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ASSESSING PELVIC FLOOR REHABILITATION EFFICACY USING ELECTROMYOGRAPHY

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ABSTRACT

Objective: The objective of this research is to assess the efficacy of individualized rehabilitation programs for female sexual dysfunction associated with neurological disorders using electromyography (EMG) to assess the functionality of the pelvic floor muscles. **Methods:** A total of 133 women with diagnosed sexual dysfunction and various neurological disorders were split into two distinct groups: a control group (n=66) receiving standard care and a treatment group (n=67) undergoing a comprehensive rehabilitation program. This program included transcutaneous tibial nerve stimulation (TTNS), biofeedback therapy and Kegel exercises. EMG was utilized to assess the amplitude and strength of the bulbocavernosus, pubococcygeus, and iliococcygeus muscles prior to and following the intervention. Results: Initial EMG measurements indicated no notable differences between the control and intervention groups (p>0.05), but post-treatment, the intervention group exhibited markedly enhanced muscle function compared to the control group. The mean amplitude (M±SD) of the bulbocavernosus muscle increased from 78.21±7.37 to 132.31±12.72 (p<0.0001), the pubococcygeus muscle from 155.57±14.89 to 254.96±24.82 (p<0.0001), and the iliococcygeus muscle from 77.21±7.37 to 132.78±12.60 (p<0.0001). **Conclusion:** The results indicate that individualized rehabilitation programs significantly enhance functionality of pelvic floor muscles in women with neurological disorders, as measured by EMG.

Key words: electromyography, sexual dysfunction, neurological disorders, pelvic floor muscles, rehabilitation programs, biofeedback, transcutaneous tibial nerve stimulation, Kegel exercises.

INTRODUCTION

Sexual dysfunction [17] is a prevalent and distressing issue among women with neurological disorders, significantly affecting their overall quality of life

[2,3]. This condition often arises due to impaired pelvic floor muscle function [11,30], which is essential for various bodily functions, including sexual health, urinary control, and the support of pelvic organs. Effective diagnosis and treatment of these muscle dysfunctions are critical for improving sexual function and overall well-being in this population [6, 8, 20, 21,28].

Electromyography (EMG) is a fundamental diagnostic instrument employed to evaluate the electrical activity of muscles, providing crucial insights into muscle function and health [9]. This technique is particularly beneficial for evaluating pelvic floor muscles. EMG can be performed using intramuscular methods, which involve inserting a wire or needle electrode directly into the muscle, or surface EMG (sEMG) [8,11], which involves placing electrodes on the skin overlying the muscles of interest. Surface EMG is preferred in many clinical settings due to its non-invasive nature and the ability to provide real-time feedback on muscle function [12].

Pelvic floor muscles (PFMs) such as the bulbocavernosus, pubococcygeus, and iliococcygeus play key roles in sexual function [10, 17]. The bulbocavernosus muscle surrounds the entrance to the vagina and covers the vestibular bulb. It stabilizes the perineal body, aids in the secretion of the greater vestibular glands, and contributes to clitoral erection by compressing the deep dorsal vein of the clitoris. The pubococcygeus muscle supports the vagina and adjacent structures, assists in controlling urinary flow, and facilitates involuntary rhythmic contractions during orgasm. The iliococcygeus muscle supports the pelvic organs, helps return the anus to its position after defecation, and also participates in involuntary rhythmic contractions during orgasm [29].

To address sexual dysfunction, individualized rehabilitation programs are essential. These programs are designed to enhance pelvic floor muscle strength and coordination through targeted interventions [16,17]. Key components of these rehabilitation programs include biofeedback therapy, transcutaneous tibial nerve stimulation (TTNS), and Kegel exercises [22,26].

Methods

This investigation was carried out to determine the efficacy of individualized rehabilitation interventions on the functionality of pelvic floor muscles in women experiencing sexual dysfunction and neurological disorders using surface electromyography (sEMG). The research was conducted at a specialized clinic, with approval from the institutional ethics committee, and informed consent was obtained from all participants prior to enrollment.

A total of 133 women aged 18 to 74 years (Table 1.1-1.2) with diagnosed sexual dysfunction and various neurological disorders were recruited for this study.

