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Original Article

A study on the effectiveness of training in the operation of an electric mobility aid in severely mentally and physically handicapped children

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ABSTRACT
Hideshima Y, Asami T, Ichiba M, Matsuo K, Murata T. A study on the effectiveness of training in the operation of an electric mobility aid in severely mentally and physically handicapped children. Jpn J Compr Rehabil Sci 2024; 15: 8–16.
Purpose: We examined whether operation training for children with severe mental and physical disabilities using recently developed electric mobility aids improves their skills in operating such aids and their daily activities. By doing so, we aimed to clarify the effectiveness of electric mobility aid operation training for children with severe mental and physical disabilities.
Method: Operation training and normal training using an electric mobility aid were conducted for 42 school-aged children with severe mental and physical disabilities, aged 8–18 years old. The trainee children were randomly assigned to two groups: 21 to the intervention group to receive operation training and 21 to the control group to receive general training. The intervention lasted 20 minutes/training session, with three sessions/week over a period of eight weeks. The Powered Mobility Program (PMP) and Pediatric Evaluation of Disability Inventory (PEDI) were used for pre- and post-intervention assessments, and SPSS was used for two-way analysis of variance (ANOVA).
Results: PMP scaled scores significantly increased ($p = 0.001$) in both groups, but there was no interaction effect. The PEDI scaled scores did not significantly increase in either of the two groups.
Discussion: The effects of the intervention and use of the electric mobility aid on the operating skills of children with severe mental and physical disabilities were explicitly demonstrated. Future long-term studies are required to clarify the effects of training in the operation of electric mobility aids on the subsequent development of severely physically and mentally handicapped children.

Key words: severely physically and mentally handicapped children, assistive technology, electric mobility aid, PEDI, PMP

Introduction

Children with severe mental and physical disabilities have difficulty achieving independent mobility in their activities of daily living (ADL) [1]. This impaired mobility limits the opportunities for these children to explore their cognitive and social environment [2]. Furthermore, reduced mobility could lead to a reduced level of engagement in activities beyond achieving mobility, hindering their experience of and stimulation by a variety of life situations [3]. The use of crutches, manual wheelchairs, or electric wheelchairs are possible ways to improve the reduced mobility of such children [4]. However, school-aged children with severe mental and physical disabilities have difficulty in acquiring the skills required to use an electric wheelchair. This is because the functions of an electric wheelchair are not adapted to their abilities and the environment in which they are trained to operate an electric wheelchair is suboptimal [5]. Additionally, in order for children with severe mental and physical

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disabilities to obtain electric wheelchairs with public assistance, they must apply for prosthetic devices based on the Comprehensive Services and Support for Persons with Disabilities Act [6]. However, the age for acquiring an electric wheelchair tends to be high, because the application for prosthetic devices requires that the child has acquired the skills to operate an electric wheelchair [3, 7].

Therefore, in recent years, various electric mobility aids have been developed to improve the mobility of children with severe mental and physical disabilities [8, 9]. One such device is the DonDonIkoo® (manufactured by Arizono Orthopedic Supplies Co., Ltd.) [10] (Figure 1). It comprises a control unit, a power-supply unit, and a drive unit at the bottom of a flat platform. At the top of the platform, a sit-to-stand device that is used daily by children with severe mental and physical disabilities can be attached, and the device can travel at a slower speed than an electric wheelchair [10]. Additionally, cross switches, piezoelectric switches, jellybean switches, etc. can be connected for operating the electric mobility aid, allowing the selection of switches according to the operator's hand functions [10, 11].

Previous studies have reported that electric wheelchair operation in children with severe physical and mental disabilities affects their operating skills, ADL, and development [12–15]. However, no study has shown that manipulation intervention of the electric mobility aid could improve manipulation skills and ADL in school-aged children with severe mental and physical disabilities, who, in addition to reduced mobility, are not cervically stable, have impaired limb movements, and have intellectual disabilities with a developmental age of approximately one year. We hypothesized that if the effects of training severely disabled children to operate electric mobility aids on their operating skills and ADLs were clarified over general training in walking with crutches and wheelchair/electric wheelchair operation, the introduction of electric mobility aids would increase and improve the mobility independence of school-aged severely disabled children.

Therefore, in this study, we conducted an intervention of operation training using an electric mobility aid and general training for school-aged children with severe physical and mental disabilities. Additionally, we compared their manipulation skills and ADL before and after the intervention to clarify the effects of operation training using an electric mobility aid on their manipulation skills and ADL.

