Original article / Artykuł oryginalny

Kuba Ptaszkowski[1] 0000-0002-5690-5226
Sławomir Jarząb[1] 0000-0002-4767-1579
Małgorzata Paprocka-Borowicz[1] 0000-0003-4296-7052
Lucyna Ptaszkowska[2] 0000-0002-7706-0971

[1] *Divison of Rehabilitation in the Movement Disorders, Department of Physiotherapy, Faculty of Health Sciences, Wroclaw Medical University, 2 Grunwaldzka Street, 50-355 Wroclaw*
+48 71 786 01 86 *kuba.ptaszkowski@umw.edu.pl*
[2] *Institute of Health Science, University of Opole, 68 Katowicka Street, 45-060 Opole, Poland,*
lucyna.ptaszkowska@uni.opole.pl

Cite / Sposób cytowania Ptaszkowski K, Jarząb S, Paprocka-Borowicz M, Ptaszkowska L. Factors affecting the bioelectrical activity of the pelvic floor muscles in menopausal women - an observational study. *Aesth Cosmetol Med.* 2022;11(1):25-30. https://doi.org./10.52336/acm.2022.003

Factors affecting the bioelectrical activity of the pelvic floor muscles in menopausal women – an observational study

Czynniki wpływające na aktywność bioelektryczną mięśni dna miednicy u kobiet w okresie menopauzalnym – badanie obserwacyjne

ABSTRACT

During the perimenopausal and early postmenopausal periods, women experience several systemic and psychological changes. They mainly concern the genitourinary, central nervous, musculoskeletal, and cardiovascular systems. Changes related to the aging process of the skin also play an important role.

The aim of the study was to evaluate the influence of age, selected anthropometric data (such as body weight, body height, body mass index (BMI) and external dimensions of the pelvis), and the parameters included in the questionnaires on the bioelectric activity of the pelvic floor muscles (PFM).

Postmenopausal women achieved higher levels of resting and functional surface activity of pelvic floor muscle electromyography (sEMG PFM), indicating that PFM function improves over the years following menopause. Women who report significant symptoms of urinary incontinence had a lower PFM resting tone. This may prove significant functions of PFM, mainly during resting activity. However, this results requires further verification based on a larger study group and usage of specialized methods of assessing the degree and type of urinary incontinence.

Keywords: menopause, pelvic floor muscles, body mass index, surface electromyography

STRESZCZENIE

W okresie okołomenopauzalnym i wczesnym postmenopauzalnym, kobiety doświadczają szeregu zmian ogólnoustrojowych i psychologicznych. Dotyczą one głównie układów: moczowo-płciowego, ośrodkowego układu nerwowego, mięśniowo-szkieletowego, sercowo-naczyniowego. Istotną rolę odgrywają także zmiany związane z procesem starzenia się skóry.

Celem pracy była ocena wpływu wieku, wybranych danych antropometrycznych: masy ciała, wysokości ciała, wartości wskaźnika masy ciała BMI (*Body Mass Index*), wymiarów zewnętrznych miednicy oraz badanych parametrów aktywności bioelektrycznej mięśni dna miednicy (MDM).

Wyniki kobiet w okresie postmenopauzalnym osiągają wyższe wartości spoczynkowej i czynnościowej aktywności powierzchniowej elektromiografii mięśni dna miednicy (sEMG MDM), co wskazuje na to, że czynność MDM poprawia się wraz z upływem lat po menopauzie. U kobiet zgłaszających istotne objawy związane z nietrzymaniem moczu, występuje niższe spoczynkowe napięcie MDM. Dowodzić to może bardzo ważnych funkcji MDM, głównie podczas ich spoczynkowej aktywności. Wymaga to jednak dalszej weryfikacji w oparciu o większą grupę badaną, z zastosowaniem specjalistycznych metod oceny stopnia i rodzaju nietrzymania moczu.

Słowa kluczowe: menopauza, mięśnie dna miednicy, wskaźnik masy ciała, elektromiografia powierzchniowa

INTRODUCTION

As defined by the International Menopause Society (IMS), menopause, climacteric, is the transition period between reproductive and old age, which is divided into premenopausal, perimenopausal, menopausal, and postmenopausal periods (table 1) [1].