Participants were allocated into two groups: the control group (n=66) receiving standard care and the treatment group (n=67) participating in a comprehensive rehabilitation program. Inclusion criteria were women diagnosed with sexual dysfunction due to neurological disorders, able to perform the required exercises, and agreeing to take part in the study. Exclusion criteria included pregnancy, acute pelvic infections, severe cardiovascular conditions, and any contraindications to electrical stimulation.

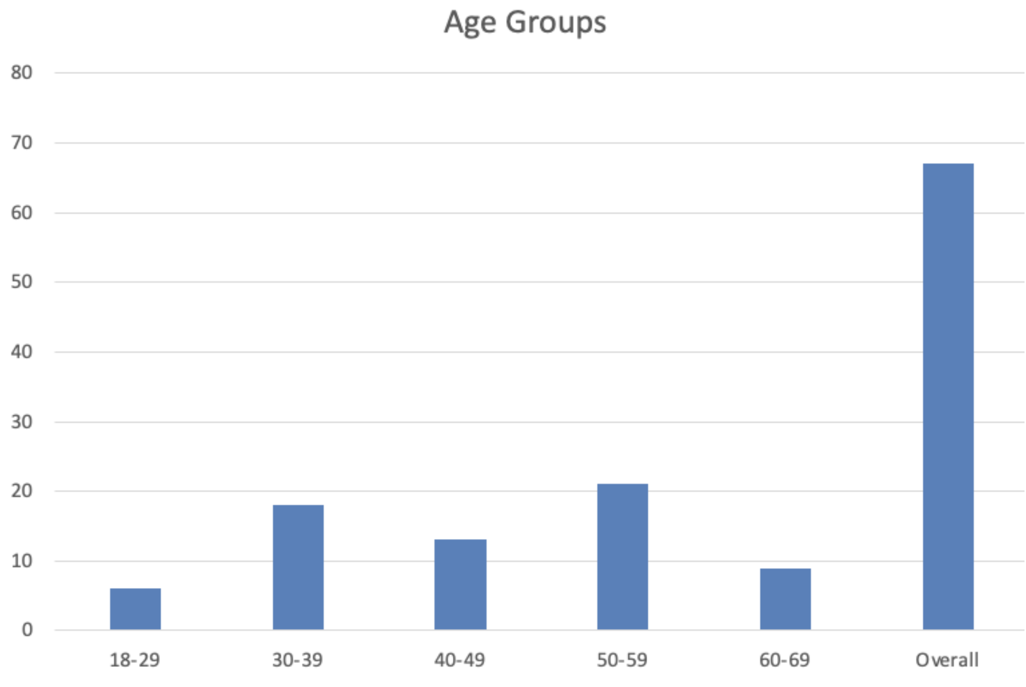

Table 1.1. Age distribution

Age	
Difference	0,165
Standard error	2,12
95% CI	-4.0294 to 4.3594
t-statistic	0,078
DF	131
Significance level	P = 0.9381

Table 1.2. Age significance

The rehabilitation program for women with sexual dysfunction and neurological disorders involves the following specialists: neurologist, gynecologist, rehabilitation therapist, endocrinologist psychotherapist [20,27].

The neurologist was responsible for assessing the neurological status and conducting additional studies such as MRI of the brain. The rehabilitation therapist planned and developed the rehabilitation program. The gynecologist examined and assessed the condition of the pelvic floor muscles assessed with the Oxford scale and supplemented by additional studies like EMG of the pelvic floor muscles. The endocrinologist assessed the hormonal status and provided recommendations for medication if necessary. The psychotherapist conducted several sessions to help patients cope with emotional consequences.

Medication prescriptions were based on consultations with the specialists involved in the program. Physiotherapy included biofeedback therapy, which was conducted two times per week for 30 minutes each session over 12 weeks, and TTNS, which involved 10 sessions every other day for 25-30 minutes each [20]. Electrical stimulation with fixed impulses and adjustable amplitude, 200 microseconds wide and 10 Hz frequency, was used [23,7]. Biofeedback and TTNS therapies were alternated to enhance treatment effectiveness.

Surface electromyography (sEMG) was utilized to evaluate pelvic floor muscle function [25] before and after the intervention. EMG recordings were taken from the bulbocavernosus, pubococcygeus, and iliococcygeus muscles. Self-adhesive disposable electrodes were placed inside the vagina [1]. Electrodes were positioned in the anterior part of the vagina near the urethra for the iliococcygeus muscle, while for the pubococcygeus muscle, electrodes were placed in the posterior part of the vagina, closer to the rectum. For the bulbocavernosus muscle, electrodes were placed near the vaginal entrance.

