Determine the Relationship Between Abdominal Muscle Strength, Trunk Control and Urinary Incontinence in Children with Diplegic Cerebral Palsy

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Purpose: The aim of this study is to determine the relationship between abdominal muscle strength, trunk control and urinary incontinence in children with diplegic cerebral palsy.

Materials and methods: The current study had a cross-sectional design using analytical study as well as an observational research model. Fifty children between the ages of 5 and 18 years who were diagnosed with diplegic clinical type of cerebral palsy were included in this study using improbable-random sampling method. After patients' demographic information were obtained, Dysfunctional Voiding and Incontinence Symptoms Score Questionnaire (DVISS), Dysfunctional Voiding Symptom Score (DVSS), the manual muscle test of the muscles, Trunk Control Test (TCT) and Trunk Control Measurement Scale (TCMS) were completed in order to evaluate trunk control. Also, Gross Motor Function Classification System (GMFCS) was performed in order to define the functional level.

Results: In this study, a highly correlated negative relationship was found between DVISS and DVSS scores with muscle abdominal strength, TCMS and TCT. In addition, a highly correlated positive relationship was found between both GMFCS and DVISS and GMFCS and DVSS.

Conclusion: This is the first study that describes the effect of trunk control and muscle strength on urinary incontinence in children with diplegic cerebral palsy. This study showed that there is a correlation between trunk control, muscle strength and urinary incontinence.

Keywords: cerebral palsy; core stabilization; muscle strength; pelvic floor; trunk control; urinary incontinence.

INTRODUCTION

Voiding dysfunction is a very common problem during childhood. It is seen in almost 1 in every 5 children who visit pediatric urology clinics. Urinary incontinence in children occurs because of either neurological problems or functional causes(1). More than half of the children with cerebral palsy visit hospitals with a voiding complaint. In order to understand the source of this issue and determine the effect of this dysfunction on voiding, a thorough clinical and functional examination needs to be done, in addition to a proper urinary system examination(2).

Trunk control insufficiency is the main cause of functional dysfunctions in cerebral palsy. The pelvic floor muscles are part of trunk stability mechanism, and this unit has passive, neural and active subsystem controls(3). The active sub-systems play an important role in protecting against urinary incontinence. They are not only necessary for urinary function, but these mechanisms also support organs against gravity in case of slow, rapid or unpredictable repletion. They are also necessary in order to increase intra-abdominal pressure(4,5). Even though main functions are independent from other muscles in this system, other trunk muscles also contribute to the function of the PFM complex(6). For example, a study which was conducted to understand the synergy between abdominal muscles and PFM, including all the muscle groups in the abdominal capsule, indicated that lumbar vertebrates, deep layers of the multifidus muscle, diaphragm, transversus abdominus and pelvic floor muscles are found in this capsule (core) structure(7). In the light of current studies, the PFM is thought to have two main functions of contributing to continence and elimination of both bladder and bowel and providing trunk stability(7) It has been reported that the pelvic floor muscle can be strengthened with the training of transversus abdominus muscle. This report is based on the belief that the pelvic floor muscles are a part of the abdominal capsule which surrounds abdominal and pelvic organs(6).

The aim of this study is to determine the relationship between abdominal muscle strength, trunk control and urinary incontinence in children with diplegic cerebral palsy.

MATERIALS AND METHODS

Participants

This study has a cross-sectional design using an analytical study of the observational research model. The subjects were selected from the children with cerebral palsy

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Table 1. Muscle strength, trunk control and voiding test results of the individuals

n:50		X±SD	Min-max
Muscle Strength	Upper Abdominal	2.50 ± 0.73	1-5
	Lower Abdominal	2.14 ± 0.80	0-4
Trunk Control Measurement Scale (TCMS)	Static sitting	6.78 ± 5.25	0-20
	Dynamic sitting	9.36 ± 7.82	0-28
	Dynamic lying	4.00 ± 2.73	0-10
	Total score	19.54 ± 14.40	0-56
Trunk Control Test (TCT)		11.16 ± 5.36	0-18
Dysfunctional Voiding and Incontinence Symptoms Score (DVISS) Questionnaire		10.26 ± 8.09	0-29
Dysfunctional Voiding Symptom Score (DVSS)		8.86 ± 5.15	1-20

who had been treated in three Special Education and Rehabilitation Centers in Malatya city center. These three centers were also selected by lot from among the nine Special Education and Rehabilitation Centers in Malatya city center. The patients who agreed to participate, and to provide the participation criteria were selected using the improbable random sampling method. In the power analysis, the sampling size was calculated as at least 43 patients in the 5% level of insignificance and 95% confidence interval, assuming that the incidence of diplegic cerebral palsy in the population is 3/1000. In order to conduct this study, the required permission and consent was obtained from the Scientific Research and Publication Ethics Committee of Inonu University Health Sciences (2015/5-5). An informative consent form was provided to parents of each patient before the study . The study protocol was approved based on the ethical standards of the Declaration of Helsinki.

Procedures

Fifty children between the ages of 5 and 18 years who were diagnosed with diplegic clinical type of cerebral palsy were included in this study, using improbable-random sampling method. After the patient demographic information was obtained, the Dysfunctional Voiding and Incontinence Symptoms Score Questionnaire (DVISS), the Dysfunctional Voiding Symptom Score (DVSS), the manual muscle test for the muscles, the Trunk Control Test (TCT) and the Trunk Control Measurement Scale (TCMS) for the evaluation of trunk control were completed. Also, Gross Motor Function Classification System (GMFCS) was performed in order to define the functional level and spasticity was assessed by Modified Ashworth Scale.

DVISS consists of a total of 15 items in which one item evaluates quality of life and 14 items measure whether there is night and day voiding disorder in children if at all, questioning how it affects violence and activities of daily living[8,9]. The results were evaluated using the DVISS mean value in this study; values below 10 were good, values above 10 were considered bad. In addition, the percentage of responses to each item was recorded.

The Dysfunctional Voiding Symptom Score (DVSS) is a test which examines the urinary dysfunction with 10 items by evaluating its sensitivity and specificities [10,11]. The manual muscle test was used to evaluate the upper and lower muscle weakness. The Trunk Control Test (TCT) is a scale which consists of 6 items. The scoring was performed by grading the movements, such as 0: cannot start, 1: can start a movement partially, 2: can perform more than half of the movement, 3: can complete the movement. The total score range was between 0 and 18. The values generally that are below average were accepted as bad, and the values above the average are accepted as good in the interpretation of the test[12,13]. To evaluate the quality of trunk movement, the postur-

Table 2. Percentage of each question and answer of dysfunctional voiding and incontinence symptoms score (DVISS) questionnaire

1	Does your child wet during the day?	No	Sometimes	1–2 times/day	Always
	%	26%	38%	18%	18%
2	How wet is your child during the day?	Damp underwear	Damp pants only	Pants soaking wet	
	%	44%	32%	24%	
3	Does your child wet during the night?	No	1–2 Nights/Week	3–5 Nights/week	6–7 Nights/Week
	%	44%	34%	12%	10%
4	How wet is your child during the night?	Damp underwear	Damp bed sheet only	Bed sheets soaking wet	
	%	42%	38%	20%	
5	How many times does your child void?	1–7/Day	More than7/day		
	%	92%	8%		
6	My child is too quick to finish his/her pee.	No	Yes		
	%	92%	8%		
7	My child strains during voiding.	No	Yes		
	%	92%	8%		
8	My child feels pain during voiding.	No	Yes		
	%	86%	14%		
9	My child voids intermittently.	No	Yes		
	%	94%	6%		
10	My child needs to go back voiding soon after finishes his/her pee.	No	Yes		
	%	94%	6%		
11	My child has a sudden feeling of having to urinate immediately.	No	Yes		
	%	88%	12%		
12	My child holds by crossing his/her legs.	No	Yes		
	%	68%	32%		
13	My child wets on the way to the toilet.	No	Yes		
	%	80%	20%		
14	My child misses his/her bowel movement every day!	No	Yes		
	%	38%	62%		
QUALITY OF LIFE					
If your child experiences symptoms mentioned above, does it affect his/her family, social or school life?		No	Sometimes	Yes affects	Seriously Affects
	%	18%	44%	24%	14%

Table 3. The relationships between muscle strength, trunk control and voiding dysfunction of the individuals

n:50		Muscle Strength		TCMS				TCT
		Upper Abdominal	Lower Abdominal	Static Sitting	Dynamic Sitting	Dynamic Lying	Total score	
DVISS	r	-0.533	-0.573	-.0.711	-0.592	-0.574	-0.636	-0.717
	p	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
DVSS	r	-0.407	-0.461	-0.586	-0.393	-0.415	-0.466	-0.585
	p	0.003*	0.001*	0.000*	0.005*	0.003*	0.001*	0.000*

*$P < 0.01$

al control and the functional strength of the trunk, the Trunk Control Measurement Scale (TCMS) was used. TCMS is formed from two main parts in terms of static sitting balance and dynamic sitting balance. The static sitting balance examines the static trunk control during movements of upper and lower extremity. The dynamic sitting control is classified as selective motor control and dynamic lying. The selective movement control of the dynamic sitting balance is a scale which evaluates the specific movements of the source of the support (trunk) in three dimensions. In the lower parts of the scale, there are 15 items which consist of 5, 7 and 3 different sub-items. The total score of the TCMS ranges from 0 to 58[14,15].

The Gross Motor Function Classification System (GMFCS) is a scale which evaluates the functional levels of individuals. In this scale, evaluation is measured between Level 1 and Level 5. In Level 1, mobilization is provided independently and the mobilization is limited in Level 5[16].

Data Analysis

SPSS version 16 package program was used in the statistical evaluation of this study. The mean ± standard deviation value was used for the definitive results, and variables which have non-normal distribution were assigned by using the median and interquartile range (frequency tables for the ordinal variables). The suitability of the normal distribution was investigated by using visual (histogram and probability graphs) and analytical (Kolmogrow-Smirnov/Shapiro-Wilk) tests. The relationship between DVISS and DVSS values and ordinal GMFCS levels were compared through use of the Kruskal-Wallis test. Pairwise comparisons were done using the Mann-Whitney U test. The correlation coefficient which is defined with the measured variables and statistical significances were calculated using the Pearson test. The correlation coefficients and statistical significance for the relationship between ordinal variables were calculated using the Spearman test. For the statistical significance, a 5% Type-1 error level was used. Results were determined through the use of graphs and tables. Using the power analysis with the NCSS PASS 13 program, the sampling size was determined to have a %5 error level, and at a 95% confidence interval, a sample size of at least 43 had 80% power.

RESULTS

50 children with diplegic cerebral palsy were included in this study. 48% of the participating children[24] were male and 52% of them[26] were female. The average age of the children was 8.90 ± 3.75 years, the average height was 124.75 ± 25.42 cm, and the average body mass was 30.2 ± 14.81 kg. In evaluating the Modified Ashwort Scale, children's gastrocinemius spasticity values were 1.71±1.01, hamstring spasticity value was 1.21 ± 0.82. The manual muscle test values for the abdominal muscles of the children, TCT, TCMS, DVISS and DVSS scores are presented in **Table 1**.

The average of the Dysfunctional Voiding and Incontinence Symptoms Score (DVISS) Questionnaire was found as 10.26 ± 8.09. In the context of the scale, some questions were asked to patients and their relatives. Their responses are given in **Table 2**.

According to correlation analysis of our study, significantly negative correlation was found between DVISS and DVSS scores and abdominal muscle strength, TCMS low parameter and total score, and TCT (**Table 3**).

In addition, significantly positive correlation was found between both GMFCS and DVISS and GMFCS and DVSS (**Table 4**). As GMFCS levels were evaluated according to voiding values, DVISS and DVSS values also increased with the rising GMFCS levels (Table 4). It was found that the difference between paired comparisons sourced from the GMFCS IV level.

DISCUSSION

This is the first study that describes the effect of trunk control and muscle strength on the urinary incontinence in children with cerebral palsy. This study showed that there is a moderate correlation between trunk control,

Table 4. The relationships between voiding dysfunction and scores GMFCS of the individuals and voiding dysfunction value according to level

				N:50	X±SD	Min-max
Dysfunctıonal Voıdıng And Incontınence Symptoms Score (DVISS) Questıonnaıre	r	0.618	GMFCS I	3	0.00 ± 0.000	0-0
	p	0.000*	GMFCS II	18	6.38 ± 4.28	1-13
			GMFCS III	16	10.37 ± 7.06	1-23
			GMFCS IV	13	17.84 ± 8.25	2-29
Dysfunctional Voiding Symptom Score (DVSS)	r	0.663	GMFCS I	3	3.00 ± 1.73	1-4
	p	0.000*	GMFCS II	18	6.16 ± 3.12	1-13
			GMFCS III	16	8.12 ± 3.55	3-17
			GMFCS IV	13	14.84 ± 4.37	5-20

*$P < 0.01$

muscle strength and urinary incontinence.

Dysfunctional urination is an issue which occurs either because of abnormal activity of pelvic floor muscles or insufficient relaxation. It occurs through developing the wrong urination habits during childhood. The pelvic floor muscles are striated muscles which are under voluntary control. These muscles especially play an important role in the development of detrusor instability. In children, the dysfunction of destructor sphincter muscle has been shown as a urinary incontinence issue[17,18].

The neurological mechanisms behind urinary incontinence has not been very well understood, yet. However, recent functional MRI studies indicated that there is a complex neurological mechanism behind this system[19]. The neurological dysfunction in children with cerebral palsy occurs in the early developmental stage of the central nervous system[20]. Several studies showed that there is a strong correlation between IQ and bladder control in children during developmental progression[21,22]. A study which was performed with 346 children with bilateral cerebral palsy showed that Gross Motor Functional Classification Score (GMFCS) and intellectual ability are strongly associated, which is independent from the sex factor[20]. A study which was performed on 105 children with mental retardation indicated that severe motor disability might be the reason which prevents a child with CP to be toilet trained[23]. In our study, a significant relationship was found between GMFCS and incontinence. It was looked at as the relationship between functional level and incontinence, and the children with better functional level had lower incontinence. It may be thought that incontinence decreases with increasing muscle strength, muscle coordination and functionality. As a newborn urinates approximately 20 times in a day with involuntarily muscle contractions, the urine volume increases in infancy with the development of muscle strength and coordination. The frequency of urination starts to decrease between the first and second years of age, and bladder repletion begins. In children aged 2 through 4, the ability to inhibit urination begins with sufficient sphincter control. Therefore, a child should gain a normal urination function after 4 years of age. It has been shown that muscle strength and coordination is necessary for normal urination[24].

The basic reason of the functional disorders in children with cerebral palsy is insufficient trunk control. Trunk control was shown to affect functional mobility and balance in children with CP[13]. In children with cerebral palsy, weak postural control, insufficient postural and balance reactions cause a delay in developing motor control[9,10]. Restriction in balance and preservative reactions can result in restrictions in postural control, and in the performance of voluntarily abilities[11,12]. In one study, the Trunk Control Measurement Scale (TCMS) was used to evaluate the static and dynamic functional ability of individuals. Since TCMS evaluates trunk abilities in a way that reflects real life, it is a clinically important tool[16,19]. Studies showed that trunk control plays an active role[15,20]. Roncesvalles et al. stated that the trunk is a key element in control of the postural stabilization and orientation. The measurements of trunk control and the relationships between trunk control, balance, walking and functional abilities indicate the important role of trunk control in daily activities[25].

In every step of the developmental stages (turning, sitting, standing, etc.), the strength of the abdominal, back and pelvis muscles and the trunk control increased in functional activities[13]. A number of studies in healthy volunteers indicated that pelvic floor co-contraction occurs during varied abdominal muscle contractions [13,18,25,26]. Thus, we believe that an increase in abdominal muscle strength and trunk control may result in an increase in pelvic floor muscle strength, and in continence ability. In our study, there was a high level of negative correlation between abdominal muscle strength and trunk control and urinary incontinence. The study by Reid et al. which was conducted with 27 children with cerebral palsy showed that the most common symptom (74%) was urinary incontinence in daytime. They also reported that there were abnormal urodynamic examination results in 85% of the patients[27]. In our study, we also observed urinary incontinence during daytime in 74% of the patients, which is compatible with the literature.

Several studies noted that various abdominal muscle contractions can occur during a pelvic floor contraction[18,26]. It has been found that co-contraction of the pelvic floor muscles was observed during the R. abdominis muscle contractions in continent women, by using a Bø&Stien concentric needle[17]. In a study that was conducted with six healthy women, Sapsford & Hodges found that pelvic floor muscle surface electromyography increases with transversus abdominus contractions[28]. This result was also supported by another study which was performed with four continent women[17]. Sapsford et al. found that the isometric abdominal contraction which transverses the abdominus and internal oblique contraction, called ‘hollowing,’ increases urethral pressure to the extent that a pelvic floor muscle contraction increases. By taking these results into consideration, Sapsford et al. suggested that training to prevent incontinence should start with the trunk stability-increasing core muscle trainings such as TrA training, rather than pelvic floor muscles[6].

The main limitation of our study was that we have not received clinical symptoms, especially the presence of urinary tract infections. Neither we have evaluated of urodynamic findings and kidney function.

In future studies, the decrease in the rate of inconsistency after strength and trunk control training can be investigated in children with cerebral palsy. In addition, the pelvic floor contraction during the abdominal muscle contraction can be evaluated through the use of an EMG in children with cerebral palsy. Even though some studies with healthy adults have been completed, neurological differences between children with cerebral palsy and healthy adults may be studied again.

There are many factors which are responsible for urinary incontinence and the effect of functional disability is one of these factors. Besides urodynamic findings, a thorough clinical and functional examination is also required in children with diplegic cerebral palsy. The urinary incontinence might be reduced by increasing muscle strength/coordination, enhancing functional levels and increasing trunk control levels.

CONFLICT OF INTEREST

None declared.

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