

Surface Electromyography (Semg) in the Assessment and Treatment of Pelvic Floor Muscles: The Importance of Signal Normalization and Procedure Standardization for Interpretation and Biofeedback

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Protocol

The pelvic floor muscles (PFM) form the floor of the pelvic base and have a dual function - providing trunk stability and continence [1-3]. The dysfunctions of PFM may be multifactorial and symptoms may appear such as urinary incontinence, lower back pain or weakness of spinal stability [2,3]. Therefore, the proper diagnosis of these ailments requires complex evaluation. Nowadays, there are many methods of PFM dysfunction assessment - uroflow, cystometry, urodynamics, urethral pressure profilometry, electromyography or ultrasonography [4,5].

Surface electromyography (sEMG) assessment of the pelvic floor muscles is an objective, non-invasive and reproducible measurement method, allowing to assess and analyze the muscles' bioelectrical activity [6,7]. In addition, sEMG biofeedback has been reported by some authors as an effective tool in the rehabilitation of pelvic floor muscle disorders such as incontinence or pelvic pain [8-12]. However, up until now, there is a lack of evidence-based medical studies reporting the application of sEMG in the evaluation and treatment of pelvic floor muscle disorders including proper signal normalization and biofeedback procedure standardization which includes its vast possibilities. The absence of methodological standardization in this area is a source of bias in diagnosis and rehabilitation of pelvic floor muscle dysfunctions. Therefore, the aim of this mini review is the presentation of potential weaknesses of available research. The novelty of this paper is that it critically reviews the diagnostic and therapeutic approach based only on pelvic floor muscle maximal isometric contraction and relaxation for the first time, indicating that proper pelvic floor functioning requires much more than only a strength high level of those muscles

Arnold Kegel [12] was first, who used and described the pressure perinometer as a biofeedback tool for intravaginal measurement of pelvic floor muscles contractile force. The objective of this first biofeedback treatment was to improve the strength of the pubococcygeus muscle [13]. Nowadays in the rehabilitation of pelvic floor muscles dysfunction also other feedback methods are used: manometry by inflatable balloons placed in the rectum or in the vagina, surface electromyography via vaginal and rectal sensors or transabdominal or transperineal ultrasonography. The additional, important in treatment process information we can gain by monitoring of external muscles e.g. rectus abdominis, external oblique, gluteal or adductors muscles [4,14]. This feedback from both - internal and external sensors helps to isolate the specific muscles and motivate the

patients showing in real-time the pelvic floor muscles activity and the treatment progression [14].

Some authors have reported the efficacy of pelvic floor muscle treatment with sEMG biofeedback [15,16]. But most of those studies were based on non-normalized sEMG amplitude, which may be the source of errors [17]. Therefore, those observations should be considered with caution.

Zang et al. [8] have evaluated bioelectrical activity of the pelvic floor muscles in women with stress urinary incontinence and in age-matched controls. The test session consisted of four 5-s contractions preceded by 10-s relaxation periods. But the variables measured by those authors took into account only the changes in non-normalized sEMG amplitude during the contraction and relaxation state. In a different authors' study treatment of pelvic floor muscles dysfunctions with biofeedback included maximal muscles contraction held by 10 seconds [5]. Cornel et al. [15] in the group of 31 men with chronic prostatitis have reported the treatment with sEMG biofeedback via alternate contraction and relaxation of pelvic floor muscles. Their results showed that after treatment the average muscles tension dropped from 4.9 mV to 1.7 mV. However, the results reported by Cornel et al. [15] showed only a change in the pelvic floor muscle amplitude in mV. The lack of sEMG signal normalization may be a source of potential error because of daily signal amplitude variability [7,17]. Moreover, similarly to previously cited research [5,8,15], they have evaluated only the mean signal amplitude during contraction and rest.

As was described by some authors [4], studies comparing treatment of pelvic floor muscles dysfunction with biofeedback or with electrical stimulation to unassisted exercises showed the higher efficacy of those two first's. sEMG biofeedback including maximal muscles contraction, as well as electrical stimulation have similar effectiveness in pelvic floor muscles rehabilitation and both were superior to unassisted exercise. A broader analysis of pelvic floor muscle sEMG activity in patients with vulvodynia was performed by Jantos et al. [16]. They also used sEMG biofeedback during pelvic floor muscles exercise, but they applied the "Glazer Protocol" [18].

