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Original Article

Differences in evaluation of functional skills of the Pediatric Evaluation of Disability Inventory (PEDI) between normally developing children and children with cerebral palsy

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Abstract
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Objective: The Pediatric Evaluation of Disability Inventory (PEDI) provides functional skills scales based on the data obtained from normally developing children. In the present study, we performed an analysis of children with cerebral palsy using the same methodology as set originally to examine differences in discrete skill items between the two groups of children.
Methods: Six hundred and two children with cerebral palsy were divided into groups based on the severity of disorder as described in the Gross Motor Function Classification System (GMFCS). The scaled scores for the PEDI functional skills were computed by Rasch analysis.
Results: Correlation coefficients between the scaled scores of children with cerebral palsy and those presented in the PEDI original data were $r = 0.890$ for self-care, $r = 0.795$ for mobility, and $r = 0.943$ for social function. In children in GMFCS level I, discrete scores increased with age, whereas in children in levels III, IV, and V, scores for mobility almost reached the plateau in the age band of 4 to <6 years.
Discussion: In the difficulty level of functional skills, the greatest difference was observed in mobility, suggesting the need to establish a difficulty level of functional skills that is adapted to the abilities of children with cerebral palsy.
Key words: cerebral palsy, Pediatric Evaluation of Disability Inventory (PEDI), functional skills, Rasch analysis

Introduction

Pediatric rehabilitation programs should reflect the evaluation of motor and mental functions—which change as the child grows up—and set appropriate goals. In addition, the goals should be clear to all stakeholders including parents/guardians and caregivers as well as health care professionals. To make a scientific assessment of the severity of disorder and motor function, a universal scale that meets the criteria such as reliability and validity is needed [1]. Although various scales differing by institution and country have traditionally been used in pediatric rehabilitation, in recent years, standardized scales including the Gross Motor Function Measure (GMFM), the Pediatric Evaluation of Disability Inventory (PEDI), and the Functional Independent Measure for Children (Wee FIM) have been used as endorsed by the Japanese Guidelines for Rehabilitation of Cerebral Palsy [2].

Among the above, the PEDI [3] is a scale for evaluating both the capability and performance of children in functional activities in daily living. In the evaluation of capability, functional skills (specific daily life skills) that the child has already mastered are confirmed and assessed. The evaluation of performance assesses the extent to which the child needs assistance from a caregiver, or the level of environmental modifications required to master the functional skills. This helps avoid an effect on the child's capability by

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environmental adaptations.

The evaluation domains of the PEDI are divided into three subdomains, i.e. self-care, mobility, and social function, which are scored using the functional skills scale (capable/unable to). In line with a detailed manual, the scoring is done according to the diagnosis based on what was found from the interviews with parents/guardians or the observations made by therapists/educators who have daily contact with the child. The scores by domain are transformed into normative standard scores and scaled scores by Rasch analysis based on the data obtained from 412 normally developing children in the northeastern region of the United States. The normative standard scores, set to yield a mean of 50 (standard deviation of 10), indicates the relative positions to the functional status presumed from the age. Ninety-five percent of normally developing children in each age group are distributed in the range of 30–70, which indicates that a child's normative standard score below 30 means his/her functional status is poorer than expected for his/her age. The scaled scores are ratings obtained by transforming raw scores measured on an ordinal scale into values indicated on an interval scale considering the difficulty level of discrete items, and they vary within the range of 0–100. The higher the score is, the higher the difficulty level of the task that the children can perform. The scaled scores enable the comparison of children's abilities on the same scale regardless of age [4,5].

In the PEDI, the data used to calculate the scaled scores for the discrete items and create maps illustrating the difficulty levels is that obtained from normally developing children. Therefore, there may be a gap between the difficulty level for disabled children and the one for normally developing children. The purpose of the present study was to assess the functional skills of children with cerebral palsy in Japan using the PEDI and analyze the results by the same methodology used in the PEDI in order to examine the difference compared to the original data.