Figure 1. Overview of the electric mobility aid.
Upper: Appearance of the electric mobility aid.
Middle: Prone position.
Lower: Operation from seated position.
The image is quoted from [10]. Image approved for publication.

Methodology

1. Subjects

Subjects were selected from among 72 school-aged children with severe mental and physical disabilities enrolled in the elementary, middle, and high school sections of special-needs schools for children with severe mental and physical disabilities in Prefecture S. Forty-two children (27 boys and 15 girls, aged 8–18 years, 13.3 ± 6.1) who were briefed regarding the contents of the study and provided their informed consent were ultimately selected as subjects. Exclusion criteria were as follows: no enrollment in a school for severely handicapped children, acquisition of an electric wheelchair, previous experience riding an electric mobility aid, no non-participation during the training period, and high skill in operating an electric mobility aid prior to the intervention (Figure 2). The breakdown of diagnoses of the severely handicapped children was 20 children with cerebral palsy (CP) and 22 children with other neurological diseases (Table 1). No subject withdrew from the study.

2. Intervention method

The intervention period was from September 6, 2019 to December 21, 2019. The intervention was conducted by classroom teachers during training classes in four special needs schools in Prefecture S.

The study design was divided into two groups: an intervention group and a control group. The intervention group received an electric mobility aid manipulation training intervention, while the control group received a regular training intervention. To address the ethical issue of ensuring that each training was administered fairly, each group received the general training and the operation training one week after the intervention [16]. The two groups were randomly assigned in the order of submission of consent forms, with odd numbers assigned to the intervention group and even numbers to the control group. The intervention group comprised 21 participants (15 males, six females, age 13.0 ± 3.1) and the control group comprised 21 participants (12 males, nine females, age 13.8 ± 8.2) (Table 1).

The tasks for the operation training for the electric mobility aid were performed in the order of the initial skills tasks in the Powered Mobility Program (PMP) data sheet (Table 2) [17]. The general training included standing, massage, crutches, and wheelchair/electric wheelchair operation [5]. Each training session lasted 20 minutes/session, three times/week for eight weeks, taking into account student fatigue. The remaining 30 minutes of session time was spent preparing and removing equipment. For the electric mobility aid operation training, the subject's usual posture maintenance device was fixed to the DonDonIkoo® [8] (Figure 1). The posture maintenance device was adjusted to fit the subject's physique so that the depth of the seat was 50 mm between the knee socket and the front edge of the cushion, and the width was the width of the pelvis [18]. The manipulation sites were selected for each subject, including the chin, cheeks, and forehead as well as the upper limbs, and input devices such as cross switches, piezoelectric switches, and jellybean switches were selected [10, 11]. For safety reasons, each training session was conducted in a gymnasium, hall, or other location free of obstacles. Additionally, appropriate visibility was maintained during operation.

3. Evaluation method

The Enjohji Developmental Test was conducted to assess the baseline of the subjects [19]. The Gross Motor Function Classification System (GMFCS), which is used to assess gross motor skills in children with severe mental and physical disabilities, was not used because the subjects included those with conditions other than CP. To assess manipulative skills, two groups were evaluated with the electric wheelchair manipulative skills evaluation chart (PMP) before and after the electric mobility aid operation training [17]. To determine the extent of functional skills and caregiver assistance, before and after

