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Original Article

Effects of electromyographic (EMG) biofeedback-guided pelvic floor muscle training on postpartum stress urinary incontinence

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Abstract: Objective: The aim of this study was to explore the efficacy of electromyographic (EMG) biofeedback-guided pelvic floor muscle training (PFMT) on postpartum stress urinary incontinence (PSUI). Methods: One hundred patients with PSUI were selected and randomly divided into an observation group and control group, according to different treatment options. Patients in the observation group received EMG biofeedback-guided pelvic floor muscle training, while those in the control group underwent regular Kegel exercises, specific for PSUI. Follow-ups were initiated 1 month after treatment and continued for 6 months. Changes in indicators of recovery of pelvic muscle contractions were compared, including TOV, VTV, VF, LT, and changes in the potential of pelvic floor muscles. The response rate of therapy was also recorded for both groups. Results: In the observation group, VTV, TOV, and LT, after treatment, were significantly lower than those in the control group ($p<0.05$). Following treatment, VTV, TOV, and LT, in both groups, were significantly decreased compared to levels before treatment ($p<0.05$). Following treatment, VF and the potential in pelvic floor muscles in the observation group were higher than those in the control group ($p<0.05$). Intragroup comparisons showed that VF and potential of the pelvic floor muscles, in both groups, increased significantly compared to levels before treatment ($p<0.05$). Furthermore, the response rate in the observation group was significantly higher than in the control group ($p<0.001$). Conclusion: Compared to Kegel exercises, pelvic floor rehabilitation by PFMT shows promising efficacy for PSUI patients by enhancing contractions of pelvic floor muscles, with significant improvement in symptoms of urinary incontinence. Thus, it should be considered for clinical practice.

Keywords: Electromyographic (EMG) biofeedback-guided pelvic floor muscle training (PFMT), Kegel exercise, stress urinary incontinence, treatment efficacy

Introduction

Postpartum stress urinary incontinence (PSUI), also known as postpartum leakage of urine, refers to an acute increase in intraperitoneal pressure, causing unconscious urination due to the loss of contraction of the detrusor muscle [1, 2]. During pregnancy, as the uterus enlarges, a concomitant increase in intra-abdominal pressure causes laxity of the vagina. In addition, damaged muscles and nerves of the pelvic floor during delivery [3] may result in the loss of control over the urinary bladder. Subsequently, any acute increase in intraperitoneal pressure causes leakage of urine [4]. Incidence of postpartum urinary incontinence is as high as 45% to 55%, a common condition affecting pregnant and postpartum women [5, 6].

Various modalities are currently used for treatment of urinary incontinence, including postpartum rehabilitation of the pelvic floor muscles, through artificial massage or Kegel exercises [7, 8]. Recent development of a pelvic floor muscle rehabilitation apparatus has provided a new option for treatment of PSUI [9, 10]. This pelvic floor muscle rehabilitation apparatus is based on Kegel exercises and stimulates the muscles and nerve fibers in the pelvic floor through an electric shock, having a specific waveform, pulse width, and frequency. It induces contraction and relaxation of the muscles, which helps to recover strength of the pelvic floor. It can be used for treatment of symptoms caused due to relaxation of pelvic floor muscles [11, 12]. Studies have confirmed that the use of the pelvic floor muscle rehabili-

Table 1. General clinical data of the observation group and control group [n (%)]

Group		Observation group (n=50)	Control group (n=50)	X^2	*P*
Age	≤50	25 (50.00)	24 (48.00)	0.040	0.841
	＞50	25 (50.00)	26 (52.00)	0.040	0.841
Reproductive way	Transvaginal delivery	30 (60.00)	29(58.00)	0.041	0.839
	Line of cesarean delivery	20 (40.00)	21 (42.00)	0.041	0.839
Pelvic organ prolapse	Have	13 (26.00)	14 (28.00)	0.051	0.821
	No	37 (74.00)	36 (72.00)	0.051	0.821
Obesity	Have	23 (46.00)	24 (48.00)	0.040	0.841
	No	27 (54.00)	26 (52.00)	0.040	0.841
Family history of stress urinary incontinence	Have	8 (16.00)	10 (20.00)	0.271	0.603
	No	42 (84.00)	40 (80.00)	0.271	0.603
Hysterectomy	Have	10 (20.00)	9 (18.00)	0.065	0.799
	No	40 (80.00)	41 (82.00)	0.065	0.799
Smoking status	Have	13 (26.00)	12 (24.00)	0.053	0.817
	No	37 (74.00)	38 (76.00)	0.053	0.817
Estrogen decline	Have	25 (50.00)	27 (54.00)	0.160	0.689
	No	25 (50.00)	23 (46.00)	0.160	0.689
High intensity physical exercise	Have	9 (18.00)	10 (20.00)	0.065	0.799
	No	41 (82.00)	40 (80.00)	0.065	0.799