Subjects

The study included 602 children with cerebral palsy (351 males, 251 females) who underwent assessment by the PEDI at 46 of the 63 facilities for children with disabilities in Japan. The mean and median ages were 8.6 years (0–18 years) and 9 years, respectively. To compare the data on the 602 children based on the severity of disorder, they were divided into groups by the Gross Motor Function Classification System (GMFCS).

GMFCS is a discriminant scale developed by Palisano et al. Based on gross motor function focusing on sitting and transfer abilities, it classifies the final stage achieved at age 6 years or older into the following five levels: I, Walks without Limitations; II, Walks with Limitation; III, Walks Using a Hand-Held Mobility Device; IV, Self-Mobility with Limitations; May Use Powered Mobility and V, Transported in a Manual Wheelchair.

Taking into account the change in motor function with age, the GMFCS has age bands of under 2 years, 2 to <4 years, 4 to <6 years, 6 to <12 years, and 12 to <18 years, providing separate descriptions of motor function corresponding to each age band for each level. The rater classifies the severity of motor impairment assuming, for each age, how the child is going to develop to the final level to be achieved [6].

The children included in the present study were classified as follows: GMFCS I, 52 (8.6%); II, 69 (11.5%); III, 161 (26.7%); IV, 176 (29.2%); and V, 144 (23.9%) (Table 1).

Methods

The functional skills (73 items for self-care, 59 items for mobility, and 65 items for social function) were scored in accordance with the PEDI manual; for institutionalized children, the scoring was performed by discussion among the staff who are familiar with the daily activities of the respective children, and for non-institutionalized children, by interview with the parents/guardians. To ensure the validity of scoring, at least one person representing each facility participated in the PEDI training prior to data collection to hear a lecture and take the subsequent test.

We calculated the scaled scores for discrete functional skills by Rasch analysis and computed the correlation coefficients compared to the "scaled scores for discrete functional skills on the basis of the data

Table 1. Children divided into groups by GMFCS. (num.)

GMFCS Level	I	II	III	IV	V	Sum
Under 2 years	0	2	1	0	6	9
2 to < 4 years	7	6	22	14	37	86
4 to < 6 years	14	11	22	17	18	82
6 to < 12 years	26	38	79	89	55	287
12 to < 18 years	5	12	37	56	28	138
Sum	52	69	161	176	144	602

obtained from normally developing children" shown in the original PEDI. The Rasch analysis was performed using Winsteps ver. 3.62.1 (Linacre JM, Winsteps Com).

Next, in children with cerebral palsy, scaled scores for the discrete skills specified in the PEDI were computed for each level defined in the GMFSC, from which mean scores by age were calculated to examine the relationship between the scores for discrete skills and age using multi-way analysis of variance.

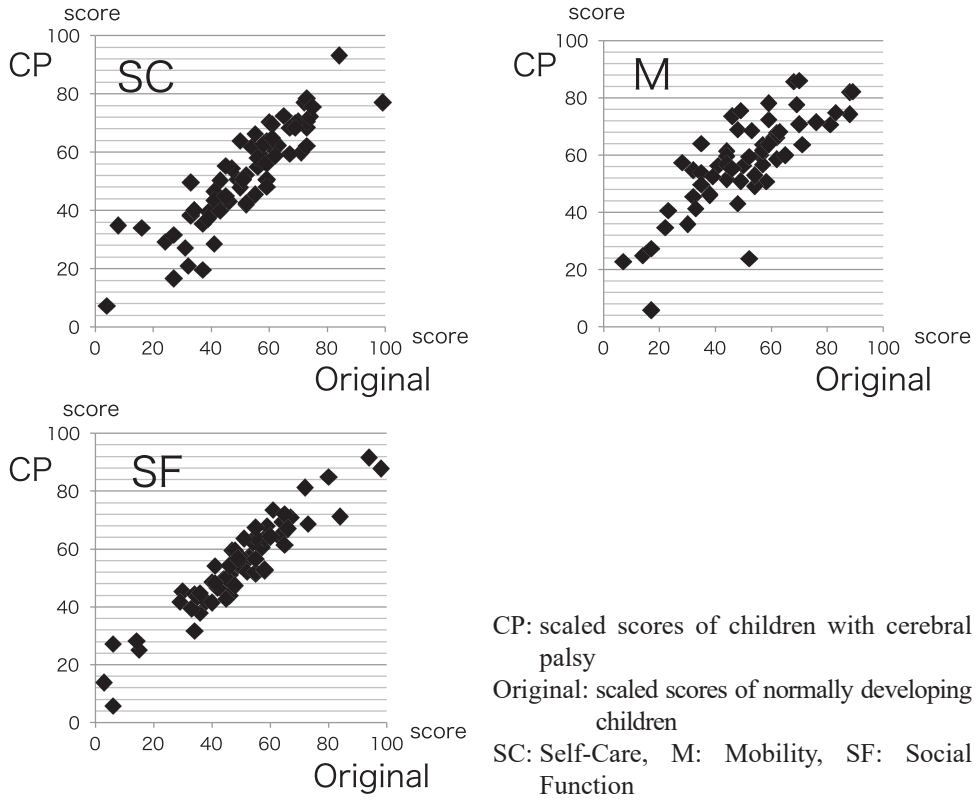
The present study was carried out under the approval of the Ethics Committee for Epidemiological and Clinical Research of the university with which the author is affiliated.