In the perimenopause and early postmenopausal period, women experience several systemic and psychological changes [2-4]. Symptoms reported by women during this period are included in the group of vasomotor symptoms. They concern the genitourinary, central nervous, musculoskeletal, and cardiovascular systems. Cosmetic changes also play an important role [3-5]. Table 2 presents the most common symptoms of menopause [3-5].

INFLUENCE OF THE MENOPAUSAL PERIOD ON THE GENITOURINARY SYSTEM AND THE PELVIC FLOOR

In the light of this study, the most important role was played by the influence of the menopausal period on the pelvic floor and the pelvic organs. It is believed that approximately 50% of menopausal women develop symptoms related to the genitourinary system. The most frequently reported symptoms are: dyspareunia, vaginal dryness, difficulty urinating, urinary incontinence (UIC), frequent urination, recurrent infections [6-8]. Table 3 presents the frequency of some of these symptoms based on the publications of various authors [7, 9-15].

Table 2 Symptoms of the menopausal period

SYMPTOMS
Vasomotor:
Hot flushes, increased sweating, restlessness, night sweats, insomnia, sleep disturbances, irritability, fatigue.
Genitourinary system:
Frequent urination, stress incontinence, increased risk of urinary tract infections, vaginal dryness, discomfort, burning, vaginal itching, dyspareunia, decreased libido, sexual dysfunction.
Central nervous system:
Depression, sadness, crying, feelings of despair, loneliness, impaired psychosocial functioning, insomnia or excessive sleepiness, weight loss or gain, increased or decreased appetite, chronic fatigue, poor concentration, headache, short-term memory problems.
The musculoskeletal system
Reduction in bone mineral density, increased risk of osteopenia / osteoporosis, joint and muscle pain.
Cardiovascular:
Increased total cholesterol, increased LDL cholesterol, decreased HDL cholesterol, increased risk of cardiovascular disease, palpitations.
Cosmetic:
Collagen loss, skin thinning, increased epidermal keratosis, skin atrophy, breast glandular atrophy, hirsutism.

Source: Own study based on [3-5]

Table 1 Women's life periods, including the menopausal transition and the main criteria for each stage

Menarche (at stage -5); Menopause (0) (between stages -1 and +1a)

Stage	-5	-4	-3b	-3a	-2	-1	+1a	+1b	+1c	+2
Period	Reproductive				Menopausal transition		Postmenopausal			
	Early	Middle (peak)	Late		Early	Late	Early		Late	
	Premenopausal									
					Perimenopausal period					
Duration	Variable				Variable	1 - 3 years	2 yeas		3 – 6 years	Rest of life
Main criteria										
The menstrual cycle	Variable / Regular	Regular	Regular	Subtle changes in occurrence and duration	Varying length (differences ⩾ 7 days); the difference in the length of successive cycles	The interval between menstruation ⩾ 60 days				
Additional criteria										
Hormones: FSH AMH Inhibin B			Low Low	Variable Low Low	↑ Variable Low Low	↑ >25 IU/L Low Low	↑ Variable Low Low	Stabilized Very low Very low		
The number of astral bubbles			Low	Low	Low	Low	Very low	Very low		
Characteristic										
Symptoms						Vasomotor disorders Likely	Vasomotor disorders Very likely			Increase in the symptoms of the genitourinary system

Source: Own study based on [1]

Table 3 The prevalence of urogenital symptoms in menopausal women (UIC - urinary incontinence, EUI - exercise urinary incontinence)