Participants performed maximum voluntary contractions (MVCs) with maximum strength for approximately five seconds. MVCs were recorded in a supine position with hips and knees flexed at 30° and 90°, respectively [5]. EMG signals were recorded to measure muscle amplitude (μV) and the speed of maximum voluntary muscle contraction (ms).

Data were analyzed using IBM SPSS Statistics 25.0. Descriptive statistics were calculated for baseline characteristics of the participants. The Kolmogorov-Smirnov test was used to check the normality of data distribution. Independent t-tests were used for comparing baseline and post-treatment EMG readings between the control and treatment groups for normally distributed data, while Mann-Whitney U tests were applied for non-normally distributed data. Effect sizes (Cohen’s d) were calculated to measure the magnitude of the treatment effect. A p-value below 0.05 was deemed statistically significant.

Rehabilitation program details varied based on the specific neurological condition of the patients. For patients with multiple sclerosis, the program included 15 sessions every other day, each lasting 45 minutes. The effectiveness was evaluated at the 10^{th} session, with the effect typically appearing from the 3^{rd}-4^{th}

session and consolidating by the 10th session. The expected moment of achieving the effect was by the 13th-14th session.

For patients with stroke sequelae, the program included 12-13 sessions every other day, each lasting 35 minutes. The effectiveness was evaluated at the 10th session, with the expected moment of achieving the effect by the 11th-12th session. For patients with traumatic brain injury, the program included 10 sessions every other day, each lasting 30 minutes. The effectiveness was evaluated at the 10th session, with the expected moment of achieving the effect by the 8th-9th session.

The determination of the number and length of sessions was based on evaluating pelvic floor muscle strength and how well the muscle apparatus adapted to consistent partial loads. The effectiveness of the therapy was evaluated based on alterations in the muscles of the pelvic floor and the overall well-being of the patient.

TTNS was provided to all patients with sexual dysfunction. Each session lasted 25-30 minutes and was conducted every other day for four weeks, tailored to the specific diagnosis and condition of the patient. Fixed impulses with adjustable amplitude, 200 microseconds in width and 10 Hz frequency, were used for electrical stimulation. Correct electrode placement was confirmed by observing plantar flexion of the big toe. After confirmation, the stimulation amplitude was reduced to just below the somatic sensory threshold.

For patients with multiple sclerosis, 15 sessions were conducted every other day, each lasting 35 minutes. The effectiveness was assessed at the 11th-12th session, with the expected effect appearing by the 8th-9th session and consolidating by the 11th. The anticipated moment of achieving the effect was by the 13th-14th session.

Patients recovering from a stroke underwent 12-13 sessions every other day, each lasting 30 minutes. Effectiveness was evaluated at the 10th session, with the expected effect appearing by the 7th-8th session and consolidating by the 10th. The anticipated moment of achieving the effect was by the 11th-12th session.

For patients with traumatic brain injury, 10 sessions were conducted every other day, each lasting 25 minutes. Effectiveness was evaluated at the 10th session, with the expected effect appearing by the 6th-7th session.

Upon completing the rehabilitation course, it is crucial to re-evaluate the patient's condition using various assessment methods, including scales and questionnaires, to confirm the effectiveness of the applied methods and determine further treatment and rehabilitation steps. Performing follow-up evaluations using methods such as pelvic floor muscle EMG, is essential for both quantitative and qualitative assessment of muscle activity, contractions, and the effectiveness of rehabilitation.

In addition to instrumental methods, it is crucial to use various scales and questionnaires to evaluate the patient's quality of life, and physical and psychological state. These tools provide information on the patient's perception of their condition and the effectiveness of rehabilitation interventions in improving their overall well-being and life quality. Involvement of each specialist in the rehabilitation process is crucial for success. Their comprehensive approach, expertise, and collaboration not only contribute to effective treatment but also lay the foundation for the successful rehabilitation of patients following traumatic brain injuries. This underscores the necessity of multidisciplinary teamwork to achieve optimal rehabilitation outcomes for patients with similar conditions.