Statistical analyses were performed by JMP 9.0.2 for computation of correlation coefficients and by IBM SPSS Statistics ver. 23 for multi-way analysis of variance.

Results

Correlation coefficients between the scaled scores for functional skills computed by Rasch analysis of the data on children with cerebral palsy and those on normally developing children shown in the original PEDI were $r = 0.890$ for self-care, $r = 0.795$ for mobility, and $r = 0.943$ for social function, demonstrating a low correlation in mobility and high correlations in self-care and social function (Figure 1).

In the scaled scores for mobility, the items that exhibited higher scores in children with cerebral palsy compared to normally developing children, namely the items that were evaluated as being more difficult for children with cerebral palsy than for normally developing children were "Indoor locomotion–distance/speed: Item 29, Moves within a room with no difficulty, and Item 31, Moves between rooms with no difficulty," "Indoor locomotion methods: Item 27, Walks without support," and "Outdoor locomotion methods: Item 39, Walks without support." Meanwhile, normally developing children showed a higher score for "Toilet transfers: Item 1, Sits if supported by equipment or caregiver" compared to children with cerebral palsy. In the scaled scores for self-care, the items that exhibited higher scores in children with cerebral palsy than in normally developing children were "Use of drinking containers: Item 10, Holds bottle or spout cup" and "Use of utensils: Item 5, Finger feeds," while the item for which normally developing children presented a higher score was "Hair brushing: Item 23, Manages tangles and parts hair." In the scaled scores for social function, children with cerebral palsy showed a higher score for "Peer interactions: Item 31, Notices presence of other children, may vocalize and gesture toward peers" compared to normally developing children



CP: scaled scores of children with cerebral palsy
Original: scaled scores of normally developing children
SC: Self-Care, M: Mobility, SF: Social Function

Figure 1. Scaled scores of normally developing children (original data in the PEDI) and children with cerebral palsy.
Distribution of the scaled scores of normally developing children (original data in the PEDI) and the scaled scores of children with cerebral palsy are illustrated by self-care, mobility, and social function.

(Table 2).

In testing the difference between correlation coefficients, z-scores were 1.420 for self-care, 1.084 for mobility, and 1.767 for social function. The values transformed into standard normal distribution (z-scores) were 1.88 between self-care and mobility, 3.71 between mobility and social function, and 1.99 between self-care and social function, exhibiting a significant difference only between mobility and social function ($p < 0.001$) based on the standard normal distribution.

In calculating the mean of the scaled scores by age for each level of the GMFCS in children with cerebral palsy, those aged under 2 years were excluded from the statistical analysis because of too few subjects. In every age band in GMFCS group I, the scaled scores for the mobility domain were higher than the other two domains, whereas in groups III, IV, and V, the scaled scores for the mobility domain were lower than the other two domains. Additionally, in groups IV and V, while the scaled scores for the mobility domain scarcely changed from ages 4 to <6 years and beyond, the scores for social function and self-care maintained moderate increases (Figure 2).

The multi-way analysis of variance showed no significant difference in interaction between each skill and age in GMFCS group I, exhibiting an F-value of 0.987 and $p = 0.439$. The F-value and p-value for the other groups were: F-value 2.267 and $p = 0.041$ for group II, F-value 7.817 and $p < 0.0001$ for group III, F-value 3.982 and $p = 0.001$ for group IV, and F-value 2.551 and $p = 0.02$ for group V, showing significant differences in groups II and V with $p < 0.05$ and in groups III and IV with $p < 0.01$. In a multiple comparison between the PEDI skills in each GMFCS level, group I showed no significant difference between self-care and social function, and group II exhibited no significant difference between any factors. Meanwhile,

Tabel 2. Copmarison of the scaled scores between normally developing children and children with cerebral palsy.

Mobility	Skill	No.	Item	Original (score)	CP (score)	Difference*
	Indoor locomotion: Distance/Speed	29	Moves within a room with no difficulty	28	57	−29
	Indoor locomotion: Distance/Speed	31	Moves between rooms with no difficulty	35	64	−29
	Toilet transfers	1	Sits if supported by equipment or caregiver	52	24	28
	Indoor locomotion: Methods	27	Walks without support	46	74	−28
	Outdoor locomotion: Methods	39	Walks without support	49	75	−26
	Tub transfers	21	Sits unsupported and moves in tub	32	55	−23
	Outdoor locomotion: Surfaces	47	Rough, uneven surfaces (lawns, gravel driveway)	48	69	−21
	Outdoor locomotion: Surfaces	49	Up and down curbs	59	78	−19
	Indoor locomotion: Methods	26	Walks, but holds onto furniture, walls, caregivers or uses devices for support	35	54	−19
	Upstairs	54	Walks up entire flight with no difficulty	68	86	−18
	Bed mobility/Transfers	16	Raises to sitting position in bed or crib	23	41	−18
	Indoor locomotion: Pulls/Carries objects	36	Carries objects large enough to require two hands	44	61	−17
	Downstairs	59	Walks down full flight with no difficulty	70	86	−16
	Tub transfers	20	Sits if supported by equipment or caregiver in a tub or sink	7	23	−16
	Outdoor locomotion: Surfaces	46	Slightly uneven surfaces (cracked pavement)	44	60	−16
	Outdoor locomotion: Surfaces	48	Up and down incline or ramps	53	69	−16
	Outdoor locomotion: Methods	38	Walks, but holds onto objects, caregiver, or devices for support	41	56	−15
Self-Care	Skill	No.	Item	Original (score)	CP (score)	Difference*
	Use of drinking containers	10	Holds bottles or spout cup	8	35	−27
	Hairbrushing	23	Manages tangles and parts hair	99	77	22
	Use of utensils	5	Finger feeds	16	34	−18
	Food textures	2	Eats ground/ lumpy foods	37	20	17
	Shoes/Socks	54	Removes socks and unfastened shoes	33	50	−17
Social function	Skill	No.	Item	Original (score)	CP (score)	Difference*
	Peer interactions (Child of similar age)	31	Notices presence of other children, may vocalize and gesture toward peers	6	27	−21
	Fuctional use of communication	11	Names things	30	45	−15

CP, scaled scores of children with cerebral palsy; Original, scaled scores of normally developing children.
*Items which absolute value is more than 15 are shown subtracting the scaled scores of children with CP from those of normally developing children

