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Research Article

Comparison of Surface Electrophysiological Parameters of the Pelvic Floor Between Three Types of Pelvic Floor Dysfunction in Perimenopausal Women

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Abstract

Objective: To investigate the differences of pelvic floor surface electromyography (sEMG) parameters between perimenopausal women with pelvic organ prolapse (POP), stress urinary incontinence (SUI), and mixed POP and SUI pelvic floor dysfunction.

Methods: All women seeking treatment for perimenopausal pelvic floor dysfunction at our institution between April 2021 and March 2023 were invited to participate in the study and signed an informed consent form. Pelvic floor sEMG parameters were obtained by Glazer assessment using the Melander instrument (MLD A2 Deluxe). Pelvic floor sEMG parameters were compared between the three groups of patients with POP, SUI, and mixed POP with SUI. Differences in pelvic floor sEMG parameters between the three groups were compared using unordered multivariate logistic regression modeling to control for potential confounding factors.

Results: A total of 237 participants were included in this study, 92, 95, and 50 in the POP, SUI, and POP+SUI groups respectively. The median, P25, and P75 for fast muscle phase peak value, slow muscle phase mean, slow muscle phase variation, slow muscle phase rise time, and slow muscle phase recovery time in all participants were 33.70 (24.05, 46.99), 21.06 (13.35, 28.84), 0.27 (0.20, 0.34), 0.41 (0.27, 0.65) and 0.88 (0.62, 1.55) respectively, with a statistically significant difference in distribution between the three groups ($p < 0.05$). The total assessment score was closely correlated with the fast muscle score, the slow muscle score, and the slow muscle mean, with correlation coefficients ρ of 0.839, 0.822, and 0.805, respectively. Multivariate logistic regression analyses showed that the mean value of the anterior resting potential was significantly higher in the SUI group than in the POP group ($P < 0.05$), whereas the SUI+POP group had similar levels of pelvic floor sEMG parameters as the other two groups ($P > 0.05$).

Conclusion: The mean value of the anterior resting potential is higher in patients with SUI than in those with POP. Patients with SUI may be candidates for treatment of perimenopausal pelvic floor dysfunction with a reduction of the anterior resting potential.

Keywords: *Perimenopause; Pelvic Floor Dysfunction; Pelvic Organ Prolapse; Stress Urinary Incontinence; Pelvic Floor Surface Electromyography*

Abbreviations

POP: Pelvic Organ Prolapse; SUI: Stress Urinary Incontinence; sEMG: Surface Electromyography

Introduction

Perimenopause is characterized by the gradual loss of oocytes from the ovaries, changes in the body's response to sexual hormone feedback, and hormonal fluctuations in the body [1]. Pelvic floor dysfunction is mainly a disease caused by the defect, degradation, injury, and dysfunction of the pelvic supporting structure. Pelvic organ prolapse (POP), stress urinary incontinence (SUI), sexual dysfunction, chronic pelvic pain, and fecal incontinence are common clinical manifestations that seriously affect women's quality of life [2]. POP refers to prolapse of the anterior and posterior walls of the vagina, the uterus (cervix), or the top of the vagina [3]. SUI refers to involuntary urine leakage caused by increased intra-abdominal pressure without detrusor contraction during bladder filling examination [4]. Pelvic floor surface electromyography (sEMG) parameters have been widely used to evaluate muscle function in young women before and after pelvic floor rehabilitation [5]. However, studies on pelvic floor sEMG parameters in perimenopausal women with pelvic floor dysfunction are limited.

Aim of the Study

This study aimed to explore the distribution and differences of pelvic floor sEMG parameters of different types of pelvic floor dysfunction in perimenopausal women.

Materials and Methods

Participants

This was an observational retrospective cohort study. All perimenopausal women with pelvic floor dysfunction who visited Weifang People's Hospital between April 2021 and March 2023 and met the following inclusion and exclusion criteria were invited to participate in the study. Inclusion criteria: 1) 40 years or older; 2) met the diagnostic criteria for pelvic floor dysfunction [4]; 3) voluntarily underwent pelvic floor muscle therapy; 4) agreed to participate in this study and signed an informed consent form. Exclusion criteria: 1) combined with neurological diseases; 2) severe organ dysfunction of the heart, liver, spleen, lung, or kidney; 3) mental illness or other diseases that lead to pelvic floor assessment and treatment cannot be performed; 4) have other medical or surgical comorbidity where doctors judge that patients are not suitable to participate in this study. This study was approved by the Ethics Committee of Weifang People's Hospital (approval number Kyll20230419-2).