Author, year	Symptoms			
	Pollakiuria	Urinary incontinence	Urinary tract infections	Vaginal dryness
Berg, 2008 [9]	-	-	-	34.5% (n= 38)
Conboy, 2001 [10]	57% (n= 247)	53% (n= 229)	-	45% (n= 190)
Dennerstein, 2000 [11]	7-15% (problems controlling urine)		1-2 %	0-2%
Hsieh, 2008 [12]	-	29.8 % (n= 485)	-	-
Jędrzejczyk, 2008 [13]	-	- patients operated on for gynecological and obstetric reasons 77% (n= 46) - unoperated patients 73% (n= 69)	-	-
Larson, 1997 [14]	-	34-57 %	-	18-37%
Nygaard, 2013 [7]	77.1% (n= 27)	EUI – 74.6% (n= 26) Mixed UIC - 82.9% (n= 29)	-	-
Schnatz, 2005 [15]	-	-	-	48.1% (n= 38)

Source: Own study based on [9-15]

Mannella et al. emphasized that the main cause of urogenital symptoms was the decrease in estrogen levels [16]. A decreased number of estrogen receptors was also observed in the epithelium of the bladder, urethra, bladder triangle, in the vaginal mucosa, and in supporting structures including a uterosacral ligament, levator ani muscle, and the cervical fascia [16, 17]. Estrogens affect the synthesis and metabolism of collagen in the lower urinary tract and increase the number of muscle fibers in the detrusor muscle or other muscle layers of the pelvic floor [16, 18]. In addition, some authors [16, 19] underlined that low estrogen levels might also have a negative effect on the neurological control of micturition, through the decreasing density of sympathetic nerve fibers within the pelvis. Basha et al. paid great attention to changes in the functioning and structure of the vaginal walls as a result of the reduced production of sex hormones [20]. Decreased vaginal blood flow, reduced contractility of vaginal smooth muscles, and changes in the structure and density of nerve endings or collagen structures were observed. This led to a reduction in the elasticity of the vaginal walls and, as a consequence, promoted the occurrence of pelvic floor dysfunctions, such as prolapse and sexual dysfunction [20, 21]. In the process of proper urinary continence, Petros et al. highlighted the crucial function of the vagina [22]. Damage or weakening of the fascial structures supporting the anterior vaginal wall, bladder, vesicourethral junction, and urethra might lead to ailments related to the lower urinary tract [22]. The position and functioning of the vagina were also influenced by the failure of the levator ani muscle (damage, denervation), which connects to the vaginal smooth muscle fibers through the pelvic fascia [23, 24].

A frequent cause of pelvic floor failure is damage to muscles, as well as connective tissue structures or nerves as a result of numerous natural births [23]. The connective tissue plays a very important function within the pelvic floor because the ligaments and fascia are largely responsible for the stabilization of the structures located in the smaller pelvis. Restoring the condition of connective tissue structures after childbirth is often associated with the replacement of type I collagen with weaker type III collagen, which contributes to the loss of elasticity of these structures [16]. Additionally, it should be emphasized that the collagen content in connective tissue generally decreases in all postmenopausal women [16].

Summing up, the weakening of individual components of the pelvis and the pelvic floor may lead to pathological symptoms related to their dysfunction. Therefore, appropriate diagnostics and therapeutic management play an essential role in preventing or reducing the degree of the discussed dysfunctions, especially in menopausal women [15, 25].

Scientific publications indicate the validity of the use of surface electromyography (sEMG) in the assessment of the bioelectric activity of the PFM, as well as the synergistic muscles for PFM [26, 27]. Therefore, the use of sEMG as an objective, non-invasive and safe method (while maintaining the correct methodology) seems appropriate to assess the muscles included in the project. The sEMG method is commonly used in everyday physiotherapeutic practice as a tool for providing feedback from muscles, the so-called biological feedback (biofeedback). There are numerous studies in the literature confirming the effectiveness of this method in the treatment of pelvic floor dysfunction. In the assessment of the pelvic floor, feedback is most often used, recorded by means of intravaginal (endovaginal) or intrarectal (endorectal) electrodes. Currently, there are many models of devices for sEMG measurements with electrodes of various sizes, shapes, and numbers of surfaces for recording myoelectric potentials. Voorham van der Zalm et al. [28] and Bo et al. [29] stated that there was a great need to conduct further research and verify the information on the use of electrodes of various shapes, lengths, widths, and electrode locