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Original Article

Evaluating Diaphragm Muscle Function in Children With Urinary Incontinence

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ABSTRACT

Background and Aim: This study evaluates the respiratory muscle strength, quality of life (QoL), respiratory function of the diaphragm, participation in postural stabilization and functionality of active diaphragmatic breathing in postural stability in children with urine incontinence symptoms and lower urinary tract dysfunction and compares them with healthy children.

Methods: This study included 49 healthy and 49 children with lower urinary tract dysfunction and urinary incontinence symptoms who applied to Kırıkkale University Pediatric Urology. Children's QoL was evaluated using the pediatric urinary incontinence QoL scale. Their symptom severity was evaluated with the voiding disorders symptom score questionnaire, their respiratory muscle strength was evaluated with POWER breathe K5 and the diaphragm was evaluated with the dynamic neuromuscular stabilization method.

Results: When comparing the diaphragm's respiratory function, participation of the diaphragm in postural stabilization, and active breathing of the diaphragm in postural stabilization of the children, a significant difference was observed ($P<0.05$). Accordingly, asymptomatic children had greater inspiratory muscular strength, maximal inspiratory pressure and volume values than children with urinary system dysfunction. There was a difference in the pediatric urinary incontinence QoL scale and voiding disorders symptom score and it was due to the patient groups ($P<0.05$).

Conclusion: Children with urinary incontinence symptoms and lower urinary tract dysfunction were found to have insufficient respiratory function, use of the diaphragm, and participation in postural stabilization of the diaphragm compared to asymptomatic children. Their respiratory muscle strength was lower.

Keywords: Urinary incontinence, Lower urinary tract dysfunction, Diaphragm, Respiratory force, Quality of life (QoL)

Introduction

Involuntary urine incontinence is the definition of pediatric urinary incontinence [1]. One sign of lower urinary tract dysfunction is urine incontinence [2]. The most frequent urological issue in children is urinary incontinence [3]. It is estimated that there are over 50 million children with urinary incontinence worldwide. The incidence of nocturnal incontinence (enuresis) by age is 15% to 20% at the age of 5 years, 5% at the age of 10 years, 2%-3% at the age of 10-17 years and 1% over the age of 17 years. Meanwhile, 15% resolve spontaneously each year. This phenomenon is observed 1.5 times more in boys compared to girls [4].

Research on the incidence and causes of urine incontinence can be found in the literature [5-7]. Up to 85% of children gain urinary control during the day and night by the age of 5 years. In the remaining 15%, enuresis persists, especially primary enuresis in 2-5% of children. The incidence varies between 1.5% and 3% in adults. Secondary enuresis in children between the ages of 5-13 years is reported to be 3-8% and its spontaneous regression is primary enuresis [5-7]. Dynamic neuromuscular stabilization (DNS) is a concept that emerged in the field of rehabilitation, developed by Professor Pavel Kolar after being influenced by Vojta's reflex movement study [8]. DNS is a functional diagnostic and treatment approach based on human ontogenesis, applying principles of movement and posture development in the early years of a healthy individual's life [8]. It provides a comprehensive clinical test set to assess closely related postural and respiratory functions [8].

Spinal stabilization relies on the coordinated balance between the diaphragm, pelvic floor and abdominal muscles to regulate intra-abdominal pressure (IAP) [9-11]. IAP provides ventral spinal stabilization [12] reduces compressive loads on the spine and works in coordination with the lumbar paraspinal muscles to provide dorsal spinal stabilization [13]. The combination of stabilization and respiratory system performance is comparatively challenging and only conceivable with excellent motor control, which indicates having a healthy central nervous system [14, 15]. During postural exercises, the diaphragm, transversus abdominis, pelvic floor and multifidus muscles exhibited synchronized synergistic activation, as reported by Hodges et al. [15].