Data collection

A self-administered questionnaire was used to collect participants' demographic characteristics and obstetric history of the participants, including age, weight and height, pregnancy history and outcomes (including numbers of vaginal deliveries, cesarean sections, miscarriages, and macrosomia), and date of last delivery.

The pelvic floor sEMG parameters were measured by the Glazer evaluation method [6] using the Maiande instrument (MLD A2 Deluxe edition), in which, the electrical activity signals of the four stages of the participants' pelvic floor muscle fibers, quantify the muscle voltage values of different muscle fibers on the surface of the pelvic floor were recorded in the form of electromyography, and convert into scores.

Procedure sEMG recording: The doctor inserts vaginal electrodes into the vagina. Following a voice prompt, the patients perform 60 seconds of relaxation, five rapid contractions and relaxations, five continuous contractions and relaxation, and then 60 seconds of continuous contractions and relaxation. sEMG and pressure curves that reflect muscle activity in each phase were recorded. The mean and variation of muscle potential in four stages, including anterior resting, fast muscle, slow muscle, and post-rest, were also automatically calculated, and exported.

Statistical analysis

All data were transferred to Excel. SPSS 26.0 statistical software was used for data analysis. Distributions of participant characteristics were described using frequency and percentage (%) for qualitative indicators, mean ± standard deviation for normally distributed quantitative data, and quartiles M (Q1, Q3) for quantitative data that did not follow a normal distribution. Differences in non-normally distributed data and qualitative variables between groups were compared using non-parametric and chi-squared tests. Pelvic floor sEMG parameters were compared between groups using non-parametric tests for K-independent samples. Pearson correlation coefficients (ρ) were calculated to measure the correlation between different sEMG parameters. Differences in sEMG parameters between types of pelvic floor dysfunction were compared using an unordered multivariate logistic regression model controlling for potential confounders.

Results

Characteristics of the participants

A total of 237 women aged between 40 and 67 years met the inclusion and exclusion criteria during the study period. The participant's body mass index (BMI) ranged from 18.1 to 35.8. Ninety-two participants were diagnosed with POP, 95 with SUI, and 50 with both POP and SUI. The results of Chi-squared tests showed that the distributions of women's age, Kupperman score, and months since last delivery were statistically significant between the three study groups (P < 0.05). No significant differences in women's BMI, type of toilet at home, number of vaginal deliveries, cesarean sections, and abortions between the three groups were identified (P > 0.05). See table 1.

Characteristics	POP group	SUI group	SUI+POP group	P value
	(N = 92)	(N = 95)	(N = 50)	
Age [years M(Q1, Q3)]	40.0 (40.0, 44.0)	41(40.0, 46.0)	46.50 (42.0, 50.7)	0.001
BMI [kg/m^2, M(Q1, Q3)]	24.5 (22.0, 26.4)	22.86 (21.5, 25.4)	23.63 (22.3, 25.4)	0.297
Toilet type n (%)				0.166
Squat dominant	10 (34.5)	12 (41.4)	7 (24.1)	
Take the lead	64 (42.1)	63 (41.4)	25 (16.4)	
Both	18 (32.1)	20 (35.7)	18 (32.1)	
Kupperman score n (%)				<0.001
Normal	48 (27.9)	86 (50.0)	38 (22.1)	
Abnormal	44 (67.7)	9 (13.8)	12 (18.5)	
Duration since last birth [years, M(Q1, Q3)]	8.0 (5.0, 12.0)	8.0 (5.0, 17.0)	12.5 (6.0, 22.0)	0.003
Giant baby n (%)				0.786
No	83 (39.0)	84 (39.4)	46 (21.6)	
Yes	9 (37.5)	11 (45.8)	4 (16.7)	
Number of vaginal delivery n (%)				0.088
0	35 (46.7)	31 (41.3)	9 (18.00)	
1	30 (32.6)	42 (44.2)	24 (48.0)	
≥ 2	27 (29.3)	22 (23.2)	17 (34.0)	
Number of cesarean sections n (%)				0.161
0	45 (33.1)	57 (41.9)	34 (25.0)	
1	30 (42.9)	28 (40.0)	12 (17.1)	
≥ 2	17 (54.8)	10 (32.3)	4 (12.9)	