Table 2. Comparison of VTV (ml/72 h) before and after treatment between the observation group and control group

Group	Observation group (n=50)	Control group (n=50)	t	*P*
Before treatment	4467.04±1302.00	4565.23±1299.12	0.378	0.707
After treatment	3457.78±1011.00	4000.45±1116.05	2.548	0.012
t	4.580	2.422		
P	<0.001	<0.05		

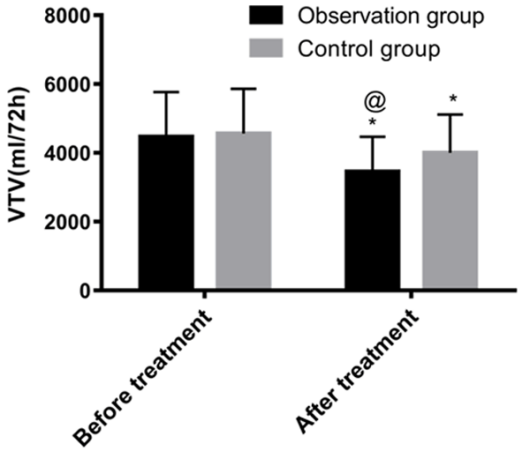

Figure 1. Comparison of VTV before and after treatment in the two groups of patients. Changes in the pelvic floor muscle recovery index were compared between the two groups. @ indicates that the VTV was significantly lower in the observation group than in the control group. Differences were statistically significant (P<0.05). VTV after treatment was significantly lower than that before treatment and differences were statistically significant (P<0.001, P<0.05).

tation apparatus, a novel nerve-muscle stimulator which relies on physiological responses to low-frequency pulses, is effective in the treatment of stress urinary incontinence and urgency of urine [13].

The present study compared the efficacy of Kegel exercises and the pelvic floor muscle rehabilitation apparatus on PSUI.

Materials and methods

General data

One hundred patients with PSUI were selected and randomly divided into an observation group (N=50) and control group (N=50). Patients in the observation group were treated with electromyographic (EMG) biofeedback-guided pelvic floor muscle training, while those in the control group underwent regular Kegel exercises, specific for PSUI. In the observation group, patients were aged between 27 and 67 years, with an average of (50.35±3.18) years. Dura-

Table 3. Comparison of TOV (times) before and after treatment between the observation group and control group

Group	Observation group (n=50)	Control group (n=50)	t	*P*
Before treatment	36.44±12.09	37.73±12.45	0.526	0.600
After treatment	25.33±7.99	32.84±9.31	4.328	<0.001
t	5.421	2.224		
P	<0.001	<0.05		

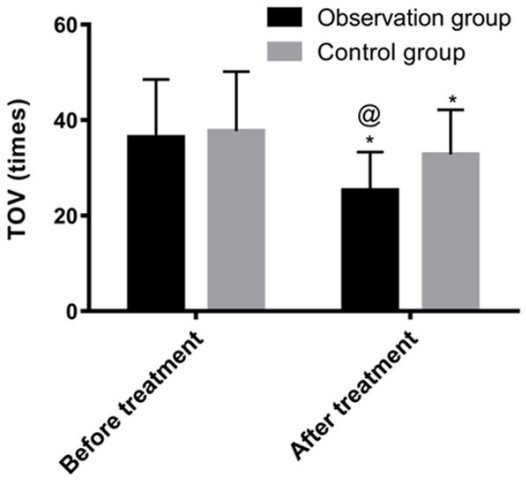

Figure 2. Comparison of TOV before and after treatment in the two groups of patients. Changes in pelvic floor muscle recovery indexes were compared between the two groups. @ indicates that the TOV of the observation group was significantly lower than that of the control group and differences were statistically significant (P<0.05); Within the group, * indicates the TOV of the group was significantly lower than that of the pre-treatment TOV and differences were statistically significant (P<0.001, P<0.05).

