formula.

$$\text{the ratio of the eye-head coordination} = \frac{\text{the eye movements (the horizontal viewing angle)}}{\text{the head movements (value of the 3-axis accelerometer)}} \quad (1)$$

The average of all trials in each task was used in the analysis. However, the sharing ratio for each trial was used to check the reproducibility of the eye-head coordination.

1) Checking the reproducibility of eye-head coordination

Using the sharing ratio of eye-head coordination in the pursuit task, ICC (1,6) was calculated for the six trials.

2) Detecting feature differences between tasks

After the sharing ratios of the eye-head coordination in each task were calculated, the CoSRP per task was calculated for each participant. This is calculated by the following formula.

$$\text{The CoSRP} = \frac{\text{the sharing ratios of the eye-head coordination in each task}}{\text{the sharing ratio of eye-head coordination in the pursuit task}} \quad (2)$$

Friedman's test was conducted to analyze the significant differences among the three tasks in healthy adults (Fig. 3).

4. Results

1) Confirmation of reproducibility of eye-head coordination

Table 1 shows some of the sharing ratios of eye-head coordination in the pursuit tasks. The ratio of the eye-head coordination for all participants ranged from 498.16–13363.35 (mean: 3248.55 median: 1971.92 interquartile range: 2468.23) and 271.20–13263.80 (mean: 2759.42 median: 1985.83 interquartile range: 2691.05)

Table 1 The sharing ratios in the pursuit task (excerpts).
The sharing ratios of eye-head coordination in the pursuit task are calculated. It can be observed that the range of values was large, depending on the participant, even for the same trial.

X axis	1	2	3	4	5	6
Sub1	9327.21	9046.78	13363.35	10344.01	9246.58	10145.20
Sub2	498.16	1045.61	1002.96	795.65	730.96	933.84
Sub3	935.98	870.34	880.49	1611.30	1497.60	1446.34
Sub4	3610.14	8010.12	6617.61	8488.36	5088.10	5013.41
Sub5	3219.93	3608.71	5797.42	3078.69	6182.15	4287.83
Y axis	**1**	**2**	**3**	**4**	**5**	**6**
Sub1	10511.65	7609.16	9081.75	13263.80	8014.11	10626.71
Sub2	601.10	611.73	359.52	330.62	271.20	272.16
Sub3	398.82	765.26	478.76	1476.53	848.19	1941.58
Sub4	3883.40	3961.86	5773.25	3575.49	2430.03	3101.74
Sub5	2834.66	2933.87	3530.79	4153.40	5719.15	3488.83

Table 2 Mean values of the sharing ratios in each task (excerpts).
The sharing ratios of the eye-head coordination in each task are calculated.
These values vary widely among participants, making it difficult to compare them uniformly.

X axis	Saccade	Visual search	Classification
Sub1	7851.07	8655.74	1158.88
Sub2	850.90	371.32	342.70
Sub3	2002.84	1512.92	397.79
Sub4	4973.12	3600.61	805.34
Sub5	5872.27	4138.72	787.69
Y axis	**Saccade**	**Visual search**	**Classification**
Sub1	8242.10	9482.29	1084.08
Sub2	374.10	580.72	280.90
Sub3	1378.01	1774.21	314.85
Sub4	2446.09	5430.24	975.04
Sub5	6060.25	5062.68	558.03

Table 3 CoSRP for each task (excerpts).
Subsequently, the CoSRP for each task is calculated. It is believed that using the assigned ratio values for each pursuit task as a standard reduces individual differences and makes it easier to observe the differences in strategies for different tasks.

X axis	Saccade	Visual search	Classification
Sub1	0.77	0.84	0.11
Sub2	1.02	0.44	0.41
Sub3	1.66	1.25	0.33
Sub4	0.81	0.59	0.13
Sub5	1.35	0.95	0.18
Y axis	**Saccade**	**Visual search**	**Classification**
Sub1	0.84	0.96	0.11
Sub2	0.92	1.42	0.69
Sub3	1.40	1.80	0.32
Sub4	0.65	1.43	0.26
Sub5	1.60	1.34	0.15

in the X and Y axes, respectively, with ICC (1,6) of 0.981 (0.954–0.994) and 0.981 (0.955–0.995) in the X and Y axes, respectively.

2) Detecting feature differences between tasks

Table 2 shows some of the sharing ratios of eye-head coordination for each task. The sharing ratios of the eye-head coordination for all participants ranged from 73.10–11002.93 (mean: 2950.41 median: 2026.90 interquartile range: 2958.95) and 74.72–14939.27 (mean: 2553.34 median: 1492.79 interquartile range: 2306.06) for the saccade task, 4.96–14207.70 (mean: 2436.07 median: 1275.89 interquartile range: 2540.68) and 6.68–12195.98 (mean: 2903.60 median: 1422.71 interquartile range: 2661.65) for the visual search task, and 58.93–1690.31 (mean: 546.46 median: 403.91 interquartile range: 492.27) and 93.22–1307.02 (mean: 477.08 median: 350.40 interquartile range: 429.01) for the classification task in the X and Y axes, respectively. The values tended to significantly differ between each participant.