Number of abortion n (%)				0.748
0	30 (37.5)	35 (43.8)	15 (18.8)	
1	14 (30.4)	19 (41.3)	13 (28.3)	
2	34 (42.5)	30 (37.5)	16 (20.0)	
≥ 3	14 (45.2)	11 (35.5)	6 (19.4)	
Number of all pregnancies n (%)				0.289
1	13 (29.5)	22 (50.0)	9 (20.5)	
2	20 (34.5)	24 (41.4)	14 (24.1)	
3	25 (43.9)	24 (42.1)	8 (14.0)	
4	20 (39.2)	20 (39.2)	11 (21.6)	
≥ 5	14 (51.9)	5 (18.5)	8 (29.6)	

Table 1: *Percentage distribution of participants' characteristics, by types of pelvic floor muscle dysfunction.*

Comparison of pelvic floor sEMG parameters between POP, SUI, and mixed groups

Results of K-independent sample non-parametric tests showed that the distributions of the peak value of the fast muscle phase, the average value of the slow muscle phase, ascending time of the slow muscle stage, the rise and recovery time of the slow muscle phase between the three groups were statistically significant ($P < 0.05$) (See table 2). The results of two-by-two comparisons showed that the peak value of the fast muscle phase, the average value of the slow muscle stage, and the rise and recovery time of the slow muscle stage were statistically significantly higher in the POP group than in the SUI and the mixed groups ($P < 0.05$). However, the variation of the slow muscle phase was significantly lower in the POP group than that in the SUI group ($P < 0.05$), whereas this variation is largely similar between the SUI and the mixed groups ($P > 0.05$).

sEMG parameter	POP group	SUI group	POP+SUI group	P value
	N = 92	N = 95	N = 50	
Average value of the pre-resting stage [μV, M(Q1, Q3)]	5.00 (2.64, 7.02)	4.88 (2.90, 6.67)	4.68 (2.38, 6.60)	0.818
Pre-resting phase variation [M(Q1, Q3)]	0.13 (0.12, 0.17)	0.14 (0.12, 0.16)	0.15 (0.12, 0.18)	0.155
Maximum value of fast muscle stage [μV, M(Q1, Q3)]	42.97 (29.84, 52.50)	29.15 (21.29, 38.86)	29.46 (17.97, 43.78)	< 0.001
Rise time of raptor stage [S, M(Q1, Q3)]	0.39 (0.33, 0.50)	0.44 (0.32, 0.58)	0.40 (0.28, 0.53)	0.372
Fast muscle stage recovery time [S, M(Q1, Q3)]	0.47 (0.38, 0.60)	0.52 (0.38, 0.74)	0.54 (0.36, 0.70)	0.304
Average value of slow muscle stage [μV, M(Q1, Q3)]	26.10 (21.58, 33.37)	16.68 (10.87, 22.20)	16.33 (9.52, 22.89)	< 0.001
Slow muscle stage variation [M(Q1, Q3)]	0.25 (0.19, 0.31)	0.29 (0.21, 0.40)	0.26 (0.20, 0.40)	0.018
Ascending time of slow muscle stage [S, M(Q1, Q3)]	0.38 (0.24, 0.50)	0.41 (0.27, 0.88)	0.51 (0.28, 0.93)	0.005
Recovery time of slow muscle stage [S, M(Q1, Q3)]	0.71 (0.57, 1.05)	1.08 (0.73, 2.49)	0.99 (0.63, 3.31)	< 0.001
Mean value of post-resting stage [μV, M(Q1, Q3)]	4.44 (2.76, 6.45)	4.28 (2.52, 6.06)	3.68 (2.57, 6.41)	0.701
Post-resting stage variation [M(Q1, Q3)]	0.14 (0.12, 0.18)	0.14 (0.12, 0.19)	0.14 (0.13, 0.20)	0.568

Table 2: *Comparison of sEMG parameters of pelvic floor muscles, by types of perimenopausal pelvic floor dysfunction.*

Note: The statistical method was a non-parametric test with K-independent samples.

Correlation between the pelvic floor sEMG parameters

The pelvic floor sEMG parameters exhibit varying degrees of correlation among them. The total evaluation score is positively related to the fast muscle score, slow muscle score, and average slow muscle score, with correlation coefficients, ρ, of 0.839, 0.822, and 0.805 respectively. Likewise, the pre-resting score has a strong negative correlation with the mean value of pre-resting, with 0.809. The fast muscle score and the peak value of fast muscle demonstrate a significant positive correlation with ρ at 0.853. The average score and average value of the slow muscle show a strong correlation, with ρ at 0.824. Similarly, the anterior resting variation has high correlation values with fast muscle rise time, slow muscle variation, and post-resting variation, ρ at 0.864, 0.869, and 0.858, respectively. The peak value of fast muscle and the average value of slow muscle also exhibit a strong correlation, with ρ at 0.804. Additionally, the rise time of fast muscle has a very strong positive correlation with the variation of slow muscle and post-resting variation with ρ at 0.988 and 0.917, respectively. Finally, the slow muscle variation and post-resting variation have a significant positive correlation, with ρ at 0.911. See table 3.