tion of symptoms ranged from 1 to 3 years, with an average duration of (1.91±0.90) years. In the control group, patients were aged between 28 and 66 years, with an average of (50.47± 3.22) years. Duration of symptoms ranged from 1 to 3 years, with an average duration of (2.00±0.81) years. Comparison of baseline data showed no statistically significant differences (p>0.05) between the groups (**Table 1**).

Inclusion and exclusion criteria: All enrolled patients admitted to the hospital for treatment conformed to international diagnostic criteria for PSUI [14]. Subjects undergoing other methods of treatment, surgery therapy, or with high severity and low hope for efficacy were excluded. Subjects with coexisting complications due to other diseases or urinary incontinence, caused by urinary tract infection or obstruction, were excluded as well. All patients and families were informed about the study and provided written informed consent.

Intervention

Control group: Patients underwent two-months of regular Kegel exercises: The vagina was elevated to close the vagina, urinary tract, and anus closely, holding for 3 to 5 seconds. Ten exercises comprised one group and at least 4 groups of exercises had to be completed. Subsequently, the ten exercises were gradually increased to 25 exercises. Thereafter, the vagina descended. This position was sustained for 3 seconds. This exercise was repeated 10 times, which comprised one group. At least 3 groups had to be completed. Gradually, 10 exercises were increased to 25 exercises. Finally, contraction of the pelvic floor muscles was sustained for 5 seconds, then slowly relaxed. After 5 to 10 seconds, the contraction was repeated.

Observation group: Two-months of EMG biofeedback-guided pelvic floor muscle training was provided using the pelvic floor muscle rehabilitation apparatus (Phenix USB 4, Guang-Zhou Shanshan Medical Apparatus & Instruments Industry Co., Ltd.). A probe was inserted into the vagina of the patients and an electric shock (50 Hz, 250 μs) was administered. This was to familiarize the patients with the stimulus. Subsequently, the electric shock was adjusted to 8 to 32 Hz and 320 to 740 μs to induce contractions of the pelvic floor muscles, thus building strength in the muscle fibers. Finally, the module exercises were performed to recover the contraction and coordination of the muscle was distributed between the abdomen and perineum. Each session lasted for 30 minutes or 40 minutes, 9 times per month. The treatment consisted of 10 to 15 sessions.

Criteria of efficacy

Two months following treatment and rehabilitation of the pelvic floor muscles, patients were evaluated using the following criteria. The follow-up period was 6 months, performed by regular telephone follow-ups and on-site visits.

Excellence: Full contraction of the pelvic floor muscles, sustained for more than 5 seconds, with a significant improvement in symptoms.

Table 4. Comparison of VF (ml) before and after treatment between the observation group and control group

Group	Observation group (n=50)	Control group (n=50)	t	*P*
Before treatment	116.02±45.23	116.55±43.79	0.060	0.953
After treatment	172.39±49.04	143.46±43.66	3.116	0.002
t	6.014	3.027		
P	<0.001	<0.05		

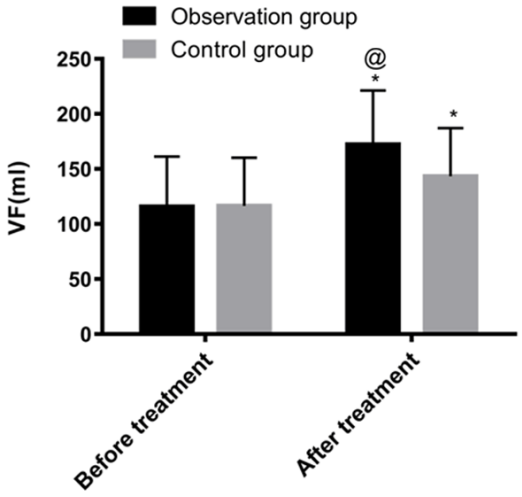

Figure 3. Comparison of VF before and after treatment in two groups of patients. Changes in the pelvic floor muscle recovery index were compared between the two groups. @ indicates that the VF of the observation group was significantly higher than that of the control group and differences were statistically significant (P<0.05); Within the group, * indicates the VF of the group was significantly higher than that of the pre-treatment VF and differences were statistically significant (P<0.001, P<0.05).