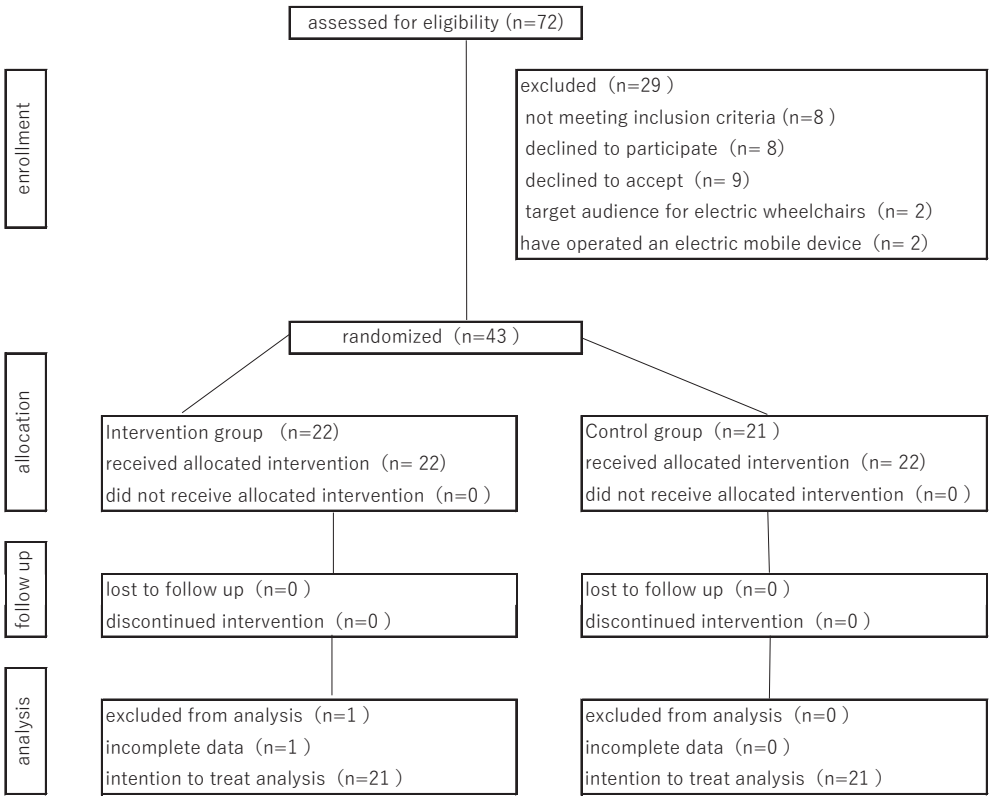

Figure 2. Recruitment, selection, and retention of participants.

Table 1. Breakdown of targets of analysis.

	All subjects (n = 42) Ave. ± SD	Intervention group: (n = 21) Ave. ± SD	Control group: (n = 21) Ave. ± SD	p-value
Sex	M(n = 27), F(n = 15)	M(n = 15), F(n = 6)	M(n = 12), F(n = 9)	
Diagnosis	CP(n = 20), Other than CP (n = 22)	CP(n = 10), Other than CP (n = 11)	CP(n = 10), Other than CP (n = 11)	
Age	13.3 ± 6.1	13.0 ± 3.1	13.8 ± 8.2	0.6713
Enjohji Developmental Test Motion (Locomotion)(Age)	0.56 ± 0.50	0.58 ± 0.44	0.48 ± 0.49	0.4683
Enjohji Developmental Test Motion (Hand movement) (Age)	0.70 ± 0.90	0.67 ± 0.85	0.69 ± 0.99	0.9345
Enjohji Developmental Test Sociality (Basic habits)(Age)	0.81 ± 0.95	0.86 ± 1.06	0.69 ± 0.82	0.4352
Enjohji Developmental Test Sociality (Interpersonal relations)(Age)	0.84 ± 0.90	0.75 ± 0.62	0.80 ± 1.05	0.2205
Enjohji Developmental Test Language (Speech)(Age)	0.82 ± 1.09	0.74 ± 0.98	0.73 ± 0.97	0.5831
Enjohji Developmental Test Language (Language comprehension)(Age)	1.15 ± 1.40	1.07 ± 1.32	1.10 ± 1.48	0.1708
PMP ※	3.5 (6.05−1.05)	3.8 (20.6−1.2)	4.1 (6.2−1.5)	0.3118
PEDI Functional skills Self-care	27.68 ± 16.63	27.59 ± 16.71	26.74 ± 14.48	0.2798
PEDI Functional skills Mobility	24.43 ± 19.25	24.39 ± 16.22	23.71 ± 18.31	0.9982
PEDI Functional skills Social function	23.86 ± 16.76	24.61 ± 16.90	20.71 ± 16.78	0.9568
PEDI Caregiver assistance Self-care	12.57 ± 18.12	15.62 ± 21.66	9.03 ± 14.81	0.7758
PEDI Caregiver assistance Mobility	13.06 ± 21.47	16.02 ± 22.72	11.39 ± 18.99	0.9169
PEDI Caregiver assistance Social function	14.99 ± 17.94	18.81 ± 17.15	11.00 ± 17.60	0.8762

CP, Cerebral palsy; PMP, Powered Mobility Program; PEDI, Pediatric Evaluation of Disability Inventory.
*$p < 0.05$.
※Results are presented as medians (25th−75th percentiles) for continuous variables or percentages for categorical variables.

manipulative training and before and after regular training, the Pediatric Evaluation of Disability Inventory (PEDI) for Rehabilitation of Children [20−22] was used to evaluate the two groups. The evaluations were conducted by the classroom teachers.

