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**REVIEW ARTICLE**

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# THE ROLE AND USE OF SURFACE ELECTROMYOGRAPHY (sEMG) FOR OBJECTIVE DIAGNOSTICS OF PERINEAL MUSCLES AND AS A METHOD OF CONSERVATIVE THERAPY OF STRESS URINARY INCONTINENCE (SUI)

**Key words:** biofeedback, stimulation ETS, sEMG, incontinence.

ABSTRACT

Urinary incontinence and disorders in the statics of the sexual organ in women are not only important clinical problems, but mainly psycho-emotional, social and economic. Establishing an appropriate therapy is not possible without an objective diagnosis of perineal muscles. The measurement of bioelectrical activity of muscles and changes in action potentials carried out with the use of surface electromyography (sEMG) allows objective assessment of muscle and nerve function. With the use of sEMG and sEMG biofeedback nervous and muscular disorders can be detected. A visual biofeedback combined with electrical stimulation (ETS) make it possible to get a response from the nervous and muscular system about the possibilities of central control of muscle contraction. The assessment of the dynamics of changes in nervous and muscular responses to the applied therapy (rehabilitation, pharmacological treatment, operative therapy) significantly facilitates treatment effectiveness.

## INTRODUCTION

Disorders of the perineal muscle and nerve function, including mainly urinary incontinence (UI) and disorders of the statics of the sexual organ in women are, together with other civilization-related diseases such as changes in the cardiovascular system, osteoporosis or psychoemotional disorders, the main reasons for deterioration of life quality [21]. The number of women with urinary incontinence in Poland is estimated at approximately 2-2.5 million, which makes it a significant social problem. Bent et al., [3], define urinary incontinence as an involuntary leakage of urine through the urethra. According to the International Continence Society it is a condition in which uncontrolled loss of urine is the main source of bad social and hygienic functioning of women. Nurkiewicz and Stawarz [22] estimate that approximately 30-50% of Polish women over 45 suffer from this ailment. In the United States one in four women over 35 reports this disorder [21]. The problem with establishing the exact number of people with urinary incontinence results from large differences in methodology of studies, adopting various definitions of urinary incontinence and hiding incontinence by women. Many authors report a relatively high rate of incontinence even in

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nulliparous athletes. About 67% gymnasts, 66% basketball players and 50% tennis players reported incontinence symptoms [23].

Urinary incontinence (UI) is a symptom of complex etiopathogenesis and it should not be treated as a disease entity uniform in terms of etiology [1, 25]. According to Jolleys [16], there are three types of urinary incontinence: urinary stress incontinence, urinary urge incontinence, incontinence with overflow and with mixed or iatrogenic causes. The most common form of urinary incontinence is stress incontinence (SUI). Stress urinary incontinence negatively affects both the mental and social functional condition of women and is a significant problem not only for a woman herself, but for her family as well [13, 21]. Hygienic discomfort, limitations in everyday physical and social activity, abandoning preferred motor activities, obesity and inability to work effectively are all SUI symptoms. Feelings of depression, helplessness, low self-esteem may lead to even greater changes within the urinary system, to neuroses and systemic changes [28]. Persuading a woman to undertake actions for selective rehabilitation and offering a method adequate for her individual functional state may restore the ability of her muscular, fascial and ligament apparatus, teach her correct reactions preventing an involuntary loss of urine (blocking perineal muscles) and enable her to resume normal everyday activities [13].

## THE ROLE OF MUSCLES AND NERVES IN THE PROCESS OF URINE STORING AND RELEASING

The main cause of stress urinary incontinence (SUI) is a failure of the muscular, fascial and ligament apparatus with a consequent lowering of the bladder [19]. SUI is diagnosed when increased intra-abdominal pressure is not transmitted evenly to the bladder and the urethra, and when the intraurethral pressure exceeds the pressure of urethra closure. The causes leading to disorders of perineal muscle and nerve activity and/or symptoms of SUI are hard physical work (lifting) and some sport activities, natural labour resulting in damage of perineal muscles and nerves, retrogressive changes in the muscles and connective tissue, which appear with age, and hormonal disorders and gynaecological procedures (20% of patients after radical hysterectomy suffer from SUI). According to Fowler [12], also injuries within the spinal cord and spinal nerves result in disorders of the bladder and lower urinary tracts.

Perineal muscles play an important role in urinary continence by their ability to control the external urethral sphincter [5, 7, 22]. Their tone is constant, even in sleep. In order to overcome the abdominal press perineal muscles contract and relax, depending on the circumstances. The fibres of muscular prioreceptors located in the external sphincter and pelvis wall lead through pudendal nerves to sacral segments on the level of S2-S4. During urine storing the mechanism of bladder stretching is working which is caused by impulses in afferent fibres. The sympathetic system is stimulated and it causes reflex inhibition of the detrusor muscle and contraction of the internal and external sphincter. Therefore, whether consciously or not, the outflow of urine takes place when the intravesical pressure exceeds intraurethral pressure. Physiological passing of urine involves contraction of the detrusor muscle, which is synchronised, with a few seconds of delay, with relaxing of the sphincter. In order to empty the bladder completely the activity of periurethral muscles and sphincter has to be inhibited for the whole duration of contraction of the detrusor muscle [30].

Partial denervation or muscle injuries and damage to vasomotor nerves result in atonia of ligament apparatus and perineal muscles. The percentage content of individual types of motor units in muscles depends on the function of given muscles. Skeletal striated muscles, depending on our volition, possess the ability to make a single contraction as well as tetanic contractions, including complete and incomplete ones. Smooth muscles, independent of our volition, work according to their own contraction rhythm. Their contraction may occur spontaneously or as a result of the action of neurotransmitters. The mechanism of working of the bladder, urethra and perineal muscles in the process of storing and passing urine is highly complex and requires co-operation of autonomic, peripheral and central nervous systems.

Type I fibres (with aerobic metabolism) responsible for the constant tone, account for 70% of perineal muscles. According to Łotocki [19], as a result of ischaemia they turn into type II fibres (with anaerobic metabolism) incapable of long-term strain. According to the author “The studies used in urogynecological pathologies and involutional

changes in urine stress incontinence show that the reduction of blood flows in vessels took place as a result of denervation, intravascular clots, cellular and biochemical involution of connective tissue as well as fascial and muscular structures of the perineum".

Parasympathetic innervation of the lower part of the urinary system comes from the sacral segments of the spinal cord (S2-S4). By way of splanchnic (pelvic) nerves the fibres lead to ganglia in the bladder wall and to internal sphincter muscles. A release of acetylcholine activates muscarine receptors M2 and M3 of smooth muscles of the bladder and urethra. Then the detrusor muscle contracts and the internal sphincter relaxes, as a result of which the bladder is emptied. Stimulation of M1-type receptors located in postganglionic axons leads to a reverse stimulation, which results in inhibition of release of acetylcholine [28].

Sympathetic innervation comes from segments Th10-L2. Impulses are conducted via the lowest splanchnic nerves, inferior mesenteric plexus and hypogastric nerve towards the bladder wall and internal sphincter muscle. Storing of urine allows for stimulation of β-2 adrenergic receptors, which causes relaxation of the detrusor muscle, and stimulation of α-1 receptors results in a contraction of the internal sphincter. Thus, urine is kept in the bladder until the impulses from (volumetric and tension) mechanoreceptors leading via pelvic nerves to sacral roots S2-S4 commence the process of correlated reaction of contraction of the detrusor muscle and relaxation of the sphincter. Somatic innervation leads through neurones coming out of motor cells of the anterior horns of sacral segments (S2-S4) of the spinal cord. Through the fibres making up the pudendal nerves nicotinic–choilinergic receptors of the external sphincter of urethra are stimulated, and as a consequence, it contracts and urine is held. Striated fibres of the external sphincter muscle are also subject to noradrenergic impact, i.e. as the only ones of their kind they are equipped with autonomic and somatic junctions. From the bladder the sensory fibres lead to the spinal cords through pelvic, hypogastric and pudendal nerves.

Neurological control of bladder activity, that is controlling the activity in the stage of collecting and passing urine, is possible thanks to impulses sent from higher levels of the central nervous system. For the proper functioning of the bladder and perineal muscles nervous stimuli are conducted in an undamaged route from higher brain centres through the brain stem, spinal cord and peripheral nerves to the detrusor muscle, bladder neck, periurethral muscles, urethral sphincter and pelvic diaphragm [30]. Any disturbances in the physiological mechanisms or atrophic changes in muscles, nerves and blood vessels on any level of this complex system, may cause signs of abnormal activities of the lower urinary tracts.

## DIAGNOSTIC METHODS

The basic test in diagnosing urinary incontinence is a gynaecological examination complete with patient's medical history and Gaudenz's questionnaire. Although palpable or visual assessment of muscular activity gives some impression of the scale of anatomical and atrophic changes, it does not allow for an objective assessment of a resting tone, strength of contraction, nervous and muscular disorders, or for drawing conclusions on the needs to undertake rehabilitation or specifying its principles. Disorders of the activity of muscles and nerves can be only recognised during gynaecological examination when the lowering of sexual organs, cystocele or rectocele can be observed, that is when rehabilitation itself is insufficient to correct anatomical changes and it must be completed with an operation [22]. A technique commonly used for the assessment of the lower urinary tract is transvaginal ultrasonography. With the use of this method anatomical structures significant for continence such as the neck of the bladder, urethra and bladder walls, can be assessed. It can reveal anatomical changes such as changes in the bladder and urethra angle, falling of the bladder neck or thickening of its walls, and it is used to specify the operative treatment method [20]. Other techniques of assessment of the lower urinary tracts include urodynamic examination. Using this method the activity of the lower part of urinary tract can be assessed. The method includes:

– uroflometry – examining the time and rate of urine flow through the urethra;
– cystometry – examining the bladder capacity and susceptibility and its response in the phases of filling and emptying as an assessment of changes in intracystic pressures;
– urethral profilometry – examining the functionnal length of the urethra and the pressure of

closure of the urethra in resting and during exercise;
- electromyography – used to assess the activity of the urinary sphincter in the phase of contraction of the detrusor muscle. It is used only to examine the synergy or dissynergy between the urinary sphincter and the detrusor muscle, not to assess the strength and quality of contraction of perineal muscles.

Indications for a urodynamic examination include the lack of expected effects of conservative treatment, recurring infections, disorders of the upper urinary tract qualifying for surgical procedures. By combining these two diagnostic methods it is possible to make a more accurate diagnosis and to establish an appropriate operative treatment or exclude an operation in case an instability of the detrusor muscle is found.

There is no doubt that the diagnostics of miction malfunction should be obligatorily completed with electromyography of the perineal muscles, which, unfortunately, is still used very rarely. Some earlier studies [5, 14] demonstrated clearly that the condition for an effective therapy is correct qualification and regular performance of appropriate perineal muscle exercises. The objectivity of the used methods affects the way of qualifying for treatment. Ultrasonography or urodynamic examination do not allow for the assessment of strength of muscle contraction, the degree of their denervation, nervous and muscular disorders, resting and post-exercise level of muscle tone – very significant factors used to establish and choose the best treatment method. Therefore, what is important, the only objective method of assessing the functional state of muscles is electromyography (sEMG), performed with the use of a vaginal electrode and an electromyograph connected to a PC. EMG allows:
- visualisation and monitoring of muscle response in rest and during exercise;
- assessment of strength and stability of a contraction;
- assessment of muscle reaction time to an order to contract and relax;
- carrying out biofeedback exercises supporting central mechanisms controlling muscle activity and/or developing desired motor properties (endurance, reaction time);
- archiving data, comparing results of examinations and tests on individual stages of treatment.

The high sensitivity of the device of 0.2-2000 μV [14] makes it possible to detect even a slight generated movement. A number of authors [10, 26, 24, 14] emphasize the huge significance of application of such techniques as sEMG biofeedback and muscle stimulation as soon as possible after a muscle/nerve injury occurs, in order to prevent atrophic changes, improve blood supply and speed up healing. The only contraindications in the case of women with urinary stress incontinence are significant deviations in the anatomy of the genitourinary system and inflammatory conditions. In order to determine the correct therapeutic procedure, the mechanism of working of the bladder, urethra, perineal muscles and nerves has to be studied in detail. According to Fowler et al., [11], the functioning of this mechanism is possible thanks to the co-operation of the autonomic, peripheral and central nervous systems as well as locally regulating factors. Because each of the above systems may be characterised by various kinds of nervous and muscular disorders, an objective assessment by sEMG allows for their better diagnosis and undertaking selective therapy by choosing appropriate methods, exercise loads and electric impulses for functional stimulation (FES), which is adjusted for the functional state of the nerves and motor units significant for collecting and passing of urine.

## METHODS OF TREATMENT

Currently, the most frequently suggested way of treatment of urinary stress incontinence is operative treatment. According to Wilczyńska-Zając [28] "Over 150 ways of operative treatment of stress incontinence have been described, which best shows that there is no effective method". Operative treatment is a typical symptomatic treatment and its effectiveness assessed in the period of ten years after the operation ranges from 30 to 70% depending on the adopted method [20]. It is also related to post-operative complications in 10-30% of patients [6, 18]. Because nervous and muscular disorders diagnosed by way of perineal electromyography are considered to be functional disorders, which do not respond to operative treatment, they should be subject to conservative therapy.

Conservative treatment generally involves increasing the strength and endurance of perineal

muscles and restoration of correct nervous and muscular responses. However, pharmacological means may modify the functions of the bladder and lower urinary tract and alleviate the symptoms of stress incontinence, they do not strengthen the muscles and have numerous side effects. The choice of the method depends mainly on the EMG results. Therefore, exercises for perineal muscles should be recommended to a person who has weak volitional control of muscles as a result of innervation disorder [5, 15]. It has been proved that in people without disorders, mainly in young women, a high effectiveness (70-85%) of stress incontinence treatment is a result of exercises according to the pioneer of this method, Dr. Kegel [9, 24]. A condition for the effectiveness of this method is an assumption that they are performed strictly according to Kegel's study, where they should be carried out with the use of biofeedback in the form of perineometer or electromyograph [24]. It has been demonstrated that exercises without biofeedback are much less effective, and as a consequence lead to the lack of motivation, which results in abandoning exercises [4]. Another effective solution for activating perineal muscles is selective electrical stimulation.

Electrical stimulation of perineal muscles allows for stimulation of partially or fully denner-vated muscles and is recommended until they become innervated again, confirmed in an sEMG examination where an increase in the strength and endurance of muscles and improvement in control of muscle activity is noted [8, 10]. The method uses a diaphase symmetrical rectangular impulse or expotential impulse. The period of treatment may be two to three months, or longer in individual cases. In order to achieve good results of electrical stimulation it is necessary to correctly select its parameters, depending on the degree of denervation and muscle efficiency, also assessed in the sEMG examination [17, 27, 29]. The frequency and duration of an impulse as well as intensity must be adjusted for individual needs of a patient.

The latest technique of stimulation of flaccid and spastic paresis is Electromyographic Triggered Stimulation (ETS). Depending on the value of task threshold selected in the EMG examination (load appropriate for muscle efficiency) stimulation is triggered automatically after a contraction genera-ted by a patient, the strength of which exceeds the threshold. The effectiveness of ETS in treatment of stress incontinence is assessed at 80-85% [13]. The method is non-invasive, painless and practically does not have any side effects and limitations. The essence of ETS is using and supporting even the weakest muscle contractions generated volitionally, which leads to the strengthening of central and peripheral mechanisms of controlling a contraction. Visualisation of a contraction on a computer screen and sound effects signaling overcoming a task threshold, significantly increase patient's moti-vation to continue exercises [2]. Records of successive treatment sessions objectively document the effects of the therapy. My own investigations [13] revealed that only a five-minute ETS training is enough to teach a patient how to perform correctly, isolated perineal muscle contractions.

## CONCLUSIONS

Conservative therapy of urinary stress incontinence in women is a very complex issue and due to the disorder's complicated etiopathogenesis it requires an interdisciplinary approach, a joined effort of doctors, physiotherapists and psycho-logists. As the above description of the roles of muscles and nerves shows, it is the condition of perineal muscles, their vascularisation, resting and exercise activity, correct nervous and muscular responses which are the main factors determining the occurrence of symptoms of incontinence. Their assessment using sEMG is used not only to prevent perineal disorders but also to specify the principle of correct preoperative and postoperative rehabilitation.

It seems that it is wrong to look for one effective method of operative treatment, due to significant differences in causes of urinary stress incontinence. Each cause may result in a different type of damage with similar symptoms. Restoration of correct nervous and muscular responses is possible only by preoperative and postoperative rehabilitation. An operation itself, in spite of removing the symptoms, does not eliminate the preoperative failure of nervous and muscular structures. Undoubtedly the effectiveness of opera-tions would be higher if they were supported by preoperative and postoperative rehabilitation.

The above statements lead to a conclusion that if nervous and muscular structures play the basic role in urine continence, monitoring of their functioning using an objective method such as surface electromyography of perineal muscles is

very important in the prevention and conservative treatment of urinary stress incontinence. Also the choice of method of preventive treatment and parameters of muscle and nerve stimulation should be based on the results of sEMG as an objective diagnostic tool. Rehabilitation for patients with muscular and nervous activity disturbances should be part of a comprehensive diagnosis and treatment of stress incontinence, preceded by and monitored with electromyography of perineal muscles, irrespective of the type of planned operative treatment.

## REFERENCES


[1] Abrams P., Cardozo L., Fall M., Griffiths D., Rosier P., Ulmsten U., Van Kerrebroeck P., Victor A., Wein A., The standardization of terminology of lower urinary tract function: report from the standardization Sub-committee of the International Continence Society, *Neurourology Urodynamics*, 2002, 21 (2): 167-178.

[2] Aukee P., Immonen P., Penttinen J., Laippala P., Airaksinen O., Increase in pelvic floor muscle activity after 12 weeks' training: a randomized prospective pilot study, *Urology*, 2002, 60 (6): 1020-1023; discussion 1023-1024.

[3] Bent A.E., Richardson D.A., Ostergard D.R., Diagnosis of the lower urinary tract disorders in postmenopausal patients, *American Journal Obstetric & Gynecology*, 1983, 145: 218-222.

[4] Berghmans L.C., Frederiks C.M., de Bie R.A., Weil E.H., Smeets L.W., van Waalwijk van Doorn E.S., Janknegt R.A., Efficacy of biofeedback, when included with pelvic floor muscle exercise treatment, for genuine stress incontinence, *Neurourology Urodynamics*, 1996, 15 (1): 37-52.

[5] Bo K., Pelvic floor muscle training is effective in treatment of female stress urinary incontinence, but how does it work?, *International Urogynecology Journal of Pelvic Floor Dysfunctions*, 2004, 15 (2): 76-84.

[6] Bros M., Czajkowski K., Kornacki P., Analysis of complications of the tension-free vaginal tape procedure for surgical treatment of female stress urinary incontinence, Ginekologia Polska, 2003, 74 (9): 930-936.

[7] Cendrowski K., Evaluation of physiotherapy in patients with sexual organ disorders and incontinence, (in:) A. Gomuła, ed., Abnormalities in genital organ statics, stress urinary incontinence – undervalued clinical problem, Białystok 1999, 177-182.

[8] Crameri R.M., Weston A., Climstein M., Davis G.M., Sutton J.R., Effects of electrical stimulation-induced leg training on skeletal muscle adaptability in spinal cord injury, *Scandinavian Journal of Medicine Science Sports*, 2002, 12 (5): 316-322.

[9] Dannecker C., Wolf V., Raab R., Hepp H., Anthuber C., EMG-biofeedback assisted pelvic floor muscle training is an effective therapy of stress urinary or mixed incontinence: a 7-year experience with 390 patients., Archives of Gynecology and Obstetrics, 2005, 273 (2): 93-97.