Results

No statistically significant differences were observed in the amplitude of pelvic floor muscles at baseline between two groups. EMG results were analyzed for amplitude (µV) and the speed of maximum voluntary muscle contraction (ms). The mean (M±SD) values for the bulbocavernosus muscle were 78.21±7.37 µV in the treatment group and 78.74±7.35 µV in the control group (p=0.6787) (Table 2).

Bulbocavernosus muscle			
Before		After	
Difference	0,53	Difference	-50,11
Standard error	1,276	Standard error	1,832
95% CI	-1.9951 to 3.0551	95% CI	-53.7348 to -46.4852
t-statistic	0,415	t-statistic	-27,348
DF	131	DF	131
Significance level	P = 0.6787	Significance level	P < 0.0001

Table 2. Bulbocavernosus muscle amplitude

For the pubococcygeus muscle, the values were 155.57±14.89 µV and 158.29±16.40 µV, respectively (p=0.3183) (Table 3).

Pubococcygeus muscle			
Before		After	
Difference	2,72	Difference	-83,46
Standard error	2,715	Standard error	3,832
95% CI	-2.6518 to 8.0918	95% CI	-91.0402 to -75.8798
t-statistic	1,002	t-statistic	-21,781
DF	131	DF	131
Significance level	P = 0.3183	Significance level	P < 0.0001

Table 3. Pubococcygeus muscle amplitude

The iliococcygeus muscle showed values of 77.21±7.37 µV and 77.77±7.34 µV, respectively (p=0.6614) (Table 4).

Iliococcygeus muscle			
Before		After	
Difference	0,56	Difference	-41,67
Standard error	1,276	Standard error	1,846
95% CI	-1.9634 to 3.0834	95% CI	-45.3226 to -38.0174
t-statistic	0,439	t-statistic	-22,568
DF	131	DF	131
Significance level	P = 0.6614	Significance level	P < 0.0001

Table 4. Iliococcygeus muscle amplitude

These results indicate no significant baseline differences in muscle amplitude between the groups.

Following the rehabilitation therapy, the treatment group showed a statistically significant increase in muscle amplitude compared to the control group. The mean amplitude for the bulbocavernosus muscle in the treatment group was 132.31±12.72 μV, compared to 82.20±7.79 μV in the control group ($p<0.0001$) (Table 5).

Bulbocavernosus muscle			
Before		After	
Difference	0,57	Difference	-12,01
Standard error	0,451	Standard error	0,613
95% CI	-0.3218 to 1.4618	95% CI	-13.2220 to -10.7980
t-statistic	1,264	t-statistic	-19,602
DF	131	DF	131
Significance level	P = 0.2084	Significance level	P < 0.0001

Table 5. Bulbocavernosus muscle amplitude after treatment

For the pubococcygeus muscle, the values were 254.96±24.82 μV and 181.50±18.93 μV, respectively ($p<0.0001$) (Table 6).

Pubococcygeus muscle			
Before		After	
Difference	0,36	Difference	-11,96
Standard error	0,457	Standard error	0,625
95% CI	-0.5446 to 1.2646	95% CI	-13.1962 to -10.7238
t-statistic	0,787	t-statistic	-19,139
DF	131	DF	131
Significance level	P = 0.4326	Significance level	P < 0.0001

Table 6. Pubococcygeus muscle amplitude after treatment

The iliococcygeus muscle showed values of 132.78±12.60 μV and 89.11±8.20 μV, respectively ($p<0.0001$) (Table 7).

Iliococcygeus muscle			
Before		After	
Difference	0,52	Difference	-11,3
Standard error	0,401	Standard error	0,552
95% CI	-0.2727 to 1.3127	95% CI	-12.3927 to -10.2073
t-statistic	1,298	t-statistic	-20,458
DF	131	DF	131
Significance level	P = 0.1967	Significance level	P < 0.0001

Table 7. Iliococcygeus muscle amplitude after treatment

Initially, no statistically significant differences in the MVC of pelvic floor muscles were observed between the groups, for the bulbocavernosus muscle being 23.25±2.73 ms in the treatment group and 23.82±2.46 ms in the control group (p=0.2084). For the pubococcygeus muscle, the values were 22.46±2.80 ms and 22.82±2.46 ms, respectively (p=0.4326). The iliococcygeus muscle showed values of 22.04±2.45 ms and 22.56±2.16 ms, respectively (p=0.1967). These findings suggest no significant differences in baseline MVC between the groups.

