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Clinical efficacy of transcutaneous pelvic floor magnetic stimulation combined with urination training in the treatment of overactive bladder in children

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Abstract

Objective This study aimed to evaluate the clinical effect of transcutaneous pelvic floor magnetic stimulation combined with urination training in the treatment of overactive bladder (OAB) in children.

Methods In this study, the clinical data of 42 children with OAB who were treated with transcutaneous pelvic floor magnetic stimulation combined with the urination training method at our hospital from March 2022 to December 2022 (Group B) were collected. The clinical data of 50 children with OAB who were treated with the urination training method at our hospital from December 2021 to February 2022 (Group A) were used as controls. The clinical efficacy of treatment was compared between the two groups.

Results After 2 weeks of treatment, the Akbal scale scores of the two groups were significantly lower than those before treatment ($P < 0.05$). After two weeks of treatment, the Akbal score of Group B was significantly lower than that of Group A ($P < 0.05$). The maximum voiding volume (MVV), average voiding volume (AVV), maximum urinary flow rate, average urinary flow rate and voiding frequency significantly differed between the two groups as well as before and after treatment ($P < 0.05$). Specifically, the MVV, AVV and maximum urinary flow rate, average urinary flow rate and voiding frequency significantly differed between the two groups after treatment, and the improvement value of Group B was greater than that of Group A ($P < 0.05$). After 2 weeks of treatment, the Akbal score revealed that the degree of improvement in frequent urination throughout the day, the degree of urgency and quality of life of patients in Group B were significantly greater than those in Group A ($P < 0.05$).

Conclusion Transcutaneous pelvic floor magnetic stimulation combined with urination training was effective in the treatment of children with OAB. Compared with urination training alone, this method can achieve better therapeutic effects and can more effectively improve the symptoms, bladder capacity and urination function of children after 2 weeks of treatment.

Keywords Transcutaneous pelvic floor magnetic stimulation, Urination training, Overactive bladder, Children

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Introduction

Overactive bladder (OAB) is a common functional bladder disease in childhood. The International Children's Continence Society (ICCS) defines it as "urgency, usually accompanied by urinary frequency and nocturnal enuresis, with or without combined daytime urinary incontinence, no urinary tract infection or other obvious pathological neurological symptoms", and it is the most common urinary dysfunction in children [1]. Because symptoms occur frequently and daily, they are not only a serious physiological burden for children but also for their families, which seriously affects the children's daily life, growth and development. Urination training, also known as behaviour therapy, is the first recommended treatment for OAB defined by the ICCS [1]. However, urination training is only effective in 44% of children overall [2]. As a second-line treatment, drug therapy (anticholinergic drugs) consists mostly of pills, which have low compliance in children and many adverse reactions, such as dry mouth and dizziness. Studies have shown that the incidence of adverse reactions can reach 3%-23%, whereas patch preparations easily cause skin allergies [3, 4]. In recent years, the urination training method combined with biofeedback therapy has achieved good results, increasing the overall remission rate to 70% [5–7]. However, biofeedback therapy requires the placement of a probe in the rectum and the cooperation of instruments and equipment for training, which is painful. Cooperation is very difficult for many children with severe urgency and daytime urinary incontinence, which also greatly reduces treatment compliance. The search for effective treatment methods that are noninvasive and have few side effects consistently been popular but challenging in the field of paediatric urology.

In recent years, scientists have developed a new technique, magnetic stimulation, for the treatment of lower urinary tract dysfunction. Studies have shown that transcutaneous pelvic floor magnetic stimulation can increase bladder capacity, improve urination frequency, and significantly improve the quality of life of patients [8]. However, few reports exist on the use of pelvic floor magnetic stimulation in the treatment of OAB in children. This study summarizes the clinical experience of transcutaneous pelvic floor magnetic stimulation combined with urination training in the treatment of children with OAB at our hospital and analyses the clinical effect of this method in the treatment of OAB.

Methods

Transcutaneous pelvic floor magnetic stimulation has been implemented at our hospital since March 2022, and since then, transcutaneous pelvic floor magnetic stimulation combined with the urination training method has been used to treat children with OAB. In this study, the clinical data of 42 children with OAB who were treated with transcutaneous pelvic floor magnetic stimulation combined with the urination training method at our hospital from March 2022 to December 2022 (Group B) were collected. The clinical data of 50 children with OAB who were treated with the urination training method in our hospital from December 2021 to February 2022 (Group A) were used as controls. The clinical efficacy of the two groups was compared.

The inclusion criterion was children with OAB treated at our hospital. The exclusion criteria were as follows: (1) neurogenic bladder; (2) urinary incontinence due to other reasons; (3) urinary tract infection; (4) structural abnormalities of the urinary system; and (5) incomplete clinical data.

The diagnostic criteria for OAB include the following: (1) daytime frequency of urination exceeding 12 times per day; (2) presence of symptoms, including urgent urinary incontinence and nocturnal enuresis; and (3) noninvasive uroflowmetry indicating that each voided volume exceeds 50 ml, a low urine flow rate and volume, or a linear wave pattern consistent with typical OAB urine flow changes. If noninvasive uroflowmetry indicates that the voided volume is less than 50 ml, the result is considered unreliable and could not be included in this study. (4) Postvoid residual examination showing less than 20 ml of residual urine in the bladder; (5) absence of other neurological bladder diseases and no evidence of urinary tract infection [9].

Treatment methods

Urination training

Lifestyle adjustment Patients should avoid carbohydrates, chocolate, caffeine, and cold and raw foods. Patients should continue to drink an appropriate amount of water every day. The normal water intake for children is 70–125 ml/(d•kg), and the recommended water intake is 50–100 ml/hour. Water intake decreased by 25 ml/kg every 3 years of age increase.

Constipation management In addition to the above drinking water program, patients should supplement with an appropriate amount of fibre daily, such as low-sugar carrots and apples. Patients should be physically active and avoid sitting for long periods of time. A good biological clock of regular daily bowel movements should be established to avoid delayed bowel movements. If constipation is serious, probiotics can be properly supplemented daily, and if necessary, lactulose treatment can be adopted.

Urination training 1) Urination posture: The physician should provide guidance on the correct urination posture and techniques. The boys stood with their legs apart and their hips slightly tilted forwards. Attention should be

concentrated when urinating to avoid interruption. When urinating, attention should be given to avoid pants pressing on the urethra to affect urination. Girls should pay attention to separating their legs when urinating to reduce urinary resistance and vaginal regurgitation.

2) Instructing regular urination: Timed urination training is triggered by a timed watch alarm clock as follows. We set the electronic watch ringing time from 40 min, and the alarm sound was the signal to allow urination (once the alarm rings, the patient must urinate. The patient cannot urinate without an alarm). After 40 min of regular training, if the child tolerates the procedure and can comply with this urination time agreement, the urination reminder time can be extended to 60 min. The timed urination training was then gradually extended to 2 h. The training time ranged from waking up in the morning to sleeping at night. If the child did not cooperate training, parents can engage the child in distracting activities, such as sports, playing games, listening to a story or using electronic products.

Transcutaneous pelvic floor magnetic stimulation

Therapeutic positions and positioning methods The patient was seated in an upright position. The seat magnetic field probe featured a ring bullseye in the middle corresponding position as a positioning mark. The centre line of the ischiatic tubercle of the buttock in children should be located at the centre of the target circle. The waist can be supported by pillows, and the legs can be separated according to the seat sign. (Fig. 1)

Adjustment of the parameters A pelvic floor magnetic stimulator (Nanjing Weisi Company, China) was used. After the patient's position was adjusted properly, the mode was set to pelvic floor muscle stimulation. The stimulus pulse frequency was set at 15 Hz, the contraction stimulus duration was set at 5 s, and the relaxation duration was set at 5 s. The initial stimulus intensity values started at 20% and increased by 5% each time. The patients were asked about their subjective feelings during each adjustment, and the optimal stimulation intensity was that one that can produce anal contraction without tingling. The treatment duration was 20 min.

Treatment cycle Magnetic stimulation therapy and urination training therapy were performed simultaneously. The first 1–6 treatments were performed once per day, and the 7–10 treatments were performed once every other day. A total of 2 weeks is a course of treatment. The ICCS treatment effect was scored at the end of the course. The therapeutic effect in all patients was reassessed at 2 weeks after treatment. The maximum voiding volume (MVV) and average daily voiding volume (AVV) were measured 48 h prior to hospital readmission. Each patient's MVV and AVV were adjusted by expected bladder capacity (EBC), expressed as a percentage of EBC (MVV/EBC%, AVV/EBC%). During the follow-up examination at week 2, the noninvasive urine flow rate was measured via urodynamic detection equipment (Laborie, China), and the maximum and average urine flow rates were recorded.

The Akbal scale was used to score OAB symptoms before and after treatment [10]. The Akbal score, which was originally developed and validated by Akbal et al., is one of the most widely used scales for assessing dysfunctional voiding and has been applied in several studies. The score consists of 14 questions, 13 related to lower urinary tract symptoms and one related to quality of life. Questions one and two inquire about daytime incontinence, and questions three and four inquire about enuresis nocturna. Four questions (numbers 5, 10, 11, and 12) gather data on filling-phase symptoms, and five questions (numbers 6–9 and 13) gather data on voiding symptoms. Question 14 concerns quality of life. The higher the score is, the more severe the symptoms become. (Fig. 2)

Statistical analysis

SPSS 25.0 was used to perform the statistical analysis. Continuous data are presented as medians and quartiles. Comparisons between groups of continuous variables with a normal distribution deviation were performed via the t test. Continuous variables without a normal distribution deviation were compared through the Mann–Whitney U test. A paired t test was used to compare the effects before and after treatment. Comparisons between groups of categorical variables were performed via Fisher's exact test. A p value of <0.05 was considered to indicate statistical significance.

Results

A total of 92 children were included in this study, including 50 patients in Group A and 42 patients in Group B. All the patients' preoperative clinical data are shown in Table 1. Sex, age, Akbal scale score, MVV, AVV, maximum urine flow rate, average urine flow rate, voiding frequency or incontinence/urgency did not significantly differ between groups (Table 1).

After 2 weeks of treatment, the Akbal scale scores of the two groups were significantly lower than those before treatment ($P<0.05$). After two weeks of treatment, the Akbal score of Group B was significantly lower than that of Group A ($P<0.05$), which indicated that the OAB symptoms of the two groups were relieved after treatment, and the degree of relief of Group B was better than that of Group A. The MVV, AVV, maximum urinary flow rate, average urinary flow rate and voiding frequency significantly differed between the two groups before and after treatment ($P<0.05$). The MVV, AVV and maximum

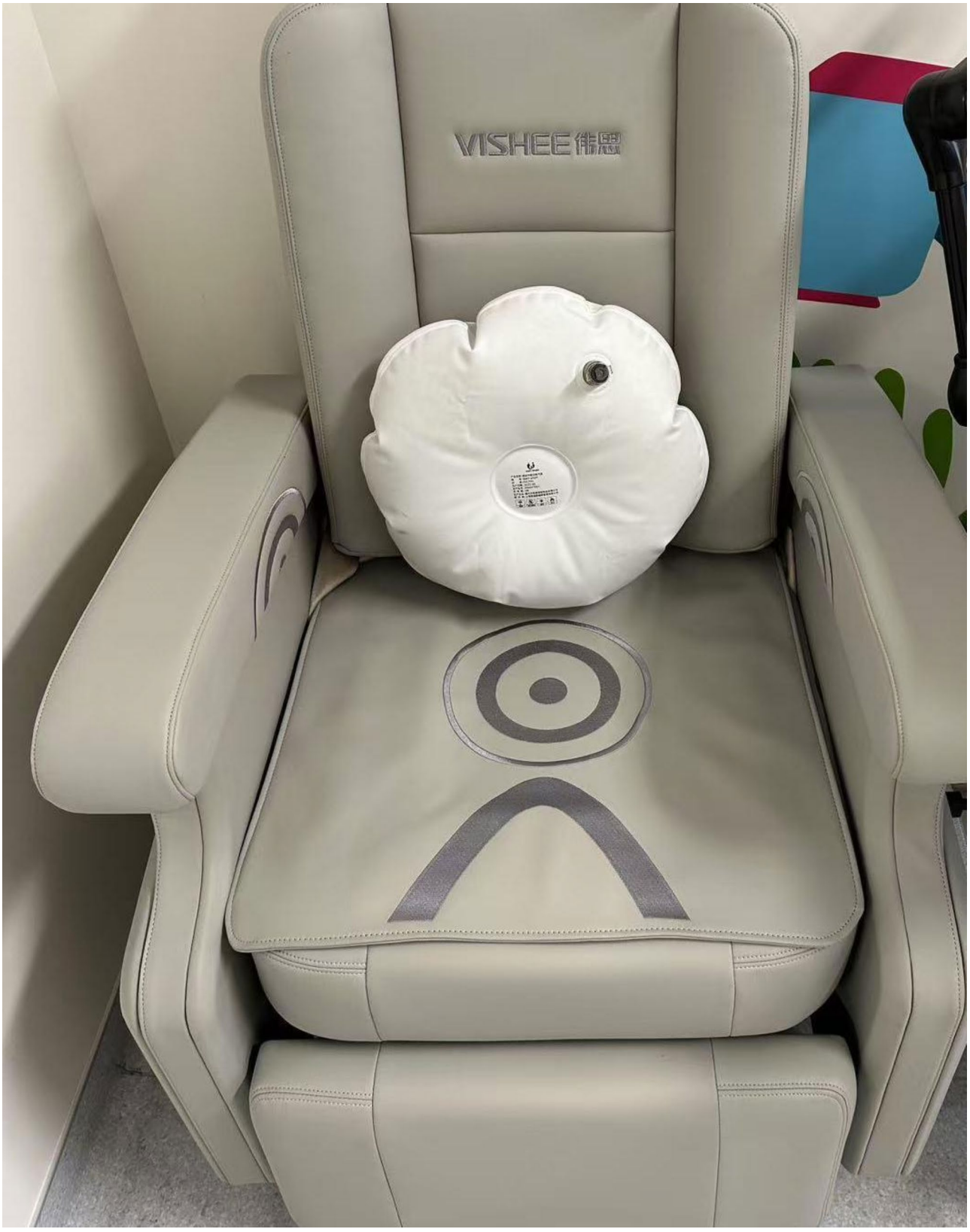

Fig. 1 The seat of the pelvic floor magnetic stimulator

1. Does your child have a urinary incontinence(pee while without in the toilet)during the day?	No	sometimes	1-2 times/day	3 or more times/day
	0	1	3	5
2. If Yes to question 2	A few drops	Only underwear wet	Outer clothing layers wet	
	1	3	5	
3. Does your child have a urinary incontinence(pee while without in the toilet)during the night?	No	1-2 nights/week	3-5 nights/week	6-7nights/week
	0	1	3	5
4. If Yes to question 4	Underwear wet		Bed wet	
	1		4	
5. my child goes toilet to pee...	Less than 7 times/day		7 or more times/day	
	0		1	
6. my child has to strain to pee	No		Yes	
	0		3	
7. my child experience pain when she/he pees	No		Yes	
	0		1	
8. my child pees intermittently when on toilet	No		Yes	
	0		2	
9. my child has to revisit the toilet soon after he/she pees	No		Yes	
	0		2	
10. my child has to run to the toilet when he/she need to pee	No		Yes	
	0		1	
T1. my child can hold his/her pee by crossing legs or "pee dance	No		Yes	
	0		2	
12. my child wet his/her clothes before he/she get to the toilet	No		Yes	
	0		2	
13. My child does not pass stool every day.	No		Yes	
	0		2	
QUALITY OF LIFE				
If your child experience any of the symptoms/issues mentioned above, does this affect his/her family life or social life?	Not at all	Sometimes	Seriously affect	
	0	1	5	

Fig. 2 Detailed items of the Akbal scale

Table 1 Comparison of the urinary situation of the two groups before treatment

	Group A	Group B	*P*
Age (year)	6 (5, 7)	6 (5.8, 8)	0.247
Boys/Girls	29/21	20/22	0.320
Akbal scale score	9 (6, 15)	11.5 (7, 15)	0.145
MVV/EBC%	51.0 (46.8, 55.3)	48.0 (40.5, 55.3)	0.158
AVV/EBC%	40.0 (34.8, 45.0)	39.0 (32.0, 46.5)	0.903
Maximum uroflow rate	20.1 (18.6, 23.7)	20.2 (16.7, 22.5)	0.295
Average uroflow rate	13.3 (12.3, 15.7)	13 (10.6, 14.9)	0.194
Voiding frequency (/day)	17 (12.8, 20)	16 (10.8, 20)	0.579
Incontinence / urgency	19 (38%)	22 (52.4%)	0.167

urinary flow rate, average urinary flow rate and voiding frequency significantly differed between the two groups after treatment, and the improvement value of Group B was greater than that of Group A ($P<0.05$). The effectiveness of the treatments of group B was significant better than group A according to ICCS ($P<0.05$). (Table 2)

After 2 weeks of treatment, the Akbal score revealed that the degree of improvement in frequent urination throughout the day, the degree of urgency and the quality of life of patients in Group B were significantly better than those in Group A ($P<0.05$). (Table 3)

Table 3 Comparison of the number of patients with improvement in Akbal scale score in the two groups after treatment

	Group A	Group B	*P*
Urinary incontinence	0 (0, 1)	0 (0, 1)	0.476
Wet pants	0 (0, 1)	0 (0, 1)	0.476
Nocturnal enuresis	0 (0, 0)	0 (0, 0)	0.587
Degree of enuresis	0 (0, 0)	0 (0, 0)	0.570
Frequent urination throughout the day	1 (0, 1)	0 (0, 1)	0.000
Difficult urination	0 (0, 0)	0 (0, 0)	0.371
Painful urination	0 (0, 0)	0 (0, 0)	0.117
Emiction interruption	0 (0, 0)	0 (0, 0)	1.000
Not enough to urinate	2 (0, 2)	0 (0, 2)	0.006
Degree of urgency	0 (0, 1)	0 (0, 0)	0.008
Stamp your feet to hold your urine	0 (0, 0)	0 (0, 0)	0.381
Wet pants in front of the toilet	0 (0, 0)	0 (0, 0)	0.680
Conditions of constipation	0 (0, 0)	0 (0, 0)	0.83
Quality of life	1 (0.75, 1)	0 (0, 1)	0.008

Discussion

OAB is a very common functional bladder disease in childhood. Urination training is a first-line treatment recommended by the ICCS. However, when the time was set for 2 h and the child was instructed to urgently urinate in the clinical application of this method, parents often faced uncertainty regarding whether to rely solely on the predetermined time for training or allow the child to express their need to urinate before using the toilet. This dilemma can lead to reduced compliance with the training program and consequently yield unsatisfactory outcomes. In contrast, for children experiencing daytime urge urinary incontinence, a duration of 2 h often exceeds their tolerance threshold. Some parents rigidly adhered to this time limit, inadvertently causing harm to their child by prolonging their discomfort and maintaining a state of wet pants throughout the day without relief. Therefore, the use of the urination training method alone is not ideal, and the overall cure rate of OAB is only 50-70%. As a second-line treatment, most anticholinergic drugs are administered in the form of tablets. Children have low compliance with medication and many side effects, such as dry mouth and vertigo. Studies have shown that the incidence of adverse reactions is 3-23%, and patch preparations easily cause skin allergies [3, 4]. Scientists have developed transcutaneous sacral nerve stimulation therapy for paediatric patients with refractory recurrent episodes and severe urgency incontinence that are unresponsive to bladder training [11–13]. Cui H et al. conducted a meta-analysis on the application of transcutaneous electrical stimulation in the treatment of OAB in children and concluded that transcutaneous electrical stimulation could effectively increase the MVV and AVV [14]. Ebert KM et al. used electrical stimulation

Table 2 Comparison of the urinary situation of the two groups after treatment

	Group A	Group B	*P*
Akbal scale score	4 (2, 8.3)*	2.5 (0, 6.3)*	0.018
MVV/EBC%	67.0 (54.0, 81.0)*	74.0 (64.0, 84.8)*	0.039
AVV/EBC%	51.0 (41.8, 62.0)*	58.5 (49.5, 71.0)*	0.025
Maximum uroflow rate	17.3 (15.3, 20.0)*	14.2 (11.6, 16.2)*	0.000
Average uroflow rate	12.3 (10.8, 14.3)*	10.6 (8.8, 12.2)*	0.001
Voiding frequency (/day)	10 (6, 15)*	6 (5, 7)*	0.000
Incontinence / urgency	17 (34%)	11 (26.2%)*	0.417
The effectiveness of the treatments			
Unresponsive by ICCS	8 (16%)	2 (4.8%)	0.044
Partial responder by ICCS	23 (46%)	14 (33.3%)	
Complete responder by ICCS	19 (38%)	26 (61.9%)	

* indicated that compared with pre-treatment data there was a statistically significant difference ($P<0.05$)

to treat OAB in children for 12 weeks and achieved good therapeutic effects [15]. However, some scholars have come to the opposite conclusion: the cure rate of OAB in children treated with urination training combined with transcutaneous electrical stimulation is not greater than that of urination training alone [16]. Sillen U et al. reported that the remission rate of transcutaneous electrical stimulation in the treatment of refractory OAB children was similar to that of urination training and that the efficacy of the combination of the two was not better than that of urination training alone [17]. Moreover, transcutaneous electrical stimulation involves attaching electrodes to the skin, adjusting the position of the child to cooperate with the treatment, and can only be used as a treatment mode of sacral neuromodulation, which is limited by the convenience of use. How to improve the cure rate of OAB in children, shorten the cure time, and find an effective treatment without trauma or side effects has been the focus of research in the field of OAB.

In recent years, scientists have invented pelvic floor magnetic stimulation therapy technology, which relies on electrical stimulation instruments. This approach is a new technology for the treatment of abnormal lower urinary tract function [18–21]. Pelvic floor magnetic stimulation therapy uses the principle of electromagnetic induction and does not require the placement of electrodes at the stimulation site. The pulsed magnetic field generated by the pelvic floor magnetic stimulator can penetrate clothing, bones and other tissues and generate an induced electric field at the stimulation site. The action site is near the pelvic floor muscles and sacral nerve 3. The magnetic field pulse accurately induces small current flow in the tissue, which can induce the depolarization of nerve axons and then trigger the propagation of nerve impulses. The subsequent release of ACH leads to depolarization and contraction of the corresponding muscle fibres, and the repeated activation of muscle activity caused by nerve depolarization can increase muscle strength and endurance, thereby changing the activity of the pelvic floor muscle group. Because the magnetic stimulation probe device does not need to contact the skin and is set on a special seat, the child only needs to sit in the designated position to receive treatment, without contact, pain or a forced position, which greatly improves the acceptance and cooperation of the child and makes the treatment of OAB children easier. Wu J et al. applied magnetic stimulation technology to the treatment of enuresis in children and reported that transcutaneous magnetic stimulation could reduce the degree and frequency of enuresis in children, increase the bladder capacity of children, and improve the total effective rate of treatment [22]. At present, few reports exist on the use of transcutaneous pelvic floor magnetic stimulation in the treatment of OAB in children. This study summarizes the clinical experience of transcutaneous pelvic floor magnetic stimulation combined with urination training in the treatment of children with OAB in our hospital and analyses the clinical effect of this method in the treatment of OAB. The results of this study revealed that after 2 weeks of treatment, the Akbal scale scores of the two groups were significantly lower than those before treatment, and the Akbal scale scores of Group B were significantly lower than those of Group A, which indicated that the OAB symptoms of the two groups were relieved after treatment and that the degree of relief in Group B was better than that in Group A. MVV, AVV, maximum flow rate and average flow rate of the two groups improved after treatment, and the improvements in MVV, AVV and maximum urinary flow rate in Group B were greater than those in Group A. Thus, the effect of transcutaneous pelvic floor magnetic stimulation combined with urination training in the treatment of OAB was better than that of urination training alone.

After 2 weeks of treatment, the scores of daily urination frequency, incomplete urination, urgency and quality of life on the Akbal scale of Group B were significantly improved compared with those of Group A. Among all the lower urinary tract symptoms, frequent urination and incomplete urination are the main reasons for the visits of most children with OAB, which directly affect their quality of life [23]. The application of magnetic stimulation therapy can modulate the activity of pelvic floor muscles and bladder detrusors in children via the use of magnetic currents. This intervention influences the discharge pattern of detrusor bioelectricity, regulates bladder function through targeted electrical stimulation frequencies, and normalizes the release of bladder bioelectricity via consistent stimulation intensity at rated frequencies. Consequently, this treatment approach effectively addresses issues related to frequent urination and urinary incontinence [24].

After treatment, the improvements in MVV and AVV in Group B were significantly greater than those in Group A, and the improvements in the maximum urinary flow rate and average urinary flow rate in Group B were also significantly greater than those in Group A. Transcutaneous pelvic floor magnetic stimulation therapy not only reduces the unstable contraction of the bladder but also improves bladder stability during receptivity, thereby restoring resting bladder capacity and facilitating prompt recovery of sensory and motor function in children's bladders [25]. Consequently, even with only a 2-week treatment duration, significant improvements in urine output and symptom scores were observed when this approach was combined with effective training. However, due to the treatment time only being two weeks, although the findings of group B was significantly better than group A, it was seen that the bladder capacity

parameters were still far from normal values. We would continue to conduct studies with long-term follow-up.

This study had several limitations. (1) This work was a single-centre study with a small number of cases. (2) This work was a retrospective study. (3) The duration of follow-up was only 2 weeks, which is a short-term efficacy follow-up. Long-term follow-up is very important for evaluating treatment efficacy, and further studies are needed.

Conclusion

Transcutaneous pelvic floor magnetic stimulation combined with urination training was effective in the treatment of children with overactive bladders. Compared with the urination training method alone, the urination training method can achieve better therapeutic effects within 2 weeks and can more effectively improve the symptoms, bladder capacity and urination function of children.

Abbreviations

OAB	Overactive bladder
MVV	Maximum voiding volume
AVV	Average voiding volume
ICCS	Intenational children's continence society
EBC	Expected bladder capacity

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Author contributions

LKN and CX conceptualized and designed the study, and they also assisted with drafting or revision of the paper. YBQ and XLY wrote the manuscript and collected the data. CZQ performed data analysis. The authors have read and approved the final manuscript.

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Data availability

The datasets of the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the ethics committee of Fujian Children's Hospital and strictly adhered to the tenets of the Declaration of Helsinki. In addition, the parents or guardians of the patients gave written informed consent for their respective minors to participate in the study.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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