

Upper Extremity Impairments and Activities in Children with Bilateral Cerebral Palsy

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Abstract

Background: There is a lack of evidence about the upper extremity impairments and function in children with diparetic cerebral palsy.

Objectives: This study was planned to investigate the upper extremity impairments, dexterity, grip strength and function in the daily living activities in children with diparetic cerebral palsy (CP).

Methods: Eighteen children with diparetic CP and 15 typical peers between the ages 5 - 12 years were included in the study. Manual Ability Classification System (MACS) was used for the classification of upper extremity fine motor skills; WeeFIM for activities of daily living; Abilhand-Kids for the manual abilities; and Pediatric Evaluation of Disability Inventory (PEDI) for the disability in the daily living activities respectively. Grip strength was evaluated with Jamar Hand Dynamometer, hand functions were assessed with Nine-hole Peg Test and Jebsen-Taylor test.

Results: Children with diparetic CP were affected in manual abilities and functions, grip strength, activities of daily living, and levels of disability and the results were statistically significant ($P < 0.05$).

Conclusions: As a conclusion, upper extremity impairments, dexterity, grip strength, and functions in the activities of daily living are affected in children with diparetic CP. Physiotherapy interventions for upper extremities and hand should be included as well as the lower extremities in the treatment of the spastic diparetic children.

Keywords: Cerebral Palsy, Upper Extremity, Rehabilitation

1. Background

Cerebral Palsy (CP) is a developmental disorder, characterized by a group of movements and postural impairments due to a lesion occurring in the motor cortex of the brain for any reason in prenatal, natal, or postnatal period and is non-progressive (1). Diplegia is a spastic type of CP in which lower extremities are affected more than the upper extremities. Muscle weakness is significant in trunk, postural and antigravity muscles. In addition, proprioception and tactile sense insufficiencies are also observed (2-4).

In children with diplegia, although lower extremity involvement is observed in varying degrees, data showing how upper extremity and hand functions are affected are insufficient. However, whatever the diagnosis is, upper extremity functions are on top of the factors providing the participation in daily living for these children. In addition to being predominantly among the most significant components affecting the functionality of upper extremity, hands play a key role in carrying out the activities of daily living activities. Disorders of hands and arms may be

affected in children with CP (5-7). While numerous studies focus on lower extremity disorders, walking abnormalities and postural control disorders of the children with CP, when considered from a viewpoint of upper extremity functions, hand dexterity, and according to international classification of function (ICF); it is observed that studies on upper extremity impairments and activities are insufficient. In addition, existing studies showing a correlation between the self-care and manual skills were carried out focusing more on children with unilateral CP (8). On the other hand, since the target group of this study is composed of children with diplegia, it is important to include their typical peers as a control group.

2. Objectives

This study was planned to investigate the impairments, skills and strength of the upper extremity and their effect on the activity level in children with bilateral CP. The results will help to figure out the needs for the rehabilitation of the upper extremity in this population.

3. Methods

A power analysis using the Gpower computer program indicated that a total sample of 11 subjects for study group and 11 subjects for control group would be needed to detect large effects with 94% power using a t test between means with alpha at 0.05. So the study included 18 voluntary children with spastic diplegia, aged between 5 and 12 years with no mental problem according to their health report, and able to cooperate in terms of communication, and 15 typically developing peers with normal development characteristics as the control group with a total of 33 children.

Families included in the study were informed about the method and purpose of the study. The families who accepted to participate in the study were evaluated and signed an informed consent form. Following the evaluation by non-interventional clinical research ethics board of Hacettepe University, our study was approved as confirming to medical ethics (project Ref No. GO15/516, date of evaluation 29.07.2015, decision No. GO 15/516 - 13).

Inclusion criteria for children with CP between the ages 5 - 12 years; classified in levels I, II, III of the Gross Motor Function Classification System (GMFCS); having no visual perceptual problems; able to follow verbal instructions; having noninvasive intervention on hand and upper extremity in the last 6 months. The typical developed group was composed of the children referred from our university school offering mainstream education. Children who had an upper extremity problem that might affect upper extremity functions were excluded.

The demographic information of the children as age, gender, gestational age, type of birth, body mass index (BMI), dominant hand, surgical and Botox A injection history were recorded. The children were asked about the hand they prefer to use for writing and in the activities requiring strength in the daily living activities, and their dominant hands were thus recorded.

Gross motor function was classified using the GMFCS (9), self-initiated hand function was classified with MACS (10), WeeFIM (11) was used to assess the activities of daily living, Turkish version of Abilhand-Kids (12) was used to evaluate manual abilities, and Pediatric Evaluation of Disability Inventory (PEDI) (13) was used to assess the activities of daily living. The grip strength was evaluated with Jamar Hand Dynamometer (Lafayette Instrument, USA) (14) hand functions were assessed by Nine-hole Peg Test (15) and Jebsen-Taylor Test (16).

1. Gross Motor Function Classification System (GMFCS): Children with CP below the age of 12 years were divided into five levels, based on self-initiated movements, sitting and walking (9).

2. Manual Abilities Classification System (MACS): Manual ability classification system was developed in order to classify the abilities to grip objects by hand, during the activities of daily living in children with CP aged 4 - 18 years. MACS classifies in 5 levels. While Level I defines the child with CP having minor limitations when compared with normally developing child, Level V includes the children that are unable to grip objects and children having limited abilities at the highest degree to carry out even simple activities (10).

3. Functional Independence Measure for children (WeeFIM): Activities of daily living were evaluated with WeeFIM. It includes a total of 18 items in 6 domains as self-care, sphincter control, transfers, locomotion, and communication, social and cognitive dimensions. 18 points represents to fully dependent where as 126 points represents to fully independent (11).

4. Abilhand-Kids: Abilities of the hand of CP was evaluated by using Abilhand-Kids questionnaire. It consists of 21 daily living activities asked reported by parents. Scores are '0 = Impossible', '1 = Difficult,' and '2 = Easy'. At most a total of 42 points can be obtained. The Turkish version of this system was already carried out (12).

5. Pediatric Evaluation of Disability Inventory (PEDI): Turkish version of Functional Skills dimension of PEDI was used to manifest motor development levels reflecting themselves on functions of children with CP. The child is assigned scores as "0 = Unable" and "1 = Capable". At the end of each dimension, scores of the said section are summed up and functional skills (FS) total score is obtained by adding the scores of all subcategories (13).

6. Nine-Hole Peg Test: Hand function of the children was assessed by Nine-Hole Peg test. Children were asked to take the pegs from a container, one by one, and place them into the holes on the board as quickly as possible. Scores are based on the time taken to complete the test activity, recorded in seconds. This procedure was applied on dominant and non-dominant hand (14).

7. Jebsen-Taylor Hand Function Test: Jebsen-Taylor Hand Function Test consists of a series of sub-tests representing hand functions in daily life and evaluates hand skills. Scores are based on the time taken to complete the test activity (15).

8. Jamar Hand Dynamometer: Jamar Hand Dynamometer was used to evaluate hand strength. All the measurements were done according to American Society of Hand Therapists (ASHT) recommended position. For the test procedure, 3 measurements were taken with one-minute breaks given inbetween each hand grip test, and averages were recorded in kilograms (16).

Outcome measures were evaluated by a 15 year experienced physiotherapist in pediatrics. All the assessment

was done in a clinical setting appropriate for the age of the target population. The assessment procedure was started after a 15 minutes rest of the children.

3.1. Statistical Analysis

Statistical analyses of the study were carried out with “statistical package for social sciences” (SPSS) version 18.0 (SPSS INC., Chicago, IL, USA) software. Age, gestational age, and body mass index were provided by using crosstabs. Categorical variables were noted in frequency and percentage. Conformity of the data to normal distribution was analyzed with visual (histogram and probability graphs) and analytical (Kolmogorov-Smirnov/Shapiro-Wilk tests) methods. Descriptive analyses were presented by using mean and standard deviations for normally distributed variables. WeeFIM, ABILHAND-Kids and PEDI parameters were compared by using student-T test between the groups. Descriptive analyses were presented using means and intervals between quadrants for the non-normally distributed and ordinal variables. Jebesen-Taylor Test, 9-hole PEG Test, dominant and non-dominant side strength results parameters were presented by using Mann-Whitney U Test, since they are non-normally distributed variables. The level of significance was set at $P < 0.05$ (17).

4. Results

There was no difference between the general characteristics of the groups. The demographic characteristics of the cases are given in Table 1. The five of the children with CP were Level I according to gross motor function system, 8 were at Level II, and 5 were at level III. According to MACS, 5 of the children with CP were at Level I, while 13 of them were at Level II.

Average scores of WeeFIM, Abilhand Kids, and PEDI of children with CP were as 104.61, 32.83 and 163.72 respectively; and the average scores of healthy children comprising the control group were 123.53, 41.13 and 193.13 respectively. The control group had statistically significant scores in WeeFIM, Abilhand Kids score, and PEDI score ($P < 0.05$) between the groups.

Based on the grip strength assessment carried out by the hand dynamometer, a statistically significant difference was observed between both dominant and non-dominant upper extremities ($P < 0.05$) (Table 3). The control group had greater scores in all JTHFT dimensions, which were statistically significant and the result is presented in Table 4.

5. Discussion

This is the first study on evaluating the hand and upper extremity function, dexterity, strength and activity in spastic diplegia. Our primary results indicate that manual skills, functions, and grip strength, along with the activities of daily living and functional skills are affected in children with diplegia compared to their healthy peers. It was concluded that, while implementing a physiotherapy rehabilitation program, it should be emphasized that upper extremity function should be taken into account as well as the lower extremities in children with spastic diplegia.

Although the disorders that develop in CP, occurs depending on the size and region of the insult in the brain, the effect definitely appears on a certain region in the body, and the rest of the body is also believed to be affected as well. But there is less clear data about the non-involved side and/or the part of the body, which was the main objective of this study.

According to the demographic characteristics, the only difference was the gestational age between the groups, which was an expected result. One of the most common reasons of CP is the natal factors. Although there are some studies showing no association between the gestational age and CP, the number of children under the term age is higher than the term age in this population.

In children with CP, certain restrictions are observed in upper extremity functions and the skills in the activities of daily living depending on motor activation (18, 19). In a study by Law et al., it was suggested that manual functions were affected more in especially tetraparetic and diparetic CP cases compared to triparetic cases. Also, in the same study, the recorded WeeFIM scores of triparetic children with single upper extremity involvement were observed as higher compared to hemiparetic and diparetic children, and when compared with their peers, they showed similar performance (18). However, this result that manifests contradiction with the current study also puts forth that manual dexterity and functions may be affected from other variables such as trunk control and spasticity which were not considered in this study (20). Other than this, the reason for insufficiency in the skills in daily living compared to their peers might be linked to the use of their hands more to compensate lower extremities. In addition, it was believed that, the use of assisting devices for mobilization purposes would limit the use of their hands in such skills as feeding, dressing and eating. Similarly, when checked the functional skills section of PEDI, the fact that children with CP have insufficiencies compared to their peers put forth that, they were dependent in their daily living activities. Although children included in the study were independent on GMFCS levels of I, II, and III, limitations were

Table 1. The Demographic Characteristics of the Children with Diparetic Cerebral Palsy and the Control Group

	CP (n = 18)	Control (n = 15)	P
Age (years)	8 (6.75/9.25)	9 (7/10)	0.464
Gender (female/male)	9/9	6/9	0.729
Delivery (normal/caesarian section)	6/12	7/8	0.493
Dominant hand (right/left)	12/6	12/3	0.458
Gestational age (weeks)	30 (27.75/38)	40 (40/40)	< 0.001
Body mass index	14.87 (13.64/17.20)	16.06 (14.63/18.35)	0.219

Table 2. The Functional Test Results of the Children with Diparetic Cerebral Palsy and the Control Group

	CP, Mean \pm SD (n = 18)	Control, Mean \pm SD (n = 15)	t	P
WeeFIM (total)	104.61 \pm 19.99	123.53 \pm 5.79	-3.828	< 0.001
ABILHAND-Kids	32.83 \pm 7.61	41.13 \pm 1.73	-4.491	< 0.001
PEDI	163.72 \pm 26.0	193.13 \pm 4.69	-4.708	< 0.001

Abbreviations: SD, Standard Deviation; CP, Cerebral Palsy; PEDI, Pediatric Evaluation of Disability Inventory; ABILHAND- Kids, Manual Ability for Children with Upper Limb Impairments; WeeFIM, Functional Independence Measure for Children

Table 3. The Comparison of the Dominant and Non-Dominant Grip Strength of the Groups

	CP Median (IQR) (Score)	Control Median (IQR) (Score)	Z	P
Dominant side (kg)	3.75 (1.88/5.25)	8.00 (4/12)	-2.374	0.018
Non-Dominant side (kg)	3.00 (1.75/5.38)	7.00 (4/14)	-2.233	0.026

Abbreviation: IQR, Interquartile Range

observed in their independency in goal-oriented skills in their daily living activities.

According to manual skills and grip strength of children, there was difference between the groups, and dominant and non-dominant hands. As also shown in other studies, activities of daily living needs the coordination of both hands (21). For instance, if we want to pour water into a glass, one hand holds the glass (stabilization) while the other pours the water (movement). Therefore, manual skills as grip strength of both hands should not be expected to be the same. While such a difference can be linked to neuromusculoskeletal problems, it may also develop depending on the attitudes within the family. Overprotective attitudes of families towards their children with CP and environmental conditions may also be noted among the problems affecting the level of independence of these children (22, 23). Thus, when rehabilitation programs are prepared, it would especially become important to modify the environmental conditions according to their needs (24). In addition, in a study showing that hand grip strength and manual abilities are indirectly related with

manual skills, it was concluded that activities requiring skills are not quite related with abilities used in the daily life (3). Therefore, literature showed that, it would be important to have such functional therapies as constraint-induced movement therapy and bimanual therapy for increasing the skills rather than increasing the manual abilities and strength in children with CP (25). While, in a study by Sakzewski et al, it was reported that non-dominant grip strength, more than 1 kg, would be sufficient in bimanual activities (26), Arnould et al. in their study conducted on 136 children with CP found that grip strength in 13% of non-dominant hand was below 1 kg. While the children included in both studies had different types of CP, grip strength of both hands was found to be similar since children included in this study had spastic diplegia. Although in a study done by Arnould et al. more than half of the children with diplegia showed bilateral impairment in gross manual dexterity and grip strength (27).

There are lack of skills and functions of the hand in different types of CP (7). It is also known that upper extremities and hand functions are affected in different types

Table 4. Comparison of the Results of Jebson Taylor Test in Children with Diparetic Cerebral Palsy and the Control Group

	CP Median (IQR) (Score)	Control Median (IQR) (Score)	Z	P
Turning over cards (sn)				
Dominant	8.60 (5.25/10.57)	5.25 (3.39/8.16)	-2.314	0.021
Non-dominant	7.41 (5.29/10.49)	5.30 (3.93/6.20)	-2.802	0.005
Picking up empty and large canes				
Dominant	4.32 (3.38/7.79)	2.81 (2.18/3.17)	-4.032	< 0.001
Non-dominant	5.48 (3.91/8.07)	2.77 (2.12/3.74)	-3.688	< 0.001
Picking up small objects (sn)				
Dominant	8.64 (7.63/13.11)	5.73 (5.16/6.34)	-4.158	< 0.001
Non-dominant	10.97 (7.49/18.56)	5.68 (5.09/6.70)	-4.122	< 0.001
Simulated feeding (sn)				
Dominant	19.78 (13.30/36.94)	10.26 (9.56/11.97)	-3.724	< 0.001
Non-dominant	19.15 (22.40/50.66)	15.64 (10.92/19.43)	-4.014	< 0.001
Total score	106.04 (70.18/146.15)	55.69 (46.22/60.78)	-4.230	< 0.001

Table 5. Comparison of the Results of the 9 Hole Peg Test in Children with Diparetic Cerebral Palsy and the Control Group

	CP Median (IQR) (Score)	Control Median (IQR) (Score)	z	P
Placing (sn)				
Dominant	21.99 (16.17/41.28)	13.17 (10.78/14.90)	-3.977	< 0.001
Non-dominant	26.42 (21.52/47.86)	14.58 (12.02/15.90)	-4.519	< 0.001
Pick up (sn)				
Dominant	11.70 (9.51/19.11)	6.54 (4.95/8.02)	-4.122	< 0.001
Non-dominant	15.26 (9.72/21.18)	6.97 (4.78/8.30)	-4.483	< 0.001
Total Score	84.48 (59.15/135.72)	40.99 (32.83/46.20)	-4.483	< 0.001

Abbreviation: IQR, Interquartile Range

of CP (3). The four extremities are affected in diparetic CP, in which the lower extremities are more involved (28). In another study, fine motor skills of cases with diparetic CP were shown as not different from those of their peers (29). However, in this study, it was observed that children with diparetic CP were inadequate in their fine motor skills compared to the healthy peers. When checked the definition of CP, it is known that corticospinal pathways are affected at the early stages depending on the insult in the brain (3). Therefore both, susceptibility of these pathways and the over protective attitudes of the family members on these children for meeting their needs, restricts the use of the hand in children with CP. In addition, it is common that individuals with CP use upper extremities and hands more intensively in balance, righthining, and protective reactions. So this may be the reason for not using their hands in the daily activities. Insufficiencies, especially in the fine

motor skills, negatively affect the level of independence in daily life. It should be also considered that, if a child has some limitation in the daily living activities, there will also be some constraints at their social integration and participation.

Evaluation of hand functions in cases with different types of CP and comparison with each other would allow a more clear understanding of this issue. In addition, increasing the number of cases in the study and the presence of a control group with an intervention program would put forth the benefits of physiotherapy program.

Consequently, it is concluded that, the hand function, dexterity and skills of children with CP are affected, and correspondingly certain constraints are observed in their daily life. Beginning from the early years of life, it is necessary to focus on functional approaches oriented towards activities of daily living to improve upper extremity and

manual skills, in addition to the interventions oriented towards the disorder within the scope of ICF; such as muscle strength, spasticity, and range of motion, in physiotherapy and rehabilitation programs for such children. In addition to the physiotherapy rehabilitation programs, it would be also quite important to benefit from occupational therapy programs helping to overcome their limitations for participation in daily life and decreasing their level of disability.

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