After the intervention, the treatment group showed significant improvements in MVC compared to the control group, for the bulbocavernosus muscle being 36.78±4.28 ms in the treatment group and 24.77±2.56 ms in the control group (p<0.0001). For the pubococcygeus muscle, the values were 35.64±4.33 ms and 23.68±2.67 ms, respectively (p<0.0001). The iliococcygeus muscle showed values of 34.88±3.92 ms and 23.58±2.20 ms, respectively (p<0.0001).

These results endorse the utilization of EMG as a valuable tool for assessing and guiding rehabilitation strategies to enhance pelvic floor muscle health and sexual function.

Discussion

Pelvic floor EMG is a method utilized to assess the electrical activity produced by muscle fibers in the pelvic floor during depolarization. Intramuscular EMG involves inserting a wire or needle electrode directly into the muscle to capture the action potentials of motor units [12,18]. On the other hand, surface EMG utilizes electrodes placed on the skin in the perineal area or within the vagina or rectum [29]. In this study, we used vaginal electrode placement to assess sexual dysfunction, enabling the recording of EMG amplitude both at rest and during pelvic floor muscle contractions [30]. EMG assessments were conducted on all participants with sexual dysfunction both before and after treatment to assess the functionality of pelvic floor muscles, leading to the development of individualized training plans for each patient group. We analyzed the MVC and PFMS in women with sexual dysfunction using sEMG.

The PFMs play a critical role in sexual function, influencing the degree of sensitivity experienced during vaginal intercourse and the contraction perceived by the partner. PFMs are responsible for involuntary rhythmic contractions during orgasm (iliococcygeus and pubococcygeus muscles), the secretion of the greater vestibular glands, and clitoral erection (bulbocavernosus muscle). Additionally, they support the vagina and surrounding structures in women and aid in controlling urinary flow. The nerve supply to these muscles is provided by the pudendal nerve (n. pudendus), originating from the sacral plexus (S2-S4) [21].

In our research, we focused on the following pelvic floor muscles: m. bulbocavernosus (bulbocavernosus muscle), m. pubococcygeus (pubococcygeus muscle), and m. iliococcygeus (iliococcygeus muscle).

The bulbocavernosus muscle encircles the vaginal entrance and covers the vestibular bulb, stabilizing the perineal body, aiding gland secretion, enhancing clitoral erection by compressing the deep dorsal vein, and regulating intravaginal pressure [13, 14]. The pubococcygeus muscle supports the vagina and adjacent structures in women, assists in controlling urinary flow, and facilitates involuntary rhythmic contractions during orgasm. The iliococcygeus muscle offers support to the pelvic organs, helps return the anus to its position after defecation, and participates in involuntary rhythmic contractions during orgasm [34].

During the sEMG procedure, participants were instructed to perform MVCs with maximum strength for approximately 5 seconds to record PFM activity during voluntary contraction. MVCs were recorded in a supine position with hips and knees flexed at 30° and 90°, respectively. Self-adhesive disposable electrodes were strategically placed inside the vagina: for the iliococcygeus muscle, electrodes were positioned in the anterior part closer to the urethra; for the pubococcygeus muscle, electrodes were located in the posterior part near the rectum; and for the bulbocavernosus muscle, electrodes were placed in the anterior part near the vaginal entrance.

This comprehensive approach allowed for an accurate evaluation of pelvic floor muscle function and the efficacy of the rehabilitation programs.

Conclusion

This study demonstrates the significant impact of individualized rehabilitation programs on the functionality of the pelvic floor muscles of women with sexual dysfunction and neurological disorders. Utilizing sEMG as a diagnostic tool, we were able to objectively measure and evaluate the effectiveness of interventions such as biofeedback therapy, TTNS, and Kegel exercises. In conclusion, the study confirms that targeted rehabilitation programs, guided by precise and reliable measurement techniques like sEMG, are effective in treating sexual dysfunction. These results advocate for the integration of such evidence-based rehabilitation interventions into clinical practice to optimize patient outcomes. Future research should continue to explore the long-term benefits and potential refinements of these rehabilitation strategies to further enhance their effectiveness and accessibility.

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