We calculated the CoSRP. Table 3 shows the CoSRPs for each task. The range of the coefficients for all participants in the saccade task was from 0.04 to 2.49 (mean: 0.98 median: 0.95 interquartile range: 0.45) in

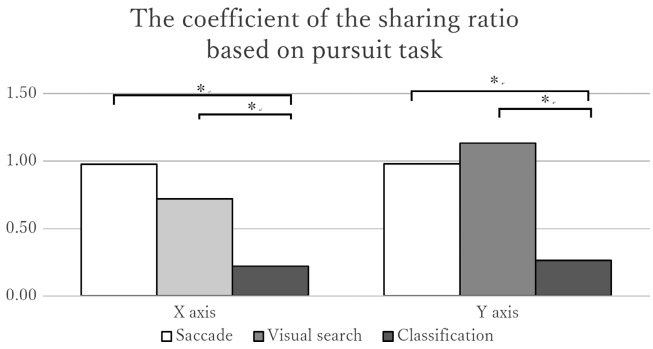

Fig. 4. Comparison of CoSRP for each task.
The vertical horizontal axes show the CoSRP and direction of the axis (X/Y axes) and task, respectively.
* Indicates items for which significant differences are found between the classification task and other tasks on the X and Y axes.

the X-axis and from 0.04 to 3.96 (mean: 0.98 median: 0.88 interquartile range: 0.74) in the Y-axis; in the visual search task, from 0.004 to 2.21 (mean: 0.72 median: 0.71 interquartile range: 0.39) in the X-axis and from 0.01 to 4.58 (mean: 1.13 median: 1.15 interquartile range: 0.77) in the Y-axis; and in the classification task, from 0.04 to 0.76 (mean: 0.22 median: 0.20 interquartile range: 0.16) in the X-axis and from 0.06 to 1.18 (mean: 0.26 median: 0.18 interquartile range: 0.18) in the Y-axis. Friedman's test showed a significant difference between tasks, with $p = 0.000$ and $p = 0.001$ in the X and Y axes, respectively. A post-hoc test was conducted to confirm the tasks that showed significant differences. Bonferroni correction was used to adjust the significance probability for the post-hoc test. Significant differences were found between the saccade and classification tasks ($p = 0.022$), visual search and classification tasks ($p = 0.000$) in the X axis, saccade and classification tasks ($p = 0.005$), and visual search and classification tasks ($p = 0.001$) in the Y axis (Fig. 4).

5. Discussions

1) The sharing ration

The sharing ratio of eye and head movements during eye-head coordination was calculated for each task. The results showed that the sharing ratio of eye-head coordination varied greatly between individuals, regardless of the task. The results of the present study are consistent with those of Takahashi et al. [17]. In addition, the reliability of the sharing rate of eye-head coordination in the pursuit task was confirmed in the present study, and the ICC was 0.981 in both the X- and Y-axes. The value was judged significant according to the classification by Shrout et al. [19]. Gresty reported that eye-head coordination is preprogrammed and controlled centrally [20] and that the intra-occipital error for each trial of the sharing ratio is small [18]. These results suggest that the sharing ratio of eye-head coordination in pursuit tasks reflects an individual's pursuit ability.

2) Relevance of calculating the coefficient of the sharing ratio based on pursuit task

As described, the reproducibility of the sharing ratio of eye-head coordination in the pursuit task is high, and the sharing ratio of eye-head coordination in the pursuit task is considered to reflect an individual's follow-up ability. Moreover, the ratio of the allocated eye-head coordination in each task significantly varied among individuals, which was partly due to the individual's follow-up ability. Therefore, it is difficult to compare the values of the sharing ratio of the eye-head coordination and calculate the characteristics of eye and head movements during eye-head coordination using the sharing ratio for each task. Presently, we calculated the CoSRP for each task, which reflects an individual's follow-up ability. This method is supposed to be highly valid because it is based on the method used to compare muscle strength during a task as a percentage of maximum muscle strength, the analysis of muscle strength in which individual differences are observed, and considered to be highly valid [21].

3) Comparison of CoSRP in each task

CoSRP was significantly smaller in the classification task than in the saccade and visual search tasks in the X and Y axes. This may indicate that eye movements in the classification task decreased more than those in the pursuit task or head movements increased more than those in the pursuit task, compared to other tasks in the X and Y axes. Morishima et al. reported that the UFoV narrows and ratio of head movements increases as the cognitive load increases [14], and the cognitive load may be greater for participants in the classification task than in the other tasks because it includes a memory component, leading to the present results. No significant differences were found between the saccade and visual search tasks. Since saccades are rapid eye movements that capture visual targets in the central fossa [22], saccades are likely to occur in the visual search task of capturing visual targets, and there was no significant difference in CoSRP between the saccade and visual search tasks.

The present study results suggest that task-specific visual characteristics, such as eye-head coordination strategies, can be reflected by determining the CoSRP for any participant. As the number of participants was small ($n = 10$) and the participants were healthy adults,

the sample size should be increased in future studies. It would be meaningful to investigate CoSRP for patients with neurodegenerative diseases, such as Parkinson's disease who show difficulties in visual information processing [23], and children with developmental disabilities who show difficulty with eye movements, and examine whether differences in strategies can be seen between tasks in these patient groups.

6. Conclusion

The sharing ratio used in the analysis of eye-head coordination is difficult to compare among individuals because of the large variation in values. Presently, we introduced the CoSRP and examined whether differences were found in saccade, visual search, and classification tasks. The results showed that the CoSRP was significantly smaller in the classification task, indicating that it could reflect the visual characteristics of each task. Eventually, we will increase the number of participants, calculate the CoSRP in patients with neurodegenerative diseases and children with developmental disabilities, and investigate whether visual characteristics may be reflected in the same manner.

Conflict of interest

No potential conflict of interest was reported by the authors.

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