The Enjohji Developmental Test, used here to assess development, can assess motor, social, and language skills in children with and without disabilities. It is

Table 2. Powered Mobility Program (PMP) datasheet.

Item	Category	Check items
Foundational movement capacities	Initial proficiency	(1) Able to turn the electric wheelchair on and off.
		(2) Able to keep the joystick depressed for at least 5 seconds.
		(3) Able to move the electric wheelchair for 5 seconds by moving the joystick, and then stop the electric wheelchair.
		(4) Able to move the electric wheelchair forward for 10 seconds and stop at a target object.
		(5) Able to look in the direction the wheelchair is moving.
		(6) Able to stop without hitting a stationary target without being instructed to do so.
	Directional control	(7) Can move the electric wheelchair forward for 3 m.
		(8) Can move the electric wheelchair forward for 3.2 m.
		(9) Can turn the electric wheelchair to the right from a stop.
		(10) Can turn the electric wheelchair to the left from a stop.
		(11) Able to move backward with at least two commands.
		(12) Able to turn left and right to reach a target 15 m away.
		(13) Able to avoid stationary targets without instructions.
	Speed control	(14) Able to move the electric wheelchair forward and maintain a low speed.
		(15) Able to understand the difference between high and low speed.
		(16) Able to stop without hitting a door. (The distance between the door and the foot support should be within 4 cm.)
		(17) Able to stop within 4 cm before the line without crossing the designated line.
Basic mobility in the designated environment	Movement capacity	(18) Able to pass through doorways without hitting the doorframe.
		(19) Able to traverse through the corridor independently for 15 m without hitting the wall.
		(20) Able to traverse a winding road in two turns.
	Traversing a walking ramp	(21) Able to pass through the ramp after stopping at the corner of the threshold.
		(22) Able to pass the threshold of the ramp backward.
		(23) Able to maintain a margin of 12 cm on either side when passing.
		(24) Able to pause at the threshold when exiting the sidewalk.
		(25) Able to pause at the beginning of a descent.
		(26) Able to traverse ramps slowly.
	Traveling on a path	(27) Able to pass through pylons placed at intervals of 90 cm and a narrow course of 70 cm width with a space of 5cm or less between pylons.
		(28) Able to follow on a wider course of 90 m with six markers on the floor placed at 90 cm intervals and spaced no more than 5 cm apart.
Basic mobility in the general environment	Daily operations	(29) Able to conform to movement etiquette, such as passing on the right side of the road, avoiding people and objects and checking for safety at intersections in corridors.
		(30) Able to operate the electric wheelchair in the presence of other people in motion and various objects.
		(31) Able to move off the sidewalk to a desired location and stop in an appropriate place.
		(32) Able to travel along and across curves.
		(33) Able to move freely in and out of small rooms.
		(34) Able to avoid holes and hazards.

capable of assessing development in six domains: locomotion and hand movements in the motor subitem, basic habits and interpersonal relationships in the social subitem, and speech and language comprehension in the language subitem [19].

The PMP used to evaluate the operational training of the electric mobility aid comprises 34 tasks that are scored on a 0−5 scale, such as being able to turn the power on or off, being able to hold the joystick pressed for at least 5 seconds, etc. After this step, a Rasch analysis was performed and a scaled score of 0−100 was calculated based on the total score; a score of 75 or higher could be evaluated as being able to operate the electric wheelchair [17].

The PEDI was used for pre- and post-intervention assessments of functional skills and degree of caregiver assistance [20−22]. As the functional skills and caregiver assistance items can be assessed with respect to the three domains of self-care, mobility, and social functioning, the tool assesses ADL items in five domains: self-care domain of functional skills, mobility domain of functional skills, social function domain of functional skills, self-care domain of caregiver assistance, and social function domain of caregiver assistance. Classroom teachers responded to 197 functional skill-related items, such as whether subjects were able to sit up if supported by equipment or a caregiver, using a binary "able" and "not able" mode of response. The PEDI is an assessment instrument designed to evaluate the abilities of infants and toddlers aged 6 months to 7.5 years. However, previous studies have reported that it can be used for children over 7.5 years of age if they have developmental delays [20−22]. In this study, we used its rating score of PEDI, which was scored from 0−100 points using a scaled score table according to the manual. The control group was also evaluated after the general training session. Additionally, class instructors were asked to record a description of how subjects performed in each training session.

