Evaluation of the Effectiveness of Dynamic Neuromuscular Stabilization Training in Children Diagnosed with Lower Urinary Tract Dysfunction and Comparison with EMG Biofeedback Treatment: A Pilot Study

Emine Nacar[1]*, Sinem Suner Keklik[2], Ahmet Taner Elmas[3]

Purpose: This study was designed to evaluate the effectiveness of dynamic neuromuscular stabilization (DNS) training in children with non neurogenic lower urinary tract dysfunction (LUTD) and compare it with biofeedback (BF) treatment.

Materials and Methods: A total of 15 participants aged 6–15 years with non neurogenic LUTD were divided into three groups: Group I, DNS exercise training; Group II, BF training; and Group III, DNS plus BF training. Dysfunctional Voiding and Incontinence Scoring System (DVISS) scores, uroflowmetry parameters, uroflow curve, post void residual (PVR) values, and deep trunk muscle strength were evaluated at baseline and at 4, 8, and 12 weeks after treatment.

Results: Total DVISS scores significantly decreased after 12 weeks in Groups I and III, while Group II showed significant decreases at 4 and 8 weeks ($P < .05$). Improvements in deep trunk muscle strength at 4 and 8 weeks were significantly greater in Groups I and III than in Group II ($P < .05$). In Group I, average flow rate increased at 4 weeks and flow time decreased at 12 weeks ($P < .05$). PVR decreased significantly at 12 weeks in Group I and at 8 weeks in Group III ($P < .05$).

Conclusion: DNS and BF training are effective in improving symptoms in patients with non neurogenic LUTD; however, groups receiving DNS exercises were superior for several parameters.

Keywords: children; lower urinary tract dysfunction; dynamic neuromuscular stabilization; biofeedback; pelvic floor rehabilitation

INTRODUCTION

Lower urinary tract dysfunction (LUTD) is characterized by urgency, holding maneuvers, incontinence, varying voiding frequency, and voiding difficulty.[1] It affects approximately 17–22% of children.[2] With growth, lower urinary tract function matures and socially acceptable continence is typically achieved by age 5.[3] More than half of children with LUTD have secondary vesicoureteral reflux and over two thirds experience recurrent urinary tract infections (UTIs).[2] LUTD may progress to chronic kidney disease and is associated with adult dysfunctional voiding; childhood LUTD may be a risk factor for adult overactive bladder.[4–6] Early detection and treatment are therefore crucial.[4] In otherwise healthy children, LUTD etiology is often functional.[7] Thus, movement based complementary therapies are important.[8] The International Children's Continence Society (ICCS) recommends standard urotherapy as first line treatment for non neurogenic LUTD, including education, adequate fluids, timed voiding, and bowel programs.[7] Specific urotherapy interventions include pelvic floor muscle (PFM) awareness, biofeedback (BF), and neuromodulation.[4] BF trains PFMs by converting myoelectric signals into visual and auditory feedback, revealing inadequate pelvic floor movements during voiding.[9] Many studies suggest voluntary PFM control can be crucial for LUTD treatment,[10,11] though BF is only one of multiple retraining approaches.[12] PFM rehabilitation is widely used for pelvic floor dysfunctions in both adults and children,[13] aiming for correct contraction and relaxation.[14] PFMs function with the diaphragm, abdominal, and paraspinal muscles as a core unit.[15] Given these links, contemporary LUTD treatments include core stabilization rather than isolated PFM exercises,[16,17] and effective core function appears important for non neurogenic LUTD.[16]

Dynamic neuromuscular stabilization (DNS), abdominal bracing, and hollowing are strategies to strengthen core muscles.[18] Core stability requires precise muscle coordination with the integrated stabilizing system of the spine (ISSS) and central regulation of intra abdominal pressure (IAP), rather than strengthening a single muscle group.[19] DNS leverages genetically encoded neonatal movement patterns and diaphragmatic function to restore optimal ISSS and IAP through developmentally inspired positions and breathing, aiming to normalize motor patterns and reduce joint overloading.[19,20–22] DNS is applied in various rehabilitation settings,[19,23] yet evidence in pediatric LUTD is limited. This study evaluates DNS, BF, and DNS+BF in non neurogenic LUTD and compares outcomes.

PATIENTS AND METHODS

[1]Affiliated Hospital of Nantong University, Emergency Department, Nantong, 226000, Jiangsu, China.
[2]Jiangsu Rudong County People's Hospital, Pharmacy Department, Nantong, 226400, Jiangsu, China.
*Correspondence: Affiliated Hospital of Nantong University, Emergency Department Nantong, 226000, Jiangsu, China.
E-mail: medicalpaper203@gmail.com.
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Table 1. Clinical and demographic characteristics of the patients.

Groups	I (n = 4)	II (n = 7)	III (n = 4)	*P*-value
Age (years)	9 (7–13.5)	8 (8–9)	7.5 (6.5–10)	.753[(a)]
Weight (kg)	32 (25–44.5)	30 (22–32)	33 (30.5–38.5)	.495[(a)]
Height (cm)	138 (130.5–152.5)	132 (125–138)	135 (131–143)	.428[(a)]
Body mass index (kg/m²)	16.85 (14.46–19.02)	17.11 (14.56–18.93)	18.2 (16.76–19.94)	.657[(a)]
Age of toilet training (years)	2.5 (1.75–3)	2.5 (2–3)	2.75 (1.5–4)	.978[(a)]
Sex: Female, n (%)	3 (75.00)	4 (42.86)	4 (100.00)	.142[(b)]
Sex: Male, n (%)	1 (25.00)	3 (57.14)	0 (0.00)	
No family history of urinary incontinence, n (%)	2 (50.00)	4 (57.14)	2 (50.00)	.662[(b)]
Mother history, n (%)	1 (25.00)	1 (14.29)	1 (25.00)	
Father history, n (%)	1 (25.00)	0 (0.00)	0 (0.00)	
Sibling history, n (%)	0 (0.00)	2 (28.57)	1 (25.00)	
Constipation, Yes, n (%)	2 (50.00)	4 (57.14)	3 (75.00)	.754[(b)]
Post void residual > 10 cc, Yes, n (%)	4 (100.00)	4 (57.14)	3 (75.00)	.327[(a)]
Regular physical activity, Yes, n (%)	0 (0.00)	0 (0.00)	1 (25.00)	.229

Categorical data are n (%); numerical variables are median (25–75% IQR). *P* value compares groups; *P* < .05 significant. (a) Kruskal–Wallis test. (b) Chi square test.

Participants

This single blind, prospective, randomized controlled clinical study included 15 eligible patients who presented to the Pediatric Nephrology clinics of İnönü University Turgut Özal Medical Center between October 2022 and February 2023. Ethics approval was obtained (Decision No: 2022-06/12, Dated:22.06.2022) and the study adhered to the Declaration of Helsinki. Written informed consent was obtained from children and parents. Inclusion criteria: normal growth and de-

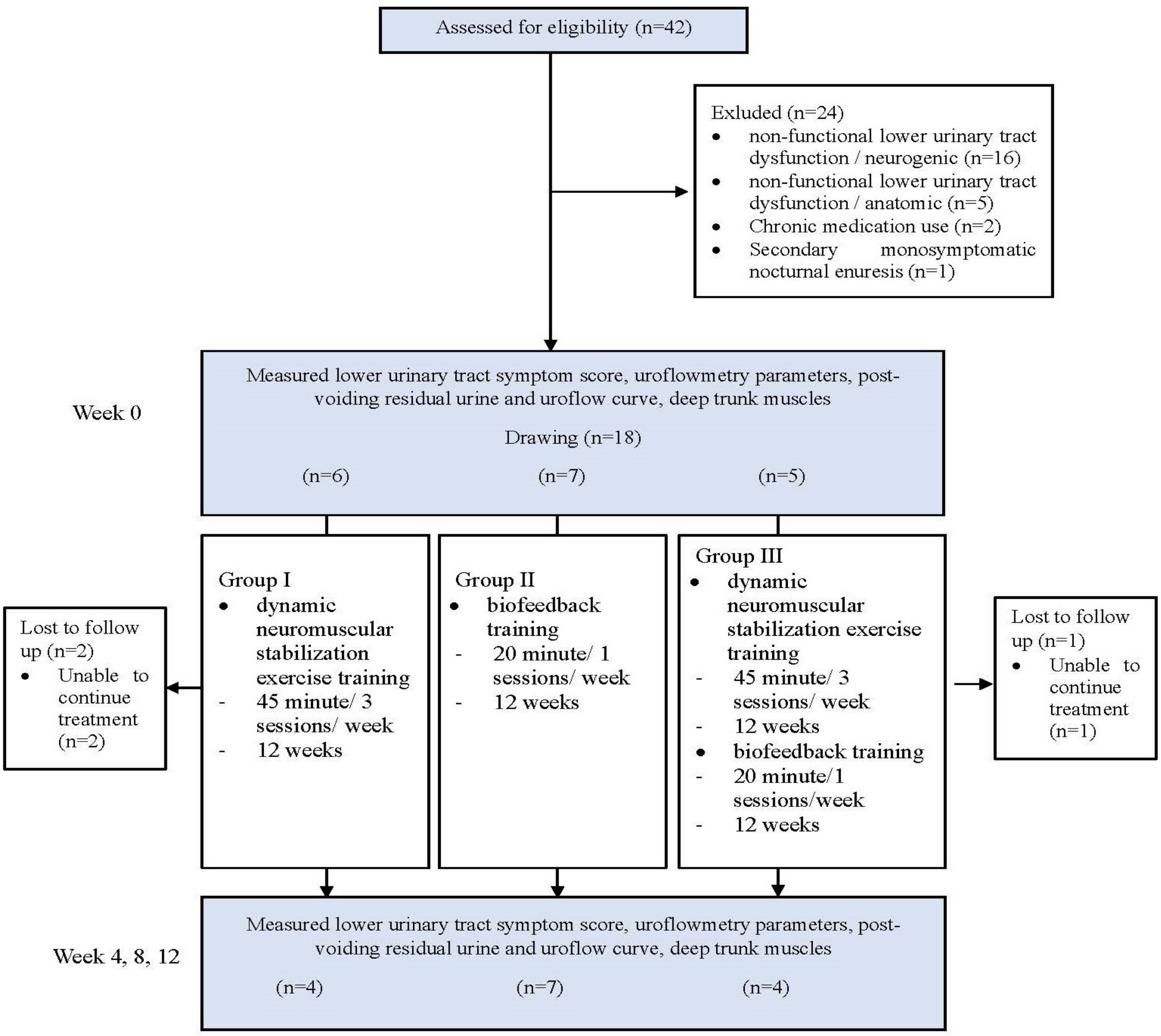

Figure 1. Flow of participants through the study

Table 2. Intragroup and intergroup variation of Dysfunctional Voiding and Incontinence Scoring System (DVISS) scores.

DVISS	I (n = 4)	II (n = 7)	III (n = 4)	*P*-value
T0	16.5 (15/18.5)A	18 (15/19)A	14.5 (12/16.5)A	.211
T1	7.5 (6/8)a	13 (11/18)b	7 (6.5/7.5)a	.005
T2	5 (3/7)	11 (10/14)B,b	2 (2/2.5)a	.003
T3	3 (2/4.5)B	9 (8/10)B,b	1 (0/2.5)B,a	.008
P**	.010	.001	.009	

Numerical variables: median (IQR). Lowercase a, b and uppercase A, B indicate post hoc differences between groups and time points, respectively. *P**, Kruskal–Wallis; P**, Friedman. $P < .05$ significant.

velopment; no psychological/behavioral disorders or related chronic medications; normal mental, motor development and neurological examination; no congenital kidney/urinary tract anomalies or abnormal ultrasound; DVISS score > 8.5.[24]

Exclusion criteria: lumbosacral skin findings suggestive of occult dysraphism; secondary monosymptomatic nocturnal enuresis; uroflowmetry (UFM) with voided volume < 100 mL and/or below 50% or above 115% of expected bladder capacity (EBC).[25–27]

Procedure

Children > 5 years were evaluated by a pediatric nephrologist with urinalysis, UFM (≥ 2), urinary ultrasound, and 2 day voiding diaries. Anatomical or neurologic incontinence was excluded. UTIs were treated prior to enrollment. Participants were allocated to Group I (DNS), Group II (BF), or Group III (DNS+BF) by non probability random sampling using registration numbers. All received 12 weeks of training; assessments at weeks 0, 4, 8, and 12. DVISS, uroflow parameters, PVR, and UFM curve were measured by blinded clinicians; deep trunk muscle strength was assessed by the treating physiotherapist. Of screened children, 21 with neurogenic LUTD, 1 with secondary monosymptomatic nocturnal enuresis, 2 with chronic medications, and 3 who discontinued were excluded. Fifteen children (6–15 years) completed the study (**Figure 1**). All had persistent symptoms despite prior standard urotherapy and anticholinergics.

Intervention

All participants received standard urotherapy education (bladder/PFM physiology, fluids, diet for constipation, timed voiding/defecation, avoiding retention maneuvers, family education). Other PF affecting exercise/physiotherapy was discouraged.

Group I (DNS): supervised individual sessions, 45 minutes, three times weekly for 12 weeks, delivered by a DNS certified physiotherapist. The DNS protocol included diaphragmatic breathing and developmentally based exercises (e.g., Baby Rock, Rolling, Side Lying, Oblique Sitting, Tripod, Kneeling, Squat, Prone, Czech Get Up), with progressive task complexity across weeks.[28] Group II (BF): animated EMG biofeedback once weekly, 20 minutes per session (12 sessions) using the Aymed Medical Locum Wireless System v.2.69.0.12. After basic PFM instruction, surface electrodes were placed at 3 and 9 o'clock on the perineum with a reference electrode on the inner thigh. Children

Table 3. Intragroup and intergroup variation of uroflowmetry parameters and post voiding residual values.

Parameter	I (n = 4)	II (n = 7)	III (n = 4)	*P*-value
Qmax T0 (ml/s)	28.96 (25.12–35.96)	18.46 (17.15–20.99)	16.41 (15.6–28.95)	.062
Qmax T1	25.5 (16.71–34.96)	17.5 (16.54–22.62)	19.53 (17.4–28.27)	.506
Qmax T2	25.9 (19.59–32.33)	17.8 (15.68–23.5)	21.16 (19.87–27.44)	.171
Qmax T3	25.05 (19.52–31)	18.2 (15.92–21.32)	21.36 (19.55–26.54)	.065
P** (Qmax)	.115	.615	.440	
Qavg T0 (ml/s)	6.55 (6.29–7.09)A	8.46 (6.63–10.83)	11.03 (8.31–12.31)	.102
Qavg T1	8.36 (8.25–8.57)	7.34 (7.16–9.65)	9.5 (8.82–9.79)	.236
Qavg T2	9.68 (9.41–9.81)B	7.86 (4.79–9.2)	9.46 (9.23–9.68)	.082
Qavg T3	9.52 (9.27–9.55)	8.6 (7.85–9.56)	9.54 (9.24–9.7)	.222
P** (Qavg)	.007	.653	.552	
Voided volume T0 (ml)	257.55 (148.15–380.6)	236.5 (111.2–297)	251.85 (148.1–399.95)	.612
T1	220.95 (130.9–348.2)	285 (110.4–295.3)	216.15 (158.45–258.8)	.732
T2	228.85 (138.95–335.7)	226.6 (104.5–265)	220.65 (161.7–274.1)	.506
T3	218.75 (139.5–303.75)	215.4 (120.4–231.5)	199.15 (153.75–247.1)	.443
P**	.416	.615	.682	
Flow time T0 (s)	46.35 (22.15–68.5)A	29.1 (15.5–35.7)	29.4 (13.75–43.75)	.559
T1	30.65 (15.5–48)	20.5 (14.7–30.2)	21.55 (15.45–28)	.696
T2	29.85 (14.95–54)	24.8 (16.7–37.4)	20.15 (15.6–26.15)	.807
T3	27.45 (15.2–45.15)B	22.6 (16.8–28.6)	18.25 (15.25–22.5)	.578
P**	.048	.697	.272	
Time to Qmax T0 (s)	5.75 (3.4–8.05)	9.6 (3.1–11.2)	6.5 (5.1–7.55)	.620
T1	5.7 (5–8.05)	8.7 (4.2–11.3)	6.5 (5.65–7.5)	.542
T2	6.1 (5.15–7.75)	5.3 (4–9)	5.35 (5.05–5.75)	.804
T3	5.8 (4.85–7.8)	5.8 (5.2–8.6)	5.4 (5.15–5.7)	.534
P**	.719	.478	.101	
PVR T0 (ml)	35 (17.5/58.5)A	10 (0/15)	35.5 (21.5/50.5)A	.051
T1	5 (0/27.5)	10 (0/15)	3.5 (0/8.5)	.698
T2	0 (0/20)	10 (0/15)	0 (0/0)B	.234
T3	0 (0/17.5)B	10 (0/10)	0 (0/0)B	.232
P**	.014	.487	.032	

Values are median (25th/75th centile). *P**, Kruskal–Wallis; *P***, Friedman. Bold P indicates $P < .05$. A/B indicate within group time differences.

Table 4. Intragroup and intergroup variation of uroflowmetry curve types.

UF curve: bell	I (n = 4)	II (n = 7)	III (n = 4)	*P*-value
T0, n (%)	0 (0.0%)	2 (28.6%)A	0 (0.0%)A	.267
T1	2 (50.0%)	2 (28.6%)A	3 (75.0%)B	.328
T2	2 (50.0%)	2 (28.6%)A	3 (75.0%)B	.328
T3	2 (50.0%)	5 (71.4%)B	3 (75.0%)B	.706
P**	.112	.029	.029	

*P**, Chi square; *P***, Cochran's Q. Bold P indicates $P < .05$. A/B denote within group time differences.

performed cycles of 10 s contraction and 30 s relaxation, guided by animations and on screen feedback to improve control and endurance.[29]

Group III (DNS+BF): DNS protocol as in Group I (45 minutes, three times weekly) plus weekly BF (20 minutes) as in Group II.

Measurements

Baseline demographics, toilet training age, family history, constipation, PVR, and physical activity were recorded. Outcomes at weeks 0, 4, 8, 12:

- Lower urinary tract symptom score: DVISS (Turkish validated), 13 symptoms + 1 QoL item; total 0–35; higher indicates worse; cut off 8.5 (90% sensitivity/specificity).[24,26]
- Uroflowmetry parameters: Intelligent System UFM Device (Aymed). Measured Qmax, Qavg, voided volume (VV), time to Qmax, and voiding time under privacy and comfort.[25,26]
- Post void residual (PVR): Logiq P9 USG within 5 minutes post UFM; ellipsoid formula (AP × transverse × longitudinal × 0.52). Age specific thresholds applied; rectal diameter measured for constipation (transverse > 30 mm).[27,30]
- Flow curve type: UFM curve categorized (bell, tower, plateau, staccato, fractional); bell considered normal.[26]
- Deep trunk muscle strength: Transversus abdominis (TrA) and deep neck flexors (DNF) by Stabilizer Pressure Biofeedback Unit. TrA assessed prone at 70 mmHg baseline; abdominal hollowing for 5 s × 3, average pressure change recorded.[31] DNF assessed supine with 20 mmHg baseline; craniocervical flexion held 10 s; best of three recorded; compensations prompted repeat.[32]

Statistical Analysis

IBM SPSS 26.0 was used. Normality assessed visually and analytically (Shapiro–Wilk, skewness/kurtosis, CV). Nonparametric tests were applied. Categorical data: n (%); numerical data: median (IQR). Cochran's Q for within group categorical comparisons; chi square for between group categorical comparisons. Friedman test for within group numerical comparisons; Kruskal–Wallis for between group numerical comparisons. Significance $P < .05$; Bonferroni adjusted pairwise tests used where appropriate (Mann–Whitney U with $P < .016$).[33]

RESULTS

Sociodemographic and baseline clinical characteristics were similar across groups ($P > .05$) (**Table 1**).

DVISS decreased significantly at 12 weeks (T3) in Groups I and III, and at 4 weeks (T1) and 8 weeks (T2) in Group II (each $P < .05$). The reduction at T3 was greater in Group III than Group II ($P < .05$) (Table 2). In Group I, Qavg increased at T2 and voiding time decreased at T3 ($P < .05$). Between group changes in UFM parameters were not significant ($P > .05$). PVR decreased significantly at T3 in Group I and at T2 in Group III ($P < .05$); between group differences in PVR change were not significant (**Table 3**).

Bell shaped UFM curves improved significantly at T3 in Group II and at T1 in Group III ($P < .05$), with no between group differences (**Table 4**).

TrA values decreased significantly at T2 and T3 in Groups I and III versus Group II (greater change; $P < .05$). DNF increased significantly at T2 and T3 in Groups I and III versus Group II ($P < .05$). No significant TrA or DNF changes occurred in Group II (**Table 5**).

DISCUSSION

Both DNS and BF improved urinary symptoms, with DNS containing protocols showing superiority in several objective parameters. BF has been reported to improve voiding patterns and QoL in pediatric LUTD,[4,35] though meta analytic data show inconsistent effects on daytime incontinence and UFM parameters.[36] Here, BF reduced symptoms and improved UFM curve type, but did not significantly change UFM parameters, PVR, or deep stabilizer strength, despite a 12 session program (contrasting with reports that four sessions might suffice).[29]Given PFMs' integration within the core unit, combining PF and core training can yield superior outcomes versus standard urotherapy alone, including reductions in PVR, EMG activity during voiding, and normalization of UFM curves.[16,17] Notably, objective UFM improvements can lag behind symptom relief, potentially reflecting neuroplastic adaptation and muscle remodeling that require at least 8 weeks.[38–40] Our DNS and DNS+BF groups showed earlier and broader objective gains than BF alone.

DNS emphasizes coordinated activation of diaphragm, TrA, multifidus, PF, and cervical flexors to optimize IAP and trunk stability,[21,41,42] which may underlie

Table 5. Intragroup and intergroup variations of transversus abdominis and deep neck flexor values.

Measure	I (n = 4)	II (n = 7)	III (n = 4)	*P*-value
TrA T0 (mmHg)	62 (61/62)[A]	60 (56/64)	60 (59/60)[A]	.312
T1	54 (54/55)	60 (54/62)	54 (52/56)	.111
T2	54 (53/54)[B,a]	60 (56/62)[b]	53 (52/55)[a]	.014
T3	54 (53/54)[B]	60 (54/62)[b]	53 (52/54)[B,a]	.017
P**	.012	.072	.015	
DNF T0 (mmHg)	24 (23/25)[A]	26 (24/28)	27 (25/29)[A]	.250
T1	31 (29/33)	26 (24/30)[a]	36 (32/41)[b]	.012
T2	34 (32/38)[B,b]	26 (26/28)[a]	38 (32/46)[b]	.005
T3	34 (32/38)[B,b]	26 (26/30)[a]	38 (33/46)[B,b]	.004
P**	.007	.138	.014	

Numerical variables: median (IQR). Lowercase a, b and uppercase A, B show post hoc differences between groups and time points, respectively. *P**, Kruskal–Wallis; *P***, Friedman. $P < .05$ significant.

greater improvements in UFM metrics and PVR. We observed strengthened DNF and TrA with DNS but not with BF, paralleling greater clinical gains and supporting the role of core stabilization in managing functional LUTD.
Limitations include small sample size and no post treatment follow up. Some LUTD symptoms not included in DVISS were not assessed. Strengths include a 12 week program and objective measures. To our knowledge, this is among the first studies evaluating DNS in pediatric LUTD; larger, follow up studies are warranted.

CONCLUSIONS

DNS and BF training improved symptoms in children with non neurogenic LUTD, with DNS based protocols showing superiority in several objective parameters. Core stabilization appears to be a valuable adjunct in pediatric LUTD rehabilitation.

SUMMARY

In children with lower urinary tract dysfunction, both biofeedback and DNS improved symptoms, but DNS based training led to greater gains in some objective measures like flow parameters, PVR, and deep core muscle strength.

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CONFLICT OF INTEREST

The authors report no conflict of interest.

REFERENCES

1. Sharifi Rad L, Ladi Seyedian S S, Kajbafzadeh A M. Interferential electrical stimulation efficacy in the management of lower urinary tract dysfunction in children: a review of the literature. Urol J. 2021;18:469 76.
2. Vaz GT, Vasconcelos MM, Oliveira EA, Ferreira AL, Magalhães PG, Silva FM, et al. Prevalence of lower urinary tract symptoms in school age children. Pediatr Nephrol. 2012;27:597 603.
3. Fuentes M, Magalhães J, Barroso Jr U. Diagnosis and management of bladder dysfunction in neurologically normal children. Front Pediatr. 2019;7:298.
4. Peco Antić A, Miloševski Lomić G. Development of the lower urinary tract and its functional disorders. Srp Arh Celok Lek. 2015;143:219 25.
5. Gong S, Khosla L, Gong F, Kasarla N, Everaert K, Weiss J, et al. Transition from childhood nocturnal enuresis to adult nocturia: a systematic review and meta analysis. Res Rep Urol. 2021:823 32.
6. Selvi I, Basar H, Baydilli N, Kizilay E, Demirci D. Which children are at risk of developing overactive bladder in early adulthood even if lower urinary tract symptoms improve during childhood? Int J Urol. 2022;29:136 42.
7. Kakizaki H, Kita M, Watanabe M, Wada N. Pathophysiological and therapeutic considerations for non neurogenic lower urinary tract dysfunction in children. Low Urin Tract Symptoms. 2016;8:75 85.
8. Morgan KE, Leroy SV, Corbett ST, Shepard JA. Complementary and integrative management of pediatric lower urinary tract dysfunction implemented within an interprofessional clinic. Children (Basel). 2019;6:88.
9. Buckley BS, Sanders CD, Kwong JS, Kilpatrick KA, Anderson CA. Conservative treatment for functional daytime urinary incontinence in children. Cochrane Database Syst Rev. 2016;2016:CD012651.
10. de Jong TP, Klijn AJ, Vijverberg MA, de Kort LM, van Empelen R, Schoenmakers MA. Effect of biofeedback training on paradoxical pelvic floor movement in children with dysfunctional voiding. Urology. 2007;70:790 3.
11. Paepe HD, Renson C, Hoebeke P, Raes A, Laecke EV, Walle JV. The role of pelvic floor therapy in the treatment of lower urinary tract dysfunctions in children. Scand J Urol Nephrol. 2002;36:260 7.
12. Ladi Seyedian S S, Sharifi Rad L, Nabavizadeh B, Kajbafzadeh A M. Traditional biofeedback vs pelvic floor physical therapy—is one clearly superior? Curr Urol Rep. 2019;20:41.
13. Ladi Seyedian S S, Sharifi Rad L, Kajbafzadeh A M. Pelvic floor electrical stimulation and muscles training: a combined rehabilitative approach for management of non neuropathic urinary incontinence in children. J Pediatr Surg. 2019;54:825 30.
14. Messelink B, Benson T, Berghmans B, Bø K, Corcos J, Fowler C, et al. Standardization of terminology of pelvic floor muscle function and dysfunction: report from the pelvic floor clinical assessment group of the International Continence Society. Neurourol Urodyn. 2005;24:374 80.
15. Neumann P, Gill V. Pelvic floor and abdominal muscle interaction: EMG activity and intra abdominal pressure. Int Urogynecol J. 2002;13:125 32.
16. Zivkovic V, Lazovic M, Vlajkovic M, Slavkovic A, Dimitrijevic L, Stankovic I, et al. Diaphragmatic breathing exercises and pelvic floor retraining in children with dysfunctional voiding. Eur J Phys Rehabil Med. 2012;48:413 21.
17. Ladi Seyedian SS, Sharifi Rad L, Ebadi M, Kajbafzadeh A M. Combined functional pelvic floor muscle exercises with Swiss ball and urotherapy for management of dysfunctional voiding in children: a randomized clinical trial. Eur J Pediatr. 2014;173:1347 53.
18. Park C, Yoon S, Yoon H, Kim K, Cha Y, Park I. Effects of core stabilization exercise on muscle activity during horizontal shoulder adduction with loads in healthy adults: a randomized controlled study. J Mech Med Biol. 2021;21:2140049.
19. Frank C, Kobesova A, Kolar P. Dynamic neuromuscular stabilization & sports

rehabilitation. Int J Sports Phys Ther. 2013;8:62.
20. Hutson M, Ward A. Oxford Textbook of Musculoskeletal Medicine. Oxford: Oxford University Press; 2015.
21. Kolář P, Šulc J, Kynčl M, Šanda J, Čakrt O, Andel R, et al. Postural function of the diaphragm in persons with and without chronic low back pain. J Orthop Sports Phys Ther. 2012;42:352 62.
22. Milić Z. The effects of neuromuscular stabilization on increasing the functionality and mobility of the locomotor system. Sports Science and Health. 2020;19:54 9.
23. Kim D H, An D H, Yoo W G. Effects of 4 weeks of dynamic neuromuscular stabilization training on balance and gait performance in an adolescent with spastic hemiparetic cerebral palsy. J Phys Ther Sci. 2017;29:1881 2.
24. Akbal C, Genc Y, Burgu B, Ozden E, Tekgul S. Dysfunctional voiding and incontinence scoring system: quantitative evaluation of incontinence symptoms in pediatric population. J Urol. 2005;173:969 73.
25. Bauer SB, Nijman RJ, Drzewiecki BA, Sillen U, Hoebeke P. ICCS standardization report on urodynamic studies of the lower urinary tract in children. Neurourol Urodyn. 2015;34:640 7.
26. Austin PF, Bauer SB, Bower W, Chase J, Franco I, Hoebeke P, et al. The standardization of terminology of lower urinary tract function in children and adolescents: update report from the ICCS. Neurourol Urodyn. 2016;35:471 81.
27. Johnson EK, Bauer SB. Neurogenic voiding dysfunction and functional voiding disorders: evaluation and nonsurgical management. In: The Kelalis–King–Belman Textbook of Clinical Pediatric Urology. Boca Raton: CRC Press; 2018. p. 820 52.
28. Mahdieh L, Zolaktaf V, Karimi MT. Effects of dynamic neuromuscular stabilization training on functional movements. Hum Mov Sci. 2020;70:102568.
29. Sener NC, Altunkol A, Unal U, Ercil H, Bas O, Gumus K, et al. Can a four session biofeedback regimen be used effectively for treating children with dysfunctional voiding? Int Urol Nephrol. 2015;47:5 9.
30. Erasmie U, Lidefelt K J. Accuracy of ultrasonic assessment of residual urine in children. Pediatr Radiol. 1989;19:388 90.
31. de Paula Lima PO, de Oliveira RR, Costa LOP, Laurentino GEC. Measurement properties of the pressure biofeedback unit in the evaluation of transversus abdominis muscle activity: a systematic review. Physiotherapy. 2011;97:100 6.
32. Falla D, O'Leary S, Farina D, Jull G. Change in deep cervical flexor activity after training is associated with pain reduction in chronic neck pain. Clin J Pain. 2012;28:628 34.
33. Barton B, Peat J. Medical Statistics: A Guide to SPSS, Data Analysis and Critical Appraisal. Chichester: John Wiley & Sons; 2014.
34. Chang SJ, Van Laecke E, Bauer SB, von Gontard A, Bagli D, Bower WF, et al. Treatment of daytime urinary incontinence: ICCS standardization document. Neurourol Urodyn. 2017;36:43 50.
35. Kopru B, Ergin G, Ebiloglu T, Kibar Y. Does biofeedback therapy improve quality of life in children with lower urinary tract dysfunction: parents' perspective. J Pediatr Urol. 2020;16:38.e1–e7.
36. Fazeli MS, Lin Y, Nikoo N, Jaggumantri S, Collet J P, Afshar K. Biofeedback for nonneuropathic daytime voiding disorders in children: systematic review and meta analysis. J Urol. 2015;193:274 80.
37. Berg Poppe P, Christensen M, Koskovich N, Stephenson C. Pelvic floor muscle resting tone in children with dysfunctional voiding symptomology following simple gross motor exercises. Pediatr Phys Ther. 2022;34:28 35.
38. McKenna PH, Herndon CA, Connery S, Ferrer FA. Pelvic floor muscle retraining for pediatric voiding dysfunction using interactive computer games. J Urol. 1999;162:1056 62.
39. Vesna Z, Milica L, Marina V, Andjelka S, Lidija D. Correlation between uroflowmetry parameters and treatment outcome in children with dysfunctional voiding. J Pediatr Urol. 2010;6:396 402.
40. Bower WF, Yew S, Sit K, Yeung C. Half day urotherapy improves voiding parameters in children with dysfunctional emptying. Eur Urol. 2006;49:570 4.
41. Son MS, Jung DH, You JSH, Yi CH, Jeon HS, Cha YJ. Effects of dynamic neuromuscular stabilization on diaphragm movement, postural control, balance and gait performance in cerebral palsy. NeuroRehabilitation. 2017;41:739 46.
42. Sapsford R. Rehabilitation of pelvic floor muscles utilizing trunk stabilization. Man Ther. 2004;9:3 12.
43. Ghaderi F, Mohammadi K, Sasan RA, Kheslat SN, Oskouei AE. Effects of stabilization exercises focusing on pelvic floor muscles on low back pain and urinary incontinence in women. Urology. 2016;93:50 4.