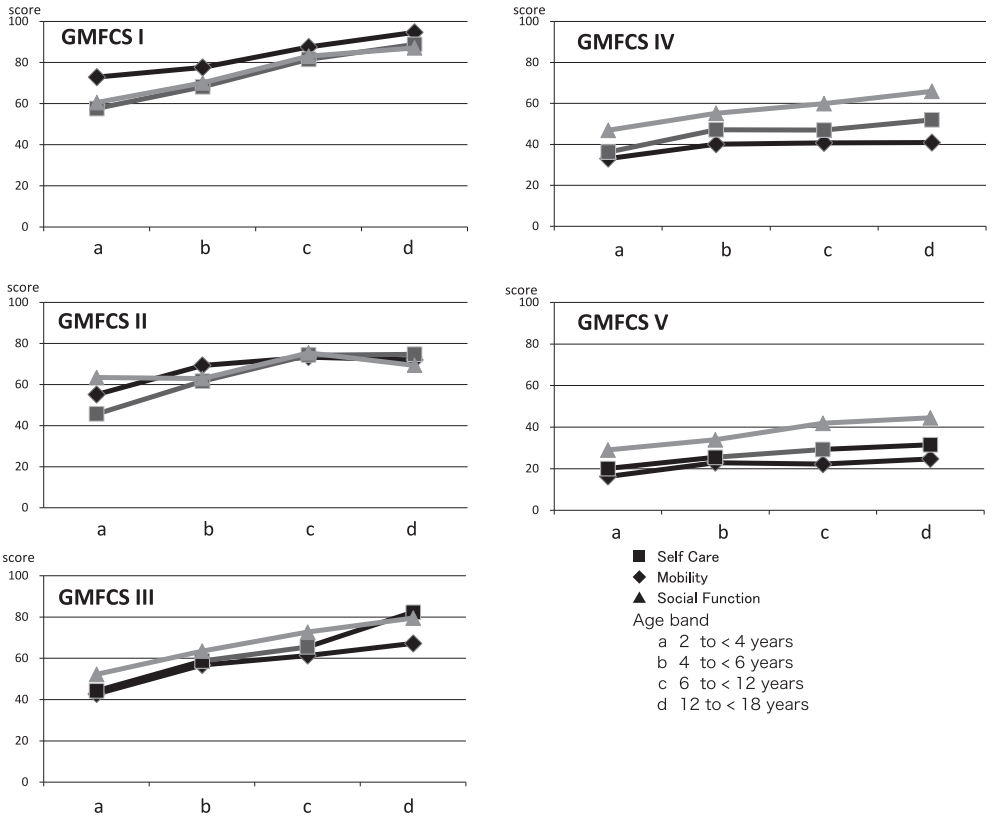


Figure 2. Scaled scores by level/age band defined in the GMFCS.
Children with cerebral palsy were divided into groups as defined in the GMFCS. Each group was further divided into five age bands based on the assessment method of the GMFCS and the means of the scaled scores for discrete domains are indicated. Children aged under 2 years were excluded from the calculation because the number of these children was too small.

in groups III, IV, and V, significant differences were found between all factors.

Discussion

In children with cerebral palsy, improvement in gross abilities is considered to peak at age 4 and thereafter, and almost come to an end at age 6 and beyond [7]. Conversely, certain abilities in daily life such as locomotion and transfers are considered to keep improving thereafter by mastering alternative means. Accordingly, goals for functional assessment should also be set on achieving the skills required in daily activities, for which the PEDI has gained wide use as an assessment tool to observe the changes with time and evaluate the effectiveness of the treatment [8,9].

However, the PEDI was developed and designed based on the data on normally developing children in the United States. As has been reported in the Dutch version of the PEDI, cultural differences are assumed to have a certain influence on the daily activities of children and hence the issue has been examined in Germany, Saudi Arabia, and Norway [10−12].

Additionally, because the PEDI was designed for normally developing children, some movements that these children can perform easily may constitute an item of a high difficulty level for children with cerebral palsy, which may decrease their rating for some items. On the other hand, since the order of the difficulty level of the items is different between children with cerebral palsy and normally developing children, score inversion phenomena, wherein the scaled scores of normally developing children are higher than those of children with cerebral palsy, may occur.

In the present study, we performed the analyses for children with cerebral palsy using the same methodology as described originally and compared the differences. The results showed that with respect to the difficulty level of performing functional skills, the greatest difference in scaled scores was observed in mobility, which was followed by self-care, and the difference in social function was the smallest. In terms of correlation coefficients, a significant difference was found between the functional skills in mobility and those in social function.

Motor function of children with cerebral palsy involves impairments ranging from very mild paralysis to severe paralysis in the trunk/limbs. The *Medical Survey Report on Prognosis of Children with Severe*

Cerebral Palsy published in 2011 reported that among a total of 475 children with cerebral palsy in Okinawa prefecture, those who were classified as GMFCS group I, II, III, IV, and V accounted for 15.8%, 12.2%, 7.6%, 37.1%, and 27.4%, respectively [13], whereas in the present study, there were fewer children in GMFCS level I (8.6%) and more children in group III (26.7%). In any case, since children in groups IV and V accounted for a high proportion in all the children with cerebral palsy included in the present study, the difference with normally developing children was liable to increase in motor function.

Meanwhile, the difference in the difficulty level of functional skills was small in terms of social function, suggesting that there is no major difference between normally developing children and children with cerebral palsy regarding the order of mastering social function set in the PEDI.

The self-care domain presented larger differences compared to social function, specifically in the items "Use of Drinking Containers: Holds bottle or spout cup," "Use of utensils: Finger feeds," and "Shoes/ Socks: Removes socks and unfastens shoes." This presumably implies that movements using fingers such as holding a feeding bottle or finger feeding, which are relatively easy and mastered at an early stage in normally developing children, constitute difficult tasks for children with cerebral palsy.

The items that yielded higher scores in normally developing children were "Toilet transfers: Sits if supported by equipment or caregiver" for mobility, and "Hair brushing: Manages tangles and parts hair" and "Food textures: Eats ground/lumpy foods" for self-care. In the PEDI original data, the items of toilet transfers in the mobility domain showed a slightly higher difficulty level than the items of indoor/outdoor locomotion [14]. On the other hand, for children with cerebral palsy, the difficulty level of the items included in indoor/outdoor locomotion is high, and hence the item of toilet transfers with assistive equipment or support by caregiver was positioned as an easier movement compared to other items. Additionally, "Hair brushing: Manages tangles and parts hair" in self-care is the item of the highest difficulty level in the original data of the self-care domain in the PEDI [14], which is likely to demonstrate the occurrence of an inversion phenomenon referred to earlier because movements using fingers are of a high difficulty level for children with cerebral palsy. Regarding "Food textures: Eats ground/lumpy foods," it is likely that normally developing children master more self-care items than children with cerebral palsy during the time period when they become able to take food with textures requiring food bolus formation instead of weaning food, which explains the higher scores exhibited by normally developing children than children with cerebral palsy.

Next, we divided the subject children in the present study by the gross motor function level defined in the GMFCS. Children in each level were divided further by age band to evaluate the functional skills of the PEDI. The severity of paralysis in children in GMFCS level I is slight, and hence they were expected to follow approximately the same tendency as normally developing children. In fact, their scores for discrete skills were found to increase with age. In contrast, in children in levels III, IV, and V, who have minor to severe paralysis, their motor function almost reached the plateau in the age band of 4 to <6. However, their scores for self-care and social function were found to increase slightly thereafter. This suggests that self-care and social function skills are likely to improve even after motor function has reached the target level. Therefore, a rehabilitation approach to help encourage such skills is needed [15].

Our study has potential limitations, the first of which is the uneven distribution of the subject age groups. Specifically, the group aged under 2 years was so small that they were excluded from the present study. Additionally, cerebral palsy has different disease types such as spastic, athetoid and mixed, and different topographic distribution of paralysis, i.e. quadriplegia, diplegia, and hemiplegia, which may cause a difference in the difficulty level of functional skills among groups of different disease types and paralysis distribution. However, we did not perform separate Rasch analysis for each group in the present study because the number of samples included in the respective groups would be diminished by such subdivision based on disease type/ paralysis distribution. These limitations are issues that should be examined in the future by increasing the number of samples by using the pediatric rehabilitation database [16,17].

Conclusion

We computed the scaled scores of children with cerebral palsy according to the method used to calculate the original data of scaled scores shown in the PEDI, and compared them with the original data. No major difference was observed in social function between children with cerebral palsy and normally developing children, whereas many items of mobility abilities showed large differences. It is hoped that the difficulty levels of functional skills will be set so that they are adapted to the abilities of children with cerebral palsy and will be utilized for rehabilitation in the future.

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