To assess subjects' skills in operating the electric mobility aid after the intervention, we compared pre- and post-intervention differences in PMPs between the intervention and control groups. Pre- and post-intervention scaled scores on the PEDI were also compared to examine pre- and post-intervention changes in functional skills and the degree of caregiver assistance. These methods were used to examine the usefulness of training in operating the electric mobility aid for children with severe physical and mental disabilities.

4. Analysis method

SPSS (version 29.0.0.0) was used to conduct a two-way ANOVA statistical analysis. The level of statistical significance was $p = 0.05$. This study was conducted in accordance with the Ethics Policy 30−40 of the Saga University School of Medicine (2019.3.27). All subjects were briefed in advance orally and in writing regarding the purpose and methods of the study. Informed consent was obtained from the study subjects and their guardians. There were no conflicts of interest in this study.

Results

1. Pre-intervention evaluation of subject children

The developmental age of all subjects was approximately one year based on the results of the Enjohji Developmental Test for mobility, social skills, and language—all were assessed at approximately 1. As the PMP scaled scores were not normally distributed, they are listed as median values. Median pre-intervention PMP scaled scores did not differ between the intervention and control groups. The pre-intervention PEDI scaled scores did not differ between the intervention and control groups (Table 1).

2. PMP results

A comparison of pre- and post-intervention PMP scaled scores (Table 3) showed that the intervention group scored 5.4 (SD: 9.27) pre-intervention and 22.3 (SD: 21.11) post-intervention. The control group scored 4.1 (SD: 2.74) pre-intervention and 17.2 (SD: 9.97) post-intervention, with a significant main effect ($p < 0.01$). However, there was no interaction (Figure 3a).

3. PEDI results

A comparison of PEDI scaled scores before and after the intervention in the two groups (Table 3) showed no significant main effects or interactions. However, in the domain of caregiver-assisted mobility, both intervention and control groups showed a trend toward less assistance, with a non-significant p-value of 0.053 (Figure 3b).

Discussion

The subjects included children aged approximately one year old with severe mental and physical disabilities; this was lower than the developmental age of 1−11 years of the subjects of previous studies [12, 14, 15]. The operation training intervention with the electric mobility aid improved the PMP scaled scores of the children with severe physical and mental disabilities (Figure 3a). The control group also exhibited an increase in PMP score after the general training, suggesting that while some form of training may improve manipulation skills even at a developmental age of approximately one year, this study did not clarify the necessity of operation training. The median PMP scaled score of 16 after the intervention corresponds to the ability to move the electric mobility aid forward for 10 seconds and stop at a target object [17].

Table 3. Comparison of PMP and PEDI scale score.

	Intervention group: (n = 21)				Control group: (n = 21)							
Domain	Pre		Post		Pre		Post		Main effect		Interaction	
	Average	SD	Average	SD	Average	SD	Average	SD	F value	p	F value	p
PNP	5.4	9.27	22.3	21.11	4.1	2.74	17.2	9.97	84.57	<.001	1.3550	0.251
Functional skills Self-care	25.1	12.71	25.9	12.24	26.7	14.48	27.8	12.56	3.063	0.088	0.064	0.802
Functional skills Mobility	23.7	19.56	25.1	18.39	23.7	18.31	24.9	17.68	3.211	0.081	0.014	0.907
Functional skills Social function	23.9	14.34	23.8	15.39	20.7	16.78	21.2	16.36	0.047	0.829	0.143	0.707
Caregiver assistance Self-care	13.6	16.08	13.8	17.53	9.0	14.81	10.7	16.41	2.24	0.142	1.397	0.244
Caregiver assistance Mobility	12.4	20.62	15.2	20.48	11.4	18.99	12.9	19.33	3.955	0.054	0.328	0.57
Caregiver assistance Social function	15.1	13.85	17.1	13.96	11.0	17.60	10.8	17.99	0.551	0.462	0.9	0.348