Improvement: Full contraction of the pelvic floor muscles, sustained for 2 to 4 seconds in 2 to 4 of antagonizations of the contraction, with improved symptoms or reduction of 50% or more in LT. Failure: Patients could contract the muscles only once. No muscle contractions sustained for less than 1 second in antagonization, with no relief in symptoms, and a reduction in LT less than 50%. Total response rate = excellence rate + improvement rate.

Outcome measures

Follow-ups were performed 2 months after treatment, comparing changes in the indicators of recovery in pelvic floor muscles, including TOV, VTV, VF, LT, and changes in the potential of pelvic floor muscles. Moreover, total response rates were determined for patients in both groups.

Statistical methods

SPSS 19.0 software (IBM, New York, USA) was used for statistical analysis. Measurement data are expressed in the form of mean ± standard deviation. Paired t-test was used for intra-group comparisons. Independent t-test was used for comparisons between groups. Numerical data were compared using Chi-squared test. *P*<0.05 indicates statistical significance.

Results

General clinical data of patients in the two groups

Clinical data of patients in the two groups, including age, delivery type, pelvic organ prolapse, obesity, history of PSUI, hysterectomy, smoking history, decrease in estrogen, and highstrength exercise, were compared at baseline. There were no statistically significant differences between the groups (p>0.05; **Table 1**).

Recovery of pelvic floor muscle contraction in both groups before and after treatment

Comparison of VTVs before and after treatment in two groups: In the observation group and control group, VTVs before treatment were (4467.04±1302.00) mL/72 h and (4565.23±1299.12) mL/72 h respectively, with no statistically significant differences (p>0.05). After treatment, VTVs decreased to (3457.78±1011.00) mL/72 h and (4000.45±1116.05) mL/72 h, respectively. VTV in the observation group, after treatment, was significantly lower than that in the control group. Differences showed statistical significance (p<0.05). Intragroup comparisons, before and after treatment, showed that VTVs in both groups were lower than those before treatment (p<0.001 or 0.05; **Table 2** and **Figure 1**).

Comparison of TOVs before and after treatment in two groups: In the observation group and control group, TOVs before treatment were (36.44±12.09) times and (37.73±12.45) times, respectively, with no statistically significant differences (p>0.05) indicated. After treatment,

Table 5. Comparison of LT (times) before and after treatment between the observation group and control group

Group	Observation group (n=50)	Control group (n=50)	t	*P*
Before treatment	29.00±11.38	28.46±11.54	0.236	0.814
After treatment	12.99±6.02	22.96±7.02	7.623	<0.001
t	8.244	2.547		
P	<0.001	<0.05		

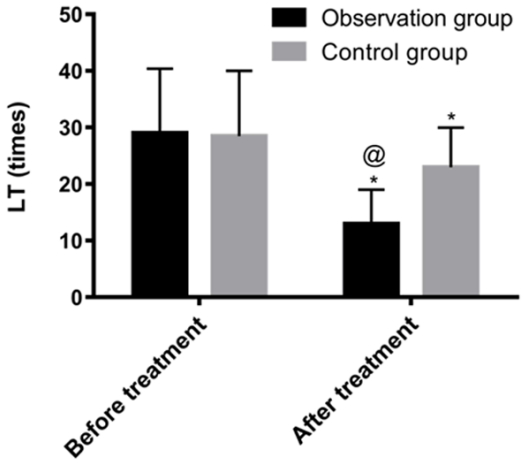

Figure 4. Comparison of LT before and after treatment in two groups of patients. Changes in the pelvic floor muscle recovery index were compared between the two groups. @ indicates that the LT was significantly lower in the observation group than in the control group and differences were statistically significant (P<0.001). The LT after treatment was significantly lower than that before treatment and differences were statistically significant (P<0.001, P<0.05).