Variable	Mean of pre-rest	Pre-rest variation	Maximum fast muscle	Fast muscle rise time	Fast muscle recovery time	Average value of slow muscle	Slow muscle variation	Rise time of slow muscle	Slow muscle recovery time	Mean of post-rest	Post-rest variation	Total evaluation score	Pre-rest score	Fast muscle score	Slow muscle score
Mean of pre-rest	1														
Pre-rest variation	0.429**	1													
Maximum fast muscle	0.173**	-0.180**	1												
Fast muscle rise time	0.518**	0.864**	--.0171**	1											
Fast muscle recovery time	-0.043	0.009	-0.343**	0.081	1										
Average value of slow muscle	0.062	-0.150*	0.804**	-0.140*	-0.256**	1									
Slow muscle variation	0.510**	0.869**	-0.141*	0.988**	-0.011	-0.148*	1								
Rise time of slow muscle	-0.060	0.000	-0.444**	0.008	0.466**	-0.431**	-0.016	1							

Slow muscle recovery time	0.002	-0.056	-0.364**	-0.031	0.357**	-0.557**	-0.019	0.682**	1						
Mean of post-rest	0.478**	-0.222**	0.267**	-0.086	0.040	0.202**	-0.100	-0.011	0.040	1					
Post-rest variation	0.493**	0.858**	-0.122	0.917**	0.065	-0.104	0.911**	-0.018	-0.050	-0.182**	1				
Total evaluation score	-0.124	-0.257**	0.767**	-0.286**	-0.475**	0.805**	-0.273**	-0.611**	-0.661**	0.046	-0.248**	1			
Pre-rest score	-0.809**	-0.029	-0.239**	-0.004	0.018	-0.113	0.003	0.013	-0.056	-0.609**	-0.016	0.049	1		
Fast muscle score	0.151*	-0.163*	0.853**	-0.179**	-0.551**	0.634**	-0.123	-0.550**	-0.444**	0.231**	-0.148*	0.839**	-0.210**	1	
Slow muscle score	0.179**	0.027	0.590**	0.055	-0.278**	0.824**	0.017	-0.548**	-0.721**	0.205**	0.052	0.822**	-0.136*	0.564**	1
Post-rest score	-0.314**	0.077	-0.225**	-0.020	0.011	-0.151*	-0.016	0.090	0.005	-0.587**	-0.003	-0.083	0.351**	-0.224**	-0.168**

Table 3: *Correlation of EMG parameters of pelvic floor muscle in perimenopausal women with pelvic floor dysfunction.*

***: At 0.01 level (two-tailed), the correlation was significant.*

**: At level 0.05 (two-tailed), the correlation was significant.*

Differences of sEMG parameters between groups of perimenopausal pelvic floor dysfunction

An unordered multivariate logistic regression model was performed to compare the differences in sEMG parameters of pelvic floor muscle between the three groups of participants. The findings of the analysis showed that the values of all the sEMG parameters in the mixed group were similar to those in the POP group ($P > 0.05$). However, the average value of pre-rest stage potential in the SUI group was significantly higher than that in the POP group (OR = 1.154, 95%CI 1.006 - 1.324), and the differences of other sEMG parameters between these two groups were not statistically significant ($P > 0.05$). See table 4.

Discussion and Conclusion

Assessment of the pelvic floor muscle function is, to some extent, complicated and difficult. Measured by using sEMG, the Glazer evaluation method is a widely accepted approach assessing pelvic floor muscle function. Oleksy reported normal sEMG reference values for the four pelvic floor stages and provided reference points for the parameters in women with different pelvic floor dysfunctions [6]. Lukasz and colleagues confirmed the validity of the Glazer method in diagnosing women's pelvic floor dysfunction [7]. In this study, using the Glazer evaluation method, we found that the anterior resting potential in the SUI group was 15.4% higher than that in the POP group (95% CI 1.006 - 1.324), but it was similar to that in the mixed POP and SUI group. This finding may be related to the disruption and impairment