[10] Draper V., Ballard L., Electrical stimulation versus electromyographic biofeedback in the recovery of quadriceps femoris muscle function following anterior cruciate ligament surgery, Knoxville Orthopedic Clinic, TN 37909, Physical Therapy, 1991, 71 (6): 455-461.

[11] Fowler C.J., Investigation of the neurogenic bladder, *Journal of Neurology, Neurosurgery, & Psychiatry*, 1996, 60 (1): 6-13.

[12] Fowler C.J., Neurological disorders of micturition and their treatment, Brain 1999, 122 (7): 1213-1231.

[13] Garstka-Namysł K., Individually planned functional ETS and EMG-biofeedback and supraspinal FES stimulation of pelvic floor muscles in women after gynaecological operations with symptoms of urinary incontinency, *New Medicine*, 2008, 12 (1): 3-7.

[14] Garstka K., Usefulness of sEMG and sEMG biofeedback in muscle activity disorders therapy, *Medycyna Sportowa*, 2006, 22 (1): 52-58.

[15] Haslam J., Nursing management of stress urinary incontinence in women, *British Journal of Nursing*, 2004, vol. 13, 32-40.

[16] Jolleys J.V., Diagnosis and management of female urinary incontinence in general practice, *Journal Royal College of General Practitioners*, 1989, 39, 277-279.

[17] Kaye J.D., Palmer J.S., Animated biofeedback yields more rapid results than nonanimated biofeedback in the treatment of dysfunctional voiding in girls, *Journal of Urology*, 2008, 180 (1): 300-305.

[18] Kuuva N., Nilsson C.G., Long-term results of the tension-free vaginal tape operation in an unselected group of 129 stress incontinent women, Acta Obstetricia et Gynecologica Scandinavica, 2006, 85 (4): 482-487.

[19] Łotocki W., Stress incontinence problems in women in clinical urogynecology of region, (in:) A. Gomuła, eds, Abnormalities in genital organ statics, stress

urinary incontinence – undervalued clinical problem, Białystok 1999, 11-21.

[20] Mills R., Persad R., Handley-Ashken M., Long-term follow-up results with the Steamy operation for stress incontinence of urine, *British Journal of Urology*, 1997, 79 (2): 303.

[21] Molander U., Sundh V., Steen B., Urinary incontinence and related symptoms in older men and women studied longitudinally between 70 and 97 years of age. A population study, Archives of Gerontology & Geriatrics, 2002, 35 (3): 237-244.

[22] Nurkiewicz W., Stawarz B., Classification of vesico-urethral dysfunctions, *Nowa Medycyna*, 2000, 1991, 13.

[23] Nygaard I.E., Thompson F.L., Svengalis S.L., Albright J.P., Urinary incontinence in elite nulliparous athletes, Obstetrics and Gynecology, 1994, 84 (2): 183-187.

[24] Perry J.D., Hullet L.T., The Bastardization of dr Kegel's exercise. Paper Presented to Northeastern Gerontological Society, New Brunswick, New Jersey 1988.

[25] Rechberger T., Postawski K., Urogynecological health problems of postmenopausal women, *Nowa Medycyna*, 2004, 123 (1): 33-38.

[26] Thakar R., Ayers S., Clarkson P., Stanton S., Manyonda I., Outcomes after total versus subtotal abdominal hysterectomy, *North England Journal of Medicine*, 2002, 24; 347 (17): 1318-1325.

[27] Turker K.S., Electromyography: some methodological problems and issues, *Journal of the American Physical Therapy Association*, 1993, 73: 698-710.

[28] Wilczyńska-Zając A., Female urinary incontinence, Therapy, 2002, 4, vol. 3, 121.

[29] Weatherall M., Biofeedback or pelvic floor muscle exercises for female genuine stress incontinence: a meta-analysis of trials identified in a systematic review, *British Journal of Urology Interntional*, 1999, 83 (9): 1015-1016.

[30] Yamanishi T., Yasuda K., Sakakibara R., Hattori T., Suda S., Randomized, double-blind study of electrical stimulation for urinary incontinence due to detrusor over activity, Urology, 2000, 55 (3): 353-357.