TOVs decreased to (25.33±7.99) times and (32.84±9.31) times, respectively. TOV in the observation group, after treatment, was significantly lower than that in the control group. Differences showed statistical significance (p<0.001). Intragroup comparisons, before and after treatment, showed that TOVs in both groups were lower than those before treatment (p<0.001 or 0.05; **Table 3** and **Figure 2**).

Comparison of VFs before and after treatment in two groups: In the observation and control group, VFs before treatment were (116.02±45.23) mL and (116.55±43.79) mL, respectively, with no statistically significant differences (p>0.05) indicated. After treatment, VFs decreased to (172.39±49.04) mL and (143.46±43.66) mL, respectively. VF in the observation group after treatment was significantly higher than that in the control group, with statistically significant differences (p< 0.05). Intragroup comparisons, before and after treatment, showed that VFs in both groups were higher than before treatment (p<0.001 or 0.05; **Table 4** and **Figure 3**).

Comparison of LTs before and after treatment in two groups: In the observation and control group, LTs before treatment were (29.00±11.38) times and (28.46±11.54) times, respectively, with no statistically significant differences (p>0.05). After treatment, LTs de-creased to (12.99±6.02) times and (22.96±7.02) times, respectively. LT in the observation group, after treatment, was significantly lower than that in the control group, wi-th statistically significant differences (p<0.001). Intragroup comparisons, before and after treatment, showed that LTs in both groups were lower than before treatment (p<0.001 or 0.05; **Table 5** and **Figure 4**).

Comparison of changes in the potential of pelvic floor muscles before and after treatment in the two groups: In the observation and control group, the potential of pelvic floor muscles before treatment was (7.35±2.99) μV and (7.40±3.07)) μV, respectively, with no statistically significant differences (p>0.05). After treatment, the potential of pelvic floor muscles decreased to (31.98±6.02) μV and (15.67±3.51) μV, respectively. The potential of pelvic floor muscles in the observation group after treatment, was significantly higher than that in the control group. Differences showed statistical significance (p<0.001). Intragroup comparisons, before and after treatment, showed that the potential of pelvic floor muscles in both groups was higher than before treatment (p< 0.001; **Table 6** and **Figure 5**).

Total rate of effectiveness in the observation group and control group after treatment: In the observation and control group, the total rate of effectiveness after treatment was 90.00% and 42.00%, respectively. Intergroup comparisons showed that the total rate of effectiveness in the observation group was significantly higher than that in the control group (p<0.001; **Table 7**).

Discussion

A chronic condition caused by dysfunction of the pelvic floor muscles, PSUI is usually seen in postpartum women or in women with a history of pregnancy. It increases with increasing age

Table 6. Changes in pelvic floor muscle potential (μv) before and after treatment in the observation group and control group

Group	Observation group (n=50)	Control group (n=50)	t	*P*
Before treatment	7.35±2.99	7.40±3.07	0.083	0.935
After treatment	31.98±6.02	15.67±3.51	16.550	<0.001
t	9.260	7.103		
P	<0.001	<0.001		

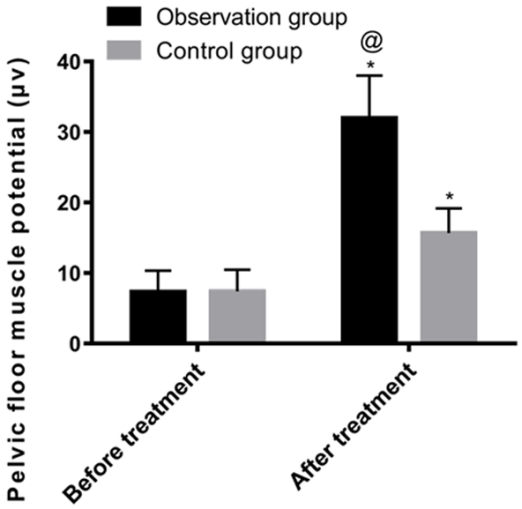

Figure 5. Pelvic floor electrical bits before and after comparison of two groups of patients. Changes in the pelvic floor muscle recovery index were compared between the two groups. @ indicates that the pelvic floor muscle potential of the observation group after treatment was significantly higher than that of the control group. Differences were statistically significant (P<0.001). * indicates that the pelvic floor muscle potential after treatment was significantly higher than the pelvic floor muscle potential before treatment. Differences were statistically significant (P < 0.001).