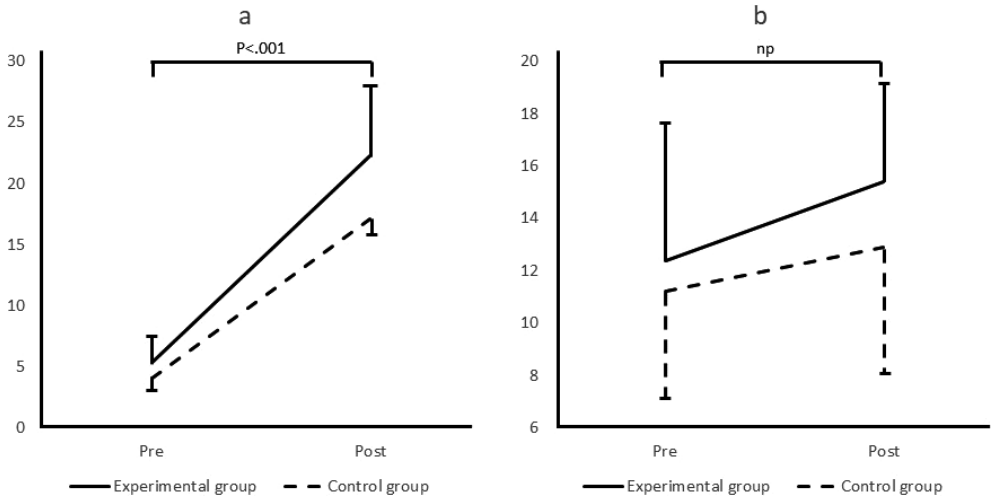

Figure 3. Effect of operation training and ordinary training.
a. Scaled score for PMP assessment, b Scaled score for mobility domain in caregiver assistance of PEDI.
The main effect of PMP is significant, and the error line is the standard error.

The PEDI assessment showed no significant main effects or interactions (Table 3). However, it showed a trend toward reduced assistance in the mobility area of caregiver assistance. Previous studies have reported that training in electric wheelchair operation in severely disabled children affects the mobility domain of functional skills and caregiver-assisted transfers [14, 23, 24].

The *p*-value for the main effect was also close to the significance level. As such, a larger population of examinees could have produced significant results. In the future, it may be necessary to increase the number of subjects or to conduct a study in which the results of the two phases are analyzed together using a crossover method.

Previous studies on electric wheelchair operation have reported that children with severe mental and physical disabilities learn at an extremely slow pace, and that training in electric wheelchair operation is desirable to introduce these skills early, not only for the acquisition and expansion of ADLs, but also for its positive effects on the maturation of physical and brain functions during these children's growth and development process [3, 8, 25, 26]. However, training interventions at rehabilitation facilities such as medical institutions and welfare facilities in Japan are brief—usually 40 minutes/week [27]. Meanwhile, training at special-needs schools—the target environment considered in this study—is conducted as a class, 50 minutes/day, five times/week, and thus provides greater opportunities to engage in operation training than at medical institutions or welfare facilities. Therefore, we expect that the training intervention in electric wheelchair operation at special-needs schools will realize more intervention opportunities and training efficacy.

A conceivable issue in the operation training environment for electric mobility aids is the small number of electric mobility aids deployed. There were eight electric mobility aids installed in the four special-needs schools in Prefecture S where this study was conducted. Increasing the number of electric mobility aids and improving the operating training environment could promote the independence of mobility of children with severe mental and physical disabilities.

The observation of the subjects' condition before and after the intervention and in the descriptions by the caregivers involved in the operation training revealed that the subjects were more active during the operation training than during the general training. Additionally, their smiles broadened as the operation training progressed. A parent who observed her child during the operation training stated, "I was thrilled to see my child, who up to now I thought would only be able to move independently if my child could stand on her own, smile as she came toward me while operating the electric mobility aid." Training children with severe physical and mental disabilities to operate the electric mobility aid is also a way of training that they can find enjoyable. We believe that in the future, it will be necessary to clarify the psychological effects of the electric mobility aid operation training on the caregivers of children with severe physical disabilities, as well as the effects of the training on the children's subsequent development through a long-term approach.

Conclusion

Training in operating the electric mobility aid improved the operating skills of the severely disabled children. However, this difference was insignificant,

although there was a tendency for the level of assistance to decrease in the area of caregiver-assisted transfers. In the future, we would like to consider an evaluation that incorporates the caregiver's perspective.

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