The Glazer Protocol is a method of pelvic floor muscle sEMG evaluation and treatment. It may be used in broad spectrum of functional genitourinary, sexual, gastrointestinal, and pain disorders. The main objective of the Glazer Protocol is standardization in all aspects of diagnosis, clinical research, biofeedback treatment and therapeutic efficacy [18,19]. The intrapelvic sEMG assessment in the

Glazer Protocol include a standardized and fixed parts of pelvic floor muscles evaluation. The following series of muscles contractions and relaxations are performed: pre-baseline rest, phasic contractions, tonic contractions, isometric contraction for muscles endurance evaluation, and post-baseline rest. The sEMG signal analysis include average sEMG amplitude, recruitment and recovery latencies, changes in spectral frequency and sEMG amplitude variability [18]. This protocol allows to gain much more bioelectric information from the sEMG signal analysis, rather than the traditional sEMG assessment which includes only pelvic floor muscles alternately, maximal contraction and relaxation.

As was reported by some authors [4,20], using the Glazer Protocol in the evaluation of pelvic floor muscles related functional disorders, e.g. urinary incontinence, pelvic pain, or sexual disorders it is possible to observe the shifts to the left in sEMG median frequency. Moreover, they also observed that changes in amplitude-related sEMG variables are less significant in pelvic floor muscles disorders evaluation. They have concluded that pelvic floor muscles training with sEMG biofeedback may influence mainly the bioelectric signal spectral frequency. Therefore the improvement in muscles contractile capabilities visible as changes in sEMG spectral frequencies may lead to pelvic floor muscles functional improvement [20].

The reason of stress urinary incontinence it is not only the pelvic floor muscles contractile weakness [19,21]. But what is important, the urethra actively supports the external urethral sphincter through the coaptation-self-sustaining closure. This process is quite complex and does not depend only on muscles contraction strength. It should be noted, that in context of therapy, the main factor in this process it is the muscles ability to rapid initiation of the contraction, and the stability to hold the contraction to support the coaptation. Therefore, the authors have concluded that the treatment of dysfunctional coaptation requires a different pelvic floor muscle rehabilitative approach than that offered by traditional sEMG biofeedback based mainly on maximum voluntary contraction training [4,21].

Research on pelvic floor muscles dysfunctions treatment with biofeedback are subject to bias. The main reasons are the lack of techniques, procedures and definitions standardization [18]. Nonetheless, the mechanisms of biofeedback effectiveness in pelvic floor muscle rehabilitation have not yet been sufficiently identified [10,18,22].

In a review article, Glazer and Laine [4] have reported that at the area of sEMG biofeedback research in the treatment of pelvic floor related disorders there is the lack of studies meeting evidence-based medicine criteria for research design and data analysis. Moreover, there is also the absence of any standardization regarding methodology and technical aspects of biofeedback application in pelvic floor muscles assessment and rehabilitation [4]. They only found seven studies which compared the biofeedback treatment to a no-treatment control group. However, these studies, have reported different biofeedback instrumentation and sEMG signal processing, or different assessment and treatment protocols. This methodological variability did not allow them to conclude any standardized definition of biofeedback as well as to generalize these findings [4,10,22].

It should also be noted that at present, the biofeedback therapeutic efficacy mechanisms have not be sufficiently identified. Therefore, more research fully meeting the evidence-based medicine criteria and allowing for standardization of assessment and treatment procedures in pelvic floor muscle disorders is needed. Moreover, an optimal

therapeutic outcome would be accurate diagnosis combined with the selection of an appropriate therapeutic intervention. It should include all factors which are important in the proper maintenance of urethral continence, such as appropriate urethral length and bladder position, pelvic floor muscle strength, endurance and coordination which are a crucial condition of urethral coaptation and adaptive changes in the pelvic floor that occur at periods of increased intra-abdominal pressure. We have suggested that diagnosis with sEMG should include all the aspects of muscle activity presented in the Glazer Protocol, which is now the most comprehensive tool for pelvic floor muscle evaluation. Moreover, treatment with sEMG biofeedback should include much more than the simple training of pelvic floor muscles' maximal strength.

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