[15-17]. PSUI, though not life-threatening, severely affects the quality of life of patients [18]. For PSUI, various modalities of treatment and recovery have been developed, including surgical and non-surgical methods. At present, clinical studies mainly focus on the prophylaxis and treatment of stress urinary incontinence at an early or middle stage.

Pelvic floor muscle rehabilitation, e.g. Kegel exercises, have been recommended for the prophylaxis and treatment of female PSUI [19, 20]. Kegel exercises are convenient and effective. They are appropriate for various types of stress urinary incontinence, but the efficacy usually declines with short-term discontinuation of the exercises. Long-term exercises however, have a promising outcome [21]. Pelvic floor muscle rehabilitation can also be implemented using the apparatus and biological feedback. Compared to simple pelvic floor muscle rehabilitation, biological feedback is more direct and easier, with equivalent long-term efficacy. It may even be superior to simple rehabilitation of pelvic floor muscles [22]. The current study compared the efficacy between Kegel exercises and pelvic floor muscle rehabilitation apparatus on PSUI. The aim was to determine the feasibility of using the pelvic floor muscle rehabilitation apparatus for PSUI, thus optimizing nursing care.

The current study found that, following treatment, patients in the observation group had lower VTV, TOV, and LT levels than the control group (p<0.05). Intragroup comparisons showed that VTVs in the two groups, after treatment, were significantly decreased, compared with levels before treatment (p<0.001 or 0.05). Related studies have shown that VTV, TOV, and LT are important indicators for recovery of pelvic floor muscle contractions [23]. Similar studies have shown that decreased VTV, TOV, and LT levels in women with stress urinary incontinence indicate the constant recovering of pelvic floor muscle contractions [24]. Bladder volume changes and pelvic floor muscle potential are closely related to occurrence of female stress urinary incontinence, while VF and pelvic floor muscle potential changes are monitoring indicators of most urinary incontinence related studies [8, 25].

In this study, VF in the observation group, after treatment, was elevated compared with levels in the control group (p<0.05). Intragroup comparisons revealed that VFs in the two groups, after treatment, were all significantly increased compared with VFs before treatment (p<0.001 or 0.05). The pelvic floor muscle potential of the observation group was significantly higher than that of the control group (P<0.05). The pelvic floor muscle potential, after treatment, in both groups, was significantly higher than that before treatment. The clinical efficacy of EMG biofeedback-guided pelvic floor muscle training on PSUI has been confirmed in various studies, with superior improvement shown in TOV, VTV,

Table 7. Total effective rate of treatment after treatment in the observation group and control group [n (%)]

Group	Observation group (n=50)	Control group (n=50)	X^2	*P*
Significant effect	18 (36.00)*	9 (18.00)	4.110	0.043
Effective	27 (54.00)*	12 (24.00)	9.458	0.002
Invalid	5 (10.00)*	29 (58.00)	25.670	<0.001
Total efficiency	45 (90.00)*	21 (42.00)	25.670	<0.001

Note: *indicates that differences are statistically significant, compared with the control group (P<0.05).

VF, LT, and potential of pelvic floor muscle to Kegel exercises. Next, the current study compared total response rates, after treatment, between the two groups. Results revealed that the total response rate in the observation was much higher than that in the control group, with statistically significant differences (p<0.001). Accumulating evidence regarding PSUI has shown that the pelvic floor muscle rehabilitation apparatus works better for treatment of PSUI than simple application of Kegel exercises. It is significant for improving the life quality of patients [26, 27].

There were still some limitations to this study. For example, included patients were all from the same region. For subjects without cross-regional backgrounds, individual factors of the patients could not be excluded. The nursing design was not perfect and may have affected the efficiency of nursing. Moreover, the choice of different assessment scales may have impacted the results. The above restrictions may have led to a contingency of research results. In future research, an improved quantitative research method will be adopted.

In conclusion, compared to Kegel exercises, the pelvic floor rehabilitation apparatus achieves better efficacy in PSUI patients. This is accomplished by enhancing the contraction of pelvic floor muscles, with a significant improvement in symptoms of urinary incontinence. Thus, it should be considered for use in clinical practice.

Disclosure of conflict of interest

None.

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