Spinal stabilization is closely related to the respiratory stereotype and also linked to the diaphragm and pelvic floor sphincter function [9, 16, 17]. The diaphragm's dome flattens during inspiration. The amount of flattening varies depending on the respiratory pattern and the postural task being carried out [9, 10, 18]. During inhalation and postural duties, the diaphragm descends caudally, increasing IAP and applying pressure to the internal organs. The abdominal wall expands as a result of this caudal descent, increasing the volume of the chest and abdominal walls eccentrically. To preserve the abdominal wall's volume, the abdominal wall contracts isometrically after this eccentric contraction. This eccentric-isometric muscle activity ideally happens following the amount of effort and movement the muscle puts forth [19]. During inspiration, the eccentric activity of the muscles that enter the thoracic and abdominal walls causes the abdominal wall to expand cylindrically in all directions. However, the diaphragm and pelvic floor do concentric concentrically toward the belly cavity. The isometric contraction of the abdominal muscles stabilizes the movement of the extremities when there is an ideal eccentric contraction in the diaphragm's flattening [19, 20].

The global coordination of core muscle activity stabilizes the body. Activation of a single body muscle or a component of the body stabilization complex alone will not be sufficient to dynamically generate adequate IAP in response to real postural demands [21].

The unstable activation of body stabilizers and insufficient regulation of IAP may be associated with urinary incontinence [17]. Optimum spinal stabilization depends on the balanced coordination between the diaphragm, pelvic floor, and abdominal muscles to regulate IAP. It is believed that the impairment of one of these synergies affects the others as well [9-11]. As a result, it is predicted that a problem in the function of the diaphragm, which is part of the IAP, can affect the function of the pelvic floor, which is also part of the IAP and hence cause urinary incontinence. Accordingly, this study evaluates this prediction and provides evidence-based new infrastructure for the diagnosis and treatment methods of children with symptomatic urinary incontinence if there is diaphragm involvement. In addition, the study compares respiratory muscle strength, quality of life (QoL), respiratory function of the diaphragm, participation in postural stabilization, and active diaphragmatic respiratory function in postural stabilization between children with lower urinary tract dysfunction with urinary incontinence symptoms and healthy children.

Materials and Methods

Study design

Between April 2021 and May 2022, a total of 49 children with lower urinary tract dysfunction and urinary incontinence symptoms who applied to the Department of Pediatrics and Pediatric Nephrology at Kırıkkale University, Faculty of Medicine Hospital and the Private Pediatric Urology Clinic

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were included in the study. A total of 49 volunteer healthy children who were relatives of the incoming patient children were included in the study following the inclusion criteria (Figure 1). The inclusion criteria for children with lower urinary tract dysfunction and urinary incontinence symptoms were diagnosis of lower urinary tract dysfunction with urinary incontinence symptoms, age between 6 and 18 years and willingness to participate in the study. Healthy children without a diagnosis of lower urinary tract dysfunction and urinary incontinence symptoms between the ages of 6 and 18 were included in the control group. Children under 6 years of age with a diagnosis of the neuropathic bladder due to central nervous system disorders, such as spina bifida, hypoxic-ischemic encephalopathy, hydrocephalus according to international guidelines, or with a diagnosis of the non-neurogenic neuropathic bladder following clinical evaluations, those who had a history of open surgery related to an existing pathology, subjects diagnosed with mental retardation or cognitive impairment, individuals with chronic illness (such as asthma, type 1 diabetes, etc.), those with a history of respiratory tract diseases, such as bronchitis, pneumonia, subjects with orthopedic disorders that would prevent evaluation, those who had previously undergone surgery that would affect the biomechanics of the body and lower extremities, and those with anatomical changes and malformations in the urinary system were excluded from the study.

Primary outcome

All evaluations were carried out face-to-face by the same experienced physiotherapist. The socio-demographic information of the children included in the study, such as age, body mass index, gender, mode of delivery, age of toilet training, and family structure, was questioned with a prepared case form, and the evaluations are given below. All evaluations were carried out face-to-face by the same experienced physiotherapist.

The primary outcome measure was respiratory inspiratory muscle strength and the diaphragm muscles performed. Respiratory inspiratory muscle strength of the children was assessed using POWER breathe K5 and the evaluation of the diaphragm muscle was performed using the DNS method.

Evaluation of diaphragm muscle function

The muscle function of the diaphragm was evaluated using the DNS method. Professor Pavel Kolar developed the concept of DNS in rehabilitation. It is a clinical test used to evaluate closely related postural and respiratory functions [22]. The test was performed in three different ways, and the physiotherapist wore a mask and gloves during the test. After each test, the patient rested. The tests were performed as follows.

Contribution of diaphragm muscle to respiration

The physiotherapist asks the child to sit on the bed. A support step is placed under the child's foot in a position where the foot is in contact. The test to be performed on the child is explained beforehand. The sitting child is asked to take a few deep breaths while keeping their spine straight and shoulders relaxed. During the test, the physiotherapist focuses on the lower ribs and shoulder movements, observing them from the front. At the same time, the physiotherapist can palpate the lower intercostal spaces and or the upper part of the groin [22]. Each test was repeated three times, and the evaluation results were recorded. The results were recorded by palpating the patient in the first method. It is requested of the patient to inhale and exhale. The degree of expansion that should be present is rated as "much" and the absence of any movement is rated as "none." The evaluation is recorded as "none," "little," "moderate" and "much."

Contribution of diaphragm muscle to postural stabilization

The physiotherapist asks the child to sit on the bed. A support step is placed under the child's foot in a position where the foot is in contact. The test to be performed on the child is explained beforehand. The child's arms and legs are relaxed, and the spine is kept straight. The physiotherapist palpates the lower abdominal regions on the groin and instructs the person being tested to activate the IAP by pushing the physiotherapist's fingers on the groin ligaments. The physiotherapist evaluates the amount and symmetry of activation while observing the abdominal contraction and any belly movement [22]. The physiotherapist performs the evaluation three times. The child is instructed to simply push the physiotherapist's hands. The degree of the instruction is evaluated as "much" if the correct direction is symmetrically done and "none" if there is no direction and no movement in the groin area. The evaluation is recorded as "none," "little," "moderate" and "much."

Active breathing of the diaphragm muscle in postural stabilization

The physiotherapist instructs the child to sit on the examination table. A footrest is placed under the child's feet so that they are in contact with the ground. The test to be performed is explained to the child beforehand. The child's arms and legs are relaxed while the spine is kept upright. The physiotherapist positions themselves behind the patient and instructs them to take a deep breath while pushing their fingers toward the lateral-dorsal parts of the abdominal wall to activate them. The physiotherapist places their fingers between the patient's lower ribs and beneath the abdominal wall. The physiotherapist visually and manually evaluates any lateral movement of the lower ribs and the activation and symmetry of the lateral-dorsal parts of the abdominal wall. The physiotherapist also monitors visually whether the spine is held upright and stable and checks for any shoulder movement or pathological synkinesis [22]. The tests were performed according to the specified procedure and recorded by the same physiotherapist. The child is expected to activate the lateral-dorsal parts of the abdominal wall symmetrically and maintain an upright body posture. The child is rated as "much" if they can activate the abdominal wall optimally and maintain proper posture, and "none" if they cannot. The evaluation is recorded as "none," "little," "moderate," or "much."

Assessment of respiratory muscle strength

The POWER breathe K5 device (POWER breathe International Ltd., Warwickshire, UK) was used to measure respiratory muscle strength. The POWER breathe K5 equipment has been developed to adapt to variations in respiratory muscle strength that occur during a breath [23]. Measurements were repeated three times for each child. After each measurement, the child rested, and then the measurement was repeated. Measurements were performed on each child individually and the room was ventilated after each measurement. For the patient, a special mouthpiece was used during the measurement. For evaluation, the patient was asked to sit on a chair with back support, in a relaxed shoulder position, and with the nose closed using a nose clip, and was first instructed to exhale, then to take a deep breath from the device placed in the mouth and the results of maximum inspiratory pressure, flow and volume were recorded as shown by the S-index. Each measurement was recorded separately and the average of all measurements was used for evaluation.

Secondary outcome

Secondary outcome measures were the QoL of the children and the severity of symptoms. The QoL of the children was assessed using the pediatric urinary incontinence QoL questionnaire (PIN-Q) [24] and the severity of symptoms was assessed using the voiding dysfunction symptom score questionnaire (VDSS) [25].

PIN-Q in children with urinary incontinence

PIN-Q is a scale developed by Bower et al. in 2006 to show how much urinary incontinence affects the QoL of children with urinary incontinence [24]. PIN-Q validity and reliability were performed by Bower et al. [24] and Turkish validity reliability was conducted by Hanımeli in 2011. The children were asked to assign a score of 0 to 4 to each question (0=never, 1=rarely, 2=sometimes, 3=often, 4=always). A higher overall score indicates a worsening of the child's QoL [24, 26].

VDSS questionnaire

VDSS was used to evaluate the severity of urinary incontinence symptoms in children. This questionnaire consists of 14 questions and was developed by Akbal et al. in 2005. A total of 13 questions assess symptoms of both overnight and daytime incontinence, frequency of urine during the day, presence of constipation and other symptoms associated with incontinence. Meanwhile, one item assesses how these symptoms affect one's QoL. On the scale, the total score goes from 0 to 35 points. An increase in the total score indicates an increase in the severity of urinary incontinence symptoms [25].

Sample size

For the post hoc power analysis, the G*Power software, version 3.1.9.7 was used and the effect size was calculated from the S-index (inspiratory muscle strength) difference between children with urinary incontinence symptoms and asymptomatic children. According to the analysis, when the two-tailed hypothesis test with statistical significance of α set to 5% and 95% CI was used, the effect size was found to be 0.84 and the study power (1-β) was 98%.

Statistical analysis

Statistical analyses were conducted using the IBM SPSS software, version 26.0 (SPSS Inc, Chicago, IL, USA). The normal distribution of variables was examined using visual methods (histograms and probability charts) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). Descriptive statistics were provided using frequency and percentage for nominal and ordinal variables, median and interquartile range for numerical variables that do not show normal distribution and Mean±SD for numerical variables that show normal distribution. When comparing two independent nominal variables, the chi-square test was used and depending on the expected values in the eyes, the use of Pearson chi-square, likelihood ratio, or one of Fisher exact test statistics was preferred. The Mann-Whitney U test was used as a non-parametric test and the independent groups t-test was used as a parametric test for comparing numerical variables between groups. Cases, where the type 1 error level was below 5%, were considered statistically significant.

Results

The study was completed with 98 children, including 49 with lower urinary tract dysfunction symptoms and urinary

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incontinence and 49 healthy children. One child with neurogenic bladder from the 105 evaluated children and 2 uncooperative children from the healthy group were excluded from the study along with 4 children whose age average was out of range (Figure 1). The physical characteristics of the children included in the study are shown in Table 1. Accordingly, the physical characteristics of children with urinary incontinence symptoms and healthy individuals were similar (Table 1). No difference was found in gender data between the two groups (P>0.05). When the family structures and birth methods of individuals were compared, a significant difference was observed. The nuclear family rate was higher in the group with urinary incontinence symptoms. When the birth methods of individuals were compared, the cesarean rate was higher in the group with urinary incontinence symptoms (Table 1).

A significant difference was found when the contribution of the diaphragm muscle to respiration, the contribution of the diaphragm muscle to postural stabilization, and the active breathing of the diaphragm muscle in postural stabilization were compared (P<0.05). Meanwhile, the diaphragm muscle of the healthy group contributed more to respiration. When considering the contribution of the diaphragm muscle to postural stabilization, the diaphragm was more effective in postural stabilization in the healthy group. Active breathing of the diaphragm muscle in postural stabilization was also found to be more common in the healthy group (Table 2).

The inspiratory muscle strength of the children included in the study, namely maximum inspiratory pressure (S-index), flow rate (flow) and volume measurements are shown in Table 3. There was a significant difference between children with urinary system dysfunction and healthy children. Inspiratory muscle strength of healthy children, maximum inspiratory pressure (S-index), flow rate (flow) and volume values were positively higher than the children with urinary system dysfunction (Table 3).

When the results of the QoL in children with urinary incontinence scale and the VDSS scale of sick children were compared as boys and girls, no significant difference was observed in PINQ (internal) and PINQ (total) values. There was a significant difference in PINQ (external) values. There was a significant difference in the result of the VDSS Scale. It was determined that the girls in the patient group had higher symptom severity of voiding disorders (Table 4).

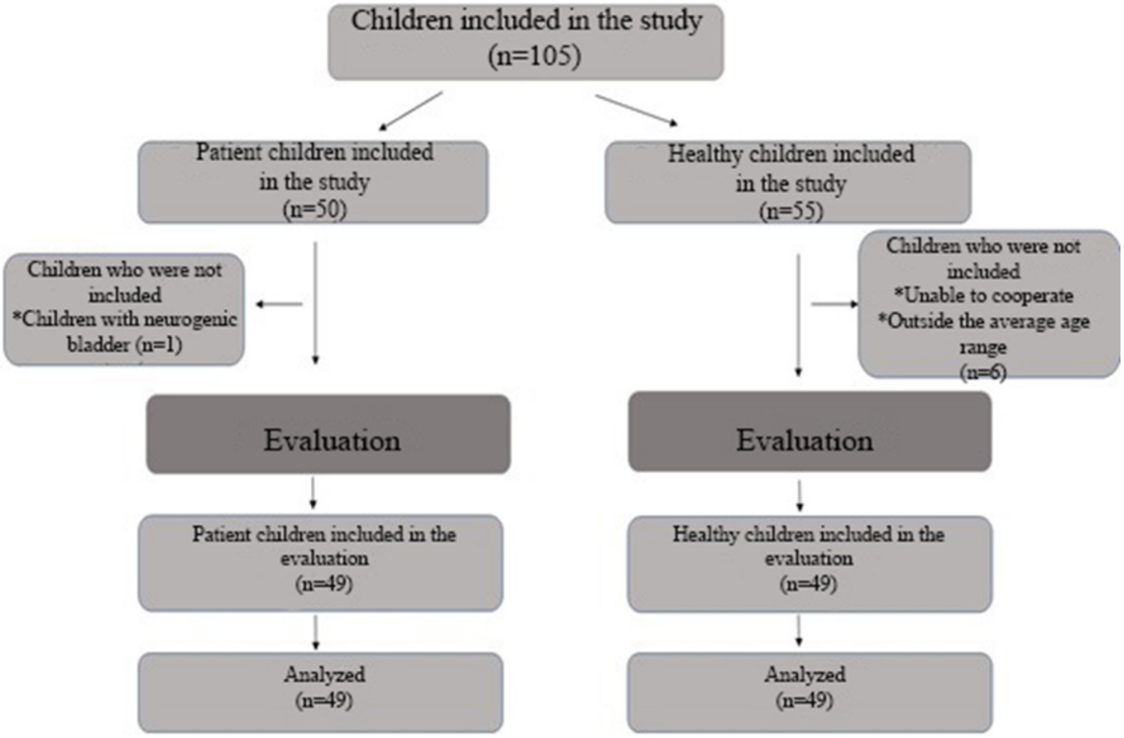

Figure 1. The CONSORT diagram for recruitment of participants

Table 1. Physical characteristics and birth information of children (n=49)

Physical Characteristics of the Children	Asymptomatic Children		Patient Children		P
	Mean±SD	Median$	Mean±SD	Median$	
Age (y)	9.96±1.60	9.8(8.7-10)	9.38±2.30	8.7(7.7-10)	0.154&
Height (cm)	138.06±10.38	135(130-143)	135.67±16.73	132(125-147)	0.236#
Weight (kg)	35.36±9.39	33(29-40)	34.38±14.26	30(24-40)	0.163#
Body mass index (kg/m²)	18.35±3.15	18.2(15.62-20.41)	18.02±3.58	17.48(15.23-20)	0.628&
Age of toilet training (m)	26.39±8.98	24(24-36)	28.24±7.11	30(24-36)	0.302#

Sociodemographic and Birth Information		No. (%)		P
		Asymptomatic Children	Patient Children	
Gender	Male	25(51)	27(55.1)	0.686
	Female	24(49)	22(44.9)	
Family structure	Nuclear family	33(67.3)	42(85.7)	0.032*
	Extended family	16(32.7)	7(14.3)	
Type of birth	Normal	32(65.3)	17(34.7)	0.002*
	Cesarean	17(34.7)	32(65.3)	

&Independent groups t-test, #Mann-Whitney U test, *P<0.05 shows chi-square test, $%25-75% interquartile range.

Discussion

Children with lower urinary tract dysfunction and urinary incontinence symptoms had a less active role of the diaphragm in respiratory function, postural stabilization, and active participation in postural stability compared to asymptomatic children in the same age group. They also had lower values in maximum inspiratory pressure, flow rate and volume parameters when evaluating respiratory muscle strength. Meanwhile, their QoL and symptom severity were negatively affected.

The timing of toilet training is still being debated in the literature [27]. The timing of toilet training varies from culture to culture. Since children's readiness skills and physical development for toilet training occur between 18-30 months, the American Academy of Pediatrics (AAP) recommends starting toilet training after the age of 2 [28]. Early daytime urinary continence training has been associated with earlier attainment of both daytime and nighttime bladder control, according to the studies of Blum et al. and Young et al. [29, 30]. Early nighttime continence training was also associated with early attainment of nighttime continence and a lower nocturnal enuresis rate, according to a study by Young et al. [30]. Chiozza et al. reported a lower rate of nocturnal enuresis in children who achieved early daytime bladder control [31]. In this study, it was observed that all children received toilet training between 24-36 months of age. Meanwhile, toilet training ages (months) between groups showed similarity.

Urinary incontinence affects both the child and the family socially, emotionally and behaviorally [32]. It puts the child at risk for social isolation, peer conflict, mocking, and classroom difficulties [33]. Children with urinary incontinence often experience low self-esteem and psychological distress as a result of their symptoms. When asked to rate the severity of wetting pants in class for school-age children, it is considered the third most stressful of 20 different life events [34].

Nevéus et al. [2] included 46 children aged 6 to 18 years with nocturnal enuresis who completed the PINQ after it was translated into Swedish. They noted that children with nighttime enuresis experienced decreased self-esteem which affected their QoL and relationships with friends. Boys reported a significantly higher impact; in other words, lower

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Table 2. Evaluation of diaphragmatic muscle function in children (n=49)

Functions of the Diaphragm			No. (%)		P
			Asymptomatic	Patient	
Contribution of the diaphragm muscle	Respiration	None	3(6.1)	35(71.4)	<0.001*
		Little	31(63.3)	13(26.5)	
		Moderate	15(30.6)	1(2)	
		Much	0	0	
Contribution of diaphragm muscle	Postural stabilization	None	0	17(34.7)	<0.001*
		Little	0	25(51)	
		Moderate	6(12.2)	4(8.2)	
		Much	43(87.8)	3(6.1)	
Active breathing of the diaphragm muscle in postural stabilization		None	35(71.4)	47(95.9)	0.001*
		Little	14(28.6)	2(4.1)	
		Moderate	0	0	
		Much	0	0	

*P<0.05 shows chi-square test.

Table 3. Evaluation of respiratory muscle strength of children (n=49)

Evaluation of Respiratory Muscle Strength	Asymptomatic		Patient		P*
	Mean±SD	Median$	Mean±SD	Median$	
Maximum inspiratory pressure	28.86±6.49	29.33(24.33-33.33)	22.48±8.58	19.67(15.67-29)	<0.001
Flow rate	1.57±0.40	1.63(1.27-1.77)	1.21±0.51	1.1(0.87-1.6)	<0.001
Volume	1.19±0.34	1.17(0.93-1.40)	1.07±0.63	0.9(0.67-1.2)	0.009

*Mann-Whitney U test, $%25-75% interquartile range.

Table 4. Comparison of QoL scale and voiding disorder symptom score questionnaire in children with urinary incontinence

Results of Voiding Disorders and QoL		Female Patient Group (n=22)		Male Patient Group (n=27)		P*
		Min-max	Median$	Min-max	Median$	
VDSS		9-38	21(17-26)	8-30	16(9-22)	0.017*
PINQ	External	2-17	8,5(6-10)	0-10	4(2-9)	0.022*
	Internal	6-49	25.5(14-32)	6-36	18(11-26)	0.103*
	Total	8-66	34(20-43)	8-46	21(16-34)	0.059*

PIN-Q: Quality of life scale in children with urinary incontinence; VDSS: Voiding disorders symptom score questionnaire.

*Mann-Whitney U test, $%25-75% interquartile range.

QoL, than girls in the area of social relationships with peers [35]. In a study conducted by Deshpande et al. a total of 138 children aged 6 to 16 years with urinary incontinence were evaluated using the PINQ scale. They found that self-esteem and mental health were the most affected areas. According to the study, girls had a worse QoL than boys [36]. Thibodeau et al. included 40 children aged 5 to 11 years with non-neurogenic daytime incontinence (10 boys, 30 girls) in their study. They confirmed the impact of urinary incontinence on children's self-esteem and QoL, as well as its serious impact on the child, family dynamics, and peer relationships [37].

In a study by Gladh et al. conducted on 120 neurologically healthy children aged 6-16 years with urinary incontinence and 239 healthy children of the same age, it was emphasized that the social situation, self-esteem, and confidence of children were most affected [38]. Similarly, in the present study, it was found that children with lower urinary tract dysfunction and urinary incontinence symptoms had worse QoL. Intervention and education programs aimed at increasing their QoL should be considered in addition to their medical treatment. Simultaneously, we should explain to the children and their families the causes of incontinence and prevent them from seeing it as their fault.

There are studies in the literature that evaluate the severity of symptoms in children with incontinence. These studies compare the changes in symptom severity before and after treatment [39, 40]. In İnals thesis study in which 69 children were included, they found that the symptom severity of children with enuresis was worse than healthy children [41]. In Saatçı's thesis study in which 86 children were included, they found that the symptom severity of children with lower urinary tract dysfunction, except for those with enuresis was worse than healthy children [42]. Similarly, according to the present study, children with lower urinary tract dysfunction and urinary incontinence symptoms had worse symptom severity than healthy children, which we believe is an expected result.

When studies comparing symptom severity by gender were examined, Thibodeau et al. found that both genders had similar effects [37]. Similarly, İnal [41] and Saatcı [42] found the same effects by gender in their studies. However, in our study, contrary to previous studies, a significant difference was observed in symptom severity by gender, and it was found that the symptom severity of incontinence was higher in girls in the patient group. We consider that this may be due to the broader patient group and variable age group. In addition, more studies are needed to obtain clearer results on this issue.

There are not many studies on therapeutic techniques focusing on manual approaches to the evaluation of the diaphragm and manual evaluation of the diaphragm in more detail. When looking at the literature, there are no studies that investigate the relationship between the diaphragm and children with lower urinary tract dysfunction who have symptoms of urinary incontinence. Our study is predicted to be the first in this area.

DNS is a neurophysiological and development-based rehabilitation approach that uses a series of functional tests to qualitatively evaluate various postural stabilization models, along with a treatment approach based on observations and subsequent developmental kinesiology models [8]. The DNS evaluation is based on comparing the patient's stabilizing pattern with that of a healthy baby's stabilizing pattern. Kobesova et al. presented a test in their article in 2020 that closely evaluates postural breathing functions [22].

Jacisko et al. [43] compared the manual evaluation we made with DNS by making objective measurements with the DNS Brace device in their study in 2021. They evaluated 25 healthy individuals (16 females, 9 males, age = 22.4 years) using five postural stability tests through subjective assessment, palpation and observation. Inter-rater reliability was determined using intra-class correlation coefficients. They used a new device (DNS brace) that externally measures abdominal wall pressure to obtain objective measurements. Reliability estimates showed that palpation measurements for three DNS tests, which were also measured in our study, were moderately reliable (intra-class correlation coefficients=0.645-0.707). In another cross-sectional study by Novak et al. [44]. they tested 31 healthy individuals (mean age=26.77±3.01 years) using anorectal manometry to measure IAP along with abdominal wall tension measured by sensors attached to body support (DNS brace). They were evaluated in five different standing breathing postures. Strong correlations were shown between anorectal manometry and DNS Brace measurements in all different measurements and DNS Brace values significantly predicted IAP values for all different measurements [44].

In the literature, there are studies other than DNS that evaluate the diaphragm manually. One of these studies is the evaluation of the diaphragm using the manual evaluation of the diaphragm scale by Bordoni et al. [45]. They aimed to define a hypothesis for the manual evaluation of the diaphragm by paying special attention to anatomical foundations. The main purpose of using this type of manual assessment is to understand whether there is any movement restriction in a specific area of the diaphragm muscle to plan a manual treatment focused on the dysfunctional area in conjunction with normal rehabilitation processes. In this study, we evaluated the diaphragm in children with lower urinary tract dysfunction and urinary incontinence symptoms using DNS. According to the results of DNS evaluation, it was observed that the participation of the diaphragm in respiratory function, participation in postural stabilizing and active diaphragm breathing in postural stabilizing were passive in children with lower urinary tract dysfunction who had urinary incontinence symptoms compared to asymptomatic children. In asymptomatic kids, participation of the diaphragm in respiratory function, participation in postural stabilizing, and active diaphragmatic breathing in postural stabilization were more active. The diaphragm and pelvic floor muscles create two opposing pistons that increase the pressure in the abdominal cavity. The contraction of the abdominal muscles resists the lateral movement of the contents within the abdominal cavity [46]. Based on this approach, the lack of active involvement of the diaphragm in children with incontinence symptoms results in insufficient IAP, which leads to a disruption in the piston relationship between the diaphragm and pelvic floor muscles, and therefore the inability of the pelvic floor to perform its task properly.

Our literature review did not show any studies that examined the effect of respiratory muscle strength on children with lower urinary tract dysfunction and urinary incontinence symptoms. Thus, our study is the first to examine the effects of respiratory muscle strength in this group with a control group. Previous studies using the power breathe device have mainly been used for inspiratory muscle training. In Solmaz's study [47], diaphragmatic mobilization techniques were used to evaluate respiratory muscle strength in obese individuals.

The results of our study demonstrated that measurements of inspiratory muscle strength (S-index), maximum inspiratory pressure (flow) and volume parameters were more active in healthy children compared to those with lower urinary tract dysfunction and urinary incontinence symptoms. The diaphragm muscle is the primary inspiratory muscle. These results support the findings of our DNS method. We conclude that the diaphragm is affected in children with urinary incontinence symptoms compared to asymptomatic children. We predict that this will be a guide for us to give importance to the diaphragm in children with urinary incontinence symptoms in the future diagnosis and treatment processes.

Conclusion

Physiotherapy studies have been conducted for pelvic floor rehabilitation in children with urinary incontinence symptoms. Various exercise programs are applied to develop the pelvic floor. At this point, although the importance of the diaphragm is partly understood, its importance in these patients has not been fully recognized. Therefore, studies are expected to be conducted to activate the diaphragm and to make correct IAP orientation. Teaching correct diaphragmatic breathing is essential for the treatment of these children. Therefore, we believe that teaching diaphragmatic breathing should be added to exercise programs. In future studies, we suggest investigating the relationship between the diaphragm and other parameters. Additionally, we suggest evaluating the DNS method used to assess the diaphragm in different positions.

Study limitations

In this study evaluating the diaphragm in patients with lower urinary tract dysfunction and urinary incontinence symptoms, there are some limitations. The limitation of this study is that the patient group includes a general group. It was a patient group that included all types of daytime incontinence and enuresis. Instead, the study could have been done by considering a single patient group. In addition, measurements can be made using anorectal manometry and DNS Brace in future studies.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Kırıkkale University (Code: 2021, GO 02/26). The parents of the children included in the study were informed and signed an informed consent form after being informed about the purpose of the study, the evaluation methods to be used, and the exercise training. In addition, this study was based on a thesis project.

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Authors' contributions

Conceptualization: Sümeyra Gölgelikay and Meral Sertel; Study design and data interpretation: Meral Sertel; Writing the original draft: Sümeyra Gölgelikay; Review, editing and final approval: All authors.

Conflict of interest

The authors declared no conflict of interest.

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