Variable	Comparison between the SUI group and POP group		Comparison between POP+SUI group and POP group	
	OR value (95%CI)	P value	OR value (95%CI)	P value
Mean of the pre-resting phase	1.154 (1.006~1.324)	0.040	0.992 (0.834~1.180)	0.925
Fast muscle stage peak value	0.960 (0.919~1.003)	0.070	0.967 (0.920~1.016)	0.187
Raptor phase rise time	0.870 (0.410~1.847)	0.717	1.178 (0.598~2.320)	0.636
Fast muscle phase recovery time	1.388 (0.379~5.079)	0.620	0.867 (0.215~3.496)	0.841
Average of the slow muscle stage	1.010 (0.947~1.077)	0.768	0.996 (0.922~1.076)	0.915
The ascending time of the slow muscle stage	2.712 (0.650~11.320)	0.171	2.179 (0.469~10.120)	0.320
Slow muscle stage recovery time	1.728 (0.941~3.172)	0.077	1.867 (0.949~3.675)	0.071
Mean of post-resting phase	(0.765~1.067)	0.232	1.094 (0.894~1.339)	0.383

Table 4: *Differences of the pelvic floor electromyography parameters between women with three types of perimenopausal pelvic floor dysfunction: results of an unordered multivariate logistic regression analysis.*

Other variables included in the model included: year, BMI, time since birth, macrocosm, toilet type, Kupperman score, number of births, and number of abortions.

of the structure and function of the pelvic floor muscles. Contraction and relaxation are controlled by nerves that are connected to muscle fibers through nerve endings. In the state of relaxation of the pelvic floor muscle fibers, the nerve endings do not send signals, and the potential level of the pelvic floor muscle at this time is the pre-resting potential. The maintenance of normal urinary function depends on a stable bladder and adequate urethral closure. Intraurethral pressure is generated by the mucosa, the rich vascular plexus of the submucosa, the longitudinal and circular smooth muscle, and the striated urethral sphincter [8]. The structural support of the normal urethra depends on the attachment of the arcuate tendon and fascia of the pelvis and the connective tissue of the pubis [9]. In patients with SUI, the anatomical support of the bladder neck and proximal urethra is compromised, thus affecting the closure function of the urethra. In patients with POP, the internal urethral pressure increases due to the body's negative feedback regulation, leading to an increase in the anterior resting potential value of the pelvic floor muscles. In addition, the anatomical support of the bladder neck, and urethra is damaged in POP patients, and the structure of the pelvic floor muscles changes. Muscle fibers are stretched and elongated, elasticity is reduced, and external closing force is reduced. In patients with POP combined with SUI, SUI led to an increase in pre-resting potential, while POP led to a decrease, and the two offset each other, resulting in a smaller difference in pre-resting potential between the mixed POP+SUI group and POP group. Therefore, the difference in pre-resting potential between patients with mixed pelvic floor dysfunction and those with single pelvic floor dysfunction was smaller.

Several studies have shown no relationship between sEMG parameters of the pelvic floor muscles during perimenopause and SUI [10]. However, a previous Chinese study suggested that the sEMG parameters of the pelvic floor muscles were lower in SUI patients than in their non-SUI counterparts [11]. This finding indicates a reduction in the contraction force and function of both fast and slow muscles in SUI patients. However, in our study, we did not find any difference in sEMG parameters in fast and slow muscles between the SUI, POP, and mixed dysfunction groups. The participants in this study were perimenopausal women who were diagnosed with pelvic floor dysfunction based on clinical guidelines, whereas the Chinese study conducted by Chen and colleagues classified patients as SUI and non-SUI groups simply relied on self-reported symptoms, including coughing, sneezing, and urine leakage when lifting heavy objects during the last three months. This method of classification highly relies on women's experience and response to interviewers' questions, which may lead to a higher risk of misclassification.

This study found a high correlation between the fast muscle, slow muscle, and total scores and several parameters of pelvic floor sEMG, which may be due to the method of calculating and weighting these scores in the Glzaer grading method. For example, the correlation coefficient (ρ) of pre-resting variation with fast muscle rise time, and slow muscle variation with post-resting variation were 0.864 and 0.869 respectively. The ρ of the slow muscle variation and the post-resting variation was 0.911. These findings suggest that the sEMG parameters should not be viewed in isolation, but as a whole for diagnosing and treating perimenopausal pelvic floor dysfunction.

Limitation of the Study

The study manifests several limitations. We conducted this study in a single centre with a limited sample size. A multicentre prospective cohort study with a larger sample size is needed to confirm the results of this study and evaluate medium and long-term effects of the application of pelvic floor sEMG parameters in the diagnosis and treatment of perimenopausal pelvic floor dysfunction.

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Conflict of Interest

There is no financial interest and conflict of interest exists.

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