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Motor Performance and Activities of Daily Living in Children with Neurodevelopmental Disorders

Melek Volkan-Yazici [1,*], Bulent Elbasan [2] and Gokhan Yazici [2]

[1]Defne Duru Special Education and Rehabilitation Center, Ankara, Turkey
[2]Department of Physical Therapy and Rehabilitation, Faculty of Health Sciences, Gazi University, Ankara, Turkey

[*]*Corresponding author*: PT, MSc, Defne Duru Special Education and Rehabilitation Center, Oguzlar Sokak No. 45, Yenicag Mahallesi, Yenimahalle Ankara, Turkey. Tel: +90-5424433822, Email: melek_volkan89@hotmail.com

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Abstract

Background: Neurodevelopmental disorders (NDDs) are developmental deficiencies that arise due to the damage of the central nervous system in the prenatal, natal, or postnatal period.
Objectives: The aim of this study was to evaluate the motor performance and activities of daily living (ADL) and examine their relationship in children with NDDs who do not have physical disabilities.
Methods: A total of 107 children who were diagnosed with NDDs, without physical disabilities, and 36 healthy peers between the ages of 4.5 years to 14.5 were included in this study. The subjects' fine and gross motor skills were assessed with Bruininks-Oseretsky test of Motor Performance and ADL with WeeFIM (Functional Independence Measure).
Results: Motor performance and ADL were found to be affected in children with NDDs compared to their healthy peers even though they did not have a physical disability. Moderate or low correlations were found amongst 12 of 14 sub-tests of motor performance assessing various activities such as running, balance, coordination, and dexterity, as well as all parameters of WeeFIM in children with NDDs. Children with NDDs with better motor performance had less problems in ADL, were more independent, and had better social cognition and communication skills.
Conclusions: Impairments found in motor performance and ADL show that even though children with NDDs, without physical disabilities, seem to be physically unaffected, it can be clearly seen that these children may have problems in coordination, motor control, and balance affecting their daily lives. Consequently, by improving motor performance, independence in ADL may be improved. In the light of these assessments, subjects with NDD's must be included in physiotherapy and rehabilitation and occupational therapy programs in order to address the problems in motor performance and insufficiencies in ADL.

Keywords: Neurodevelopmental Disorders, Motor Disorders, Activities of Daily Living, Perceptual Motor Performance

1. Background

Neurodevelopmental disorders (NDDs) are developmental deficiencies that arise due to the damage of the central nervous system in the prenatal, natal, or postnatal period (1). In children with NDDs, as a result of the central nervous system damage, problems such as delayed social development, communication disorders, learning difficulties, memory problems, repetitive behavior, and sensitivity to sound are frequently encountered (1, 2).

Deficiencies in both gross and fine motor skills can be seen in different stages of development. During infancy, problems are observed in skills such as sitting, crawling, walking, eating, and drinking; whilst different motor problems such as balance disorders and frequent falls, problems in sporting activities such as playing ball and cycling, clumsiness, poor handwriting, and failure in lessons are problems, which are encountered in school-age children (3-7). The deficiencies caused by these problems lead to poor academic performance in school, which causes a drop in the child's self-esteem and brings about restriction of independence in activities of daily living (ADL) (8, 9).

When literature is examined, it can be seen that NDD is an umbrella term used to refer to many different conditions (10). There are a vast number of children with NDD in the society, however, the numbers of studies conducted regarding rehabilitation approaches in this field are insufficient. In existing studies (11) the children were found to be deficient in terms of motor performance; however, what proportion of these deficiencies are reflected in daily living activities, which parameters are affected, and in what rate the childs' independence is affected is not known. Considering children with NDDs without physical disabilities, we

have hypothesized that even though these children do not have physical disabilities, their motor performance and activities of daily living may be affected due to coordination, motor control, and balance problems.

2. Objectives

The aim of this study was to evaluate children with NDD without physical deficiencies in terms of motor performance and activities of daily living and examine the relationship between these two parameters. Thus, by identifying the deficits, we aim to show guidance in the planning of the physiotherapy and rehabilitation programs to eliminate existing problems.

3. Methods

3.1. Participants

A total of 107 children were diagnosed with NDD without any physical disability (40 female, 67 male) with only 36 healthy subjects (20 female, 16 male), totally 143 children between the ages of 4.5 years to 14.5 years participated in the study. The diagnoses of children with NDD were as follows; 20 children with autism, 59 children with intellectual disability (borderline IQ), 22 children with specific learning difficulties, and 6 children with Down syndrome. All subjects were diagnosed by doctors who specialized in pediatrics, paediatric neurology, and paediatric psychiatry. The study was approved by Gazi University Clinical Research Ethics Board (approval number: 537). Children who could cooperate, who agreed to participate in the study, who were between 4.5 and 14.5 years of age, and had a diagnosis of either intellectual disability with borderline intelligence, autistic without a communication problem, had Down syndrome or specific learning difficulties, and healthy subjects in the same age range were included in the study. Since the aim of this study was to evaluate children with NDDs without physical disabilities, children with musculoskeletal problems, physical disabilities, or any type of disorder, which could affect normal movement and motor performance, were not included in the study for obtaining a clear result. Furthermore; those with visual, hearing, or perception problems, which could affect the results of the study, as well as those with systemic disease, and those who refused to participate in the study were excluded.

3.2. Procedure

All the children in the study as well as their parents/caregivers were informed about the study and 'consent forms' were signed stating that they were willing to participate in the study. The study protocol is consistent with the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a prior approval by the institution's human research committee. After a power analysis was conducted, a total of 107 out of 110, with NDD, who matched the inclusion criteria and agreed to participate, were included in the study. The healthy subjects who participated in the study were chosen to be age and sex matched. They were mostly going to state schools and assessments were performed in schools in the similar region. The childrens' medical histories were taken in consultation with their families, their medical files were reviewed and demographic information was recorded. All assessments were performed by a qualified physiotherapist with seven years of experience in the field of paediatric rehabilitation in a quiet and suitable enviroment. The assessments were completed in an hour, which gave the children enough time to rest when they needed to.

3.3. Measures

To assess the children's motor performance, 'Bruininks-Oseretsky test of Motor Proficiency-Short Form (BOTMP-SF)' (12) was used, which is a valid and reliable assessment of motor performance (13). This battery consists of eight subtests; running speed and agility, balance, bilateral coordination, strength, upper-limb coordination, response speed, visual motor control, upper limb speed, and dexterity. The eight subtests consist of 14 items in which the assessments are performed. Each of these items has a score equivalent to the subjects' performance and the scores recorded during the test are the subjects' raw scores. The calculation of raw scores to point scores is unique for each item. For example, in the first subtest item, a lower raw score gives a higher point score whilst in the second subtest items, a higher raw score gives a higher point score. In the subtests with more than one trial the best performance is taken notice of. After the test is completed these raw scores are converted to point scores.

Functional Independence Measure for Children (WeeFIM) was used to evaluate the children's daily life activities and functional independence (14). The WeeFIM evaluates the need for assistance and the severity of disability in children between the ages of 6 months and 18 years. WeeFIM is a reliable and objective instrument, which has shown validity in children with NDDs (15). In order to make a more detailed assessment, the WeeFIM was administered in the six parameter form. WeeFIM contains a total of 18 measurement items that are divided into six domains: Self-care (six items), sphincter control (two items), transfers (three items), locomotion (two items), communication (two items), and social cognition (three

items). The self-care domain consists of eating, grooming, bathing, dressing upper body, dressing lower body, and toileting. The sphincter control domain consists of bladder management and bowel management. The transfers subscale consists of transfer to chair or wheelchair, transfer to toilet, and transfer to tub or shower. The locomotion domain consists of walking, using a wheelchair or crawling, and using stairs. The communication domain consists of comprehension and expression. The social cognition domain consists of social interaction, problem solving, and memory. These domains are assessed via interviewing or observing a childs' ability to perform a certain task. Scoring ranges from one to seven and is done according to the amount of assistance or supervision he/she has received and whether he/she has completed the task in the necessary time. When the given task is completed with full assistance, one point is given. When the task is completed totally independently, and in the appropriate time, seven points are given.

3.4. Data Analysis

Statistical analyses were performed using the SPSS software version 21. All variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogoror-Simirnov/Shapiro-Wilk's test) to determine whether or not they are normally distributed. Descriptive analysis were presented using mean and standard deviation for normally distributed variables and were presented using median and interquartile range (IQR) for the non-normally distributed and ordinal variables. The Mann-Whitney U test was used to compare between the groups, the data of patients with NDD and healthy controls. The correlation between the WeeFIM and BOTMP-SF results was compared with the Pearson test. A 5% type-1 error level was used to infer statistical significance.

4. Results

The diagnosis and mean age of the subjects are given in Table 1. When the BOTMP-SF results of the children with NDD's and the control group were compared, statistically significant differences were found in the subtests; 'running speed and agility' ($P < 0.001$), 'standing on one leg on balance beam' ($P < 0.001$), 'bilateral coordination' ($P = 0.026$), 'sorting cards' ($P = 0.002$), and 'response speed' ($P = 0.002$); no statistically significant difference was found in the other subtests ($P > 0.05$), (Table 2). The comparison of the subjects' BOTMP-SF results is given in Table 2.

WeeFIM results of the children with NDD's and the control group were compared, statistically significant differences were found in the 'self-care' ($P < 0.001$) and 'social cognition' ($P < 0.001$) parameters whereas no statistically significant differences were found in the other parameters ($P > 0.05$), (Table 3). The comparison of the WeeFIM results is given in Table 3.

Table 1. Diagnosis and Mean Age of the Subjects

Diagnosis	Mean Age ± SD	Total Subjects
SLD	9.59 ± 1.91	22
ID	10.14 ± 2.33	59
Autism	9.85 ± 2.03	20
DS	10.00 ± 3.79	6
Control	8.72 ± 1.98	36
Total	9.65 ± 2.27	143

Abbreviations: DS, Down syndrome; ID, intellectual disability; SLD, specific learning disability.

The relationship between the BOTMP-SF and WeeFIM in subjects with NDD's is shown in Table 4. When the BOTMP-SF subtests and WeeFIM subtests were analysed in subjects with NDD, a positive correlation was found amongst all of the subtests except 'bilateral coordination' subtest of the BOTMP-SF ($P < 0.05$) (Table 4). In subjects with NDD, a positive correlation was found amongst the WeeFIM subtest; 'sphincter control' and the BOTMP-SF subtests with the exceptions of 'bilateral coordination' and 'running speed and agility' ($P < 0.05$) (Table 4). In subjects with NDD, a positive correlation was found amongst all of the BOTMP-SF subtests and all of the 'communication' and 'social cognition' subtests of the WeeFIM ($P < 0.05$) (Table 4).

5. Discussion

This study showed that children with NDD, without physical disabilities, experience more difficulties in activities that require speed, balance, and coordination and are more dependent in ADL when compared to their healthy peers. Children with NDD's are more challenged in motor skills even though they do not have physical disabilities when compared to their healthy peers; this leads to deficiencies in ADL due to the fact that both fine and gross motor skills have an impact on ADL.

5.1. The Comparison of Motor Performance in Children with NDD's and Healthy Subjects

Sandler et al. used BOTMP-SF in the assessment of 20 children whose ages were 5 - 15, with idiopathic megalocephaly and a control group. They reported that the intervention group was found to be incompetent when compared to the control group in the subtests; bilateral coordination, upper limb speed and dexterity, running speed and

Table 2. The Subjects' Bruininks-Oseretsky Motor Performance Test Results[a]

	NDD Median (IQR) (Score)	Control Median (IQR) (Score)	Z	P Value
Running speed and agility	2 (0/5)	6.50 (0/8.75)	-3.941	< 0.001
Standing on one leg on balance beam	3 (2/6)	2 (1/2.75)	-3.783	< 0.001
Walking forward heel-to-toe on balance beam	2 (1/4)	2 (1/2)	-1.328	0.184
Bilateral coordination	0 (0/1)	0 (0/1)	-2.228	0.026
Jumping up and clapping hands	1 (0/2)	1 (0/1.75)	-1.630	0.103
Standing broad jump	4 (2/5)	4 (4/5.75)	-1.657	0.098
Catching ball with both hands	2 (2/3)	3 (1/3)	-0.343	0.732
Throwing ball with preferred hand	2 (1/2)	2 (1/2)	-1.019	0.308
Sorting cards	3 (1/4)	4 (3/5)	-3.077	0.002
Response speed	4 (2/7)	8 (5/10)	-3.167	0.002
Copying circle	2 (1/2)	2 (2/2)	-1.187	0.235
Copying overlapping pencils	0 (0/1)	1 (0/2)	-1.394	0.163
Drawing a line through a straight path	4 (3/4)	4 (3.25/4)	-0.818	0.413
Making dots in circles	3 (2/4)	3 (2/5)	-1.304	0.192

Abbreviation: IQR, inter quartile range.
[a]Mann Whitney U test, P < 0.05.

Table 3. The Comparison of the WeeFIM Results[a]

	NDD Median (IQR) (Score)	Control Median (IQR) (Score)	Z	P Value
Self-care	53 (48/56)	56 (56/56)	-6.700	< 0.001
Sphincter control	14(14/14)	14 (14/14)	-1.446	0.148
Mobility/transfers	35 (35/35)	35 (35/35)	0.000	1.000
Locomotion	28 (28/28)	28 (28/28)	0.000	1.000
Communication	14 (9/14)	13 (13/14)	-1.325	0.185
Social cognition	17 (13/21)	20 (19/21)	-4.231	< 0.001

Abbreviation: IQR, inter quartile range.
[a]Mann Whitney U test, P < 0.05.

agility, response speed and visual motor control (16). Our findings comply with this study, our intervention group was also not as successful as the control group in the subtests; running speed and agility, response speed and bilateral coordination. In 3 separate studies, Tseng et al. (17), Bumin and Günal (18), and Wang et al. (19) assessed the motor performance of children with ADHD, autism, and Down syndrome, respectively, and compared the results with healthy peers. As a result, the children with NDD's were found to have performance deficits in both fine and gross motor activities. The fact that our findings are similar to these studies reveals that even if the problematic subtests show variety, eventually, when compared with healthy subjects, children with NDD's show specific motor performance problems.

Elbasan et al. (20) evaluated 35 children with DCD and 35 healthy subjects using BOTMP-SF. Parallel to our findings, they showed that in the subtests running speed and agility, balance, bilateral coordination response speed, and sorting cards, the children with DCD were not as successful as their healthy peers. Unlike our study, their findings show that the control group had better results in the subtests; jumping up and clapping hands, standing broad jump, drawing a line through a straight path, copying a circle, and making dots whereas we have found no difference amongst the performance of the groups in these subtests. In our opinion, the differences between the study that Elbasan et al. concluded and our study arise from the many different diagnoses of children with NDD's that we included in our study and the fact that these children vary from each other leading to differences in results (20).

Table 4. The Correlation Analysis of the Bruininks-Oseretsky Test of Motor Performance and WeeFIM in Subjects with NDD[a]

	Self-Care			Sphincter Control			Communication			Social Cognition		
	r	P Value		r	P Value		r	P Value		r	P Value	
Running speed and agility	0.474	0.000	→	0.185	0.057		0.510	0.000	→	0.518	< 0.001	→
Standing on one leg	0.508	0.000	→	0.310	0.001	→	0.511	0.000	→	0.514	< 0.001	→
Walking forward heel-to-toe	0.439	0.000	→	0.311	0.001	→	0.583	0.000	→	0.571	< 0.001	→
Bilateral coordination	0.181	0.064		0.149	0.127	↓	0.316	0.001	→	0.254	0.008	↓
Jumping up and clapping hands	0.374	0.000	→	0.220	0.023	→	0.521	0.000	→	0.505	< 0.001	→
Standing broad jump	0.566	0.000	→	0.363	0.000	→	0.470	0.000	→	0.506	< 0.001	→
Catching ball with both hands	0.487	0.000	→	0.390	0.000	→	0.354	0.000	→	0.366	< 0.001	→
Throwing ball -preferred hand	0.440	0.000	→	0.305	0.001	→	0.328	0.001	→	0.320	0.001	→
Sorting cards	0.485	0.000	→	0.321	0.001	→	0.248	0.010	↓	0.266	0.006	↓
Response speed	0.505	0.000	→	0.361	0.000	→	0.341	0.000	→	0.358	< 0.001	→
Copying circle	0.507	0.000	→	0.411	0.000	→	0.326	0.001	→	0.382	< 0.001	→
Copying overlapping pencils	0.324	0.001	→	0.214	0.027	↓	0.217	0.025	↓	0.275	0.004	↓
Drawing line through straight path	0.516	0.000	→	0.335	0.000	→	0.545	0.000	→	0.488	< 0.001	→
Making dots in circles	0.256	0.008	↓	0.262	0.006	↓	0.302	0.002	→	0.283	0.003	↓

[a] Pearson Correlation Analysis, P < 0.05. "→ Moderate correlation" "↓ low correlation".

5.2. The Comparison of WeeFIM Results in Children with NDD's and Healthy Subjects

Elbasan et al. investigated the ADL of 35 children with DCD and 35 healthy subjects, and stated that the healthy children were more independent in self-care tasks when compared to the children with DCD. They also put forth that the comprehension and expression skills of the children with DCD were not as established as their healthy peers (20). These results are parallel to our findings and show that children with NDD's are more dependent in the self-care, expression, and comprehension parameters of the WeeFIM when compared to their healthy peers.

In the study performed by Jasmin et al. the ADL and motor performance of 35 three and four year old children with autism were investigated. Jasmin et al. concluded that children with autism had deficiencies both in gross motor and fine motor activities. The autistic children were found to be dependent in all of the parameters of the WeeFIM with the self-care parameter being the most problematic (21). These results show resemblance with our study, however, the fact that the subjects in this study are younger than our subjects could be the reason of dependence in all of the ADL parameters.

Bumin and Günal investigated the ADL of children with autism and reported that when compared to their healthy peers, children with autism showed more dependence in the self-care, mobility, and cognition parameters (18). These findings show great similarity to our results. Deficiencies in coordination, balance, and hand skills may eventually cause restrictions in ADL, which may lead to communication problems with their environment causing additional problems in participating in ADL. Relatively, children with NDD's without physical disabilities are neither dependent nor active in everyday life when compared to their healthy peers. We have observed that children who had better physical and mental health and those who were more confident were more independent in ADL.

5.3. The Relationship Between WeeFIM and Motor Performance in Children with NDD's

Summers et al. reported that motor problems encountered in children with DCD affected ADL, especially in the self-care parameters, and parental support was essential (22). Rodger et al. stated that the decrease in motor performance had a negative influence on ADL (23). According to Jasmin et al. when the correlation between motor performance and ADL was examined a weak correlation was found amongst fine motor skills and the self-care parameter of ADL (21). Volman et al. stated that a correlation was found amongst the self-care parameter of ADL and upper extremity dexterity and coordination in children with Down syndrome (24).

In our study, we found that children who had low scores on the BOTMP-SF subtests showed more dependence on the WeeFIM parameters. There are studies that have concluded that disabilities cause negative effects on activity and social participation in life and ADL in children with NDDs (25, 26). In addition, it has been stated that participation in physical activity could have substantial health benefits by increasing mobility and social participation and may lead to a reduction in the need for personal assistance in performing ADL in youth with disabilities (27).

5.4. Conclusion

As a result, in children with NDD's who don't have physical disabilities, motor performance has been found to be restricted; these restrictions have been found to lead to problems in ADL. We have concluded that assessment of motor performance and physical abilities in children with NDD's is essential. In the light of these assessments, children with NDD's must be included in physiotherapy, rehabilitation, and occupational therapy programs in order to address the problems in motor performance and insufficiencies in ADL. It is essential to provide the appropriate support and education to the individuals in their rehabilitation programs and increase their participation in physical activities. We believe that motor performance may have a direct effect on social participation. Thus, improvements in motor performance could lead to positive effects in social participation and hence, quality of life. Many different therapy methods including strengthening exercises, coordination exercises, fine motor exercises and balance exercises should be included in the treatment program, which must be tailored according to the deficits and insufficiencies the subject has. As for the incompetence in ADL, different occupational therapy methods, which will especially address the self-care activities should be used in a clinical environment designed to serve as the childs' home school or play environment to fulfil the needs and deficiencies he/she has. Children with NDD's should participate in activities both inside and outside their domestic environment. Physiotherapists and other rehabilitation personnel must help the families of children with NDD's in order to increase independence in both motor performance and in ADL; thus leading to an increase in social participation and quality of life.

The limitation of this study is that the number of children with NDD's are not equal in each sub-group (autism, Down syndrome, intellectual disability, and specific learning disability). In further conducted studies it is suggested to include a wider range of NDD sub-groups and have an equal number of subjects in each group.

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Footnotes

Authors' Contribution: Melek Volkan-Yazici: study concept and design, acquisition of data, analysis and interpretation of data and drafting of the manuscript; Bulent Elbasan: critical revision of the manuscript for important intellectual content and study supervision; Gokhan Yazici: statistical analysis, administrative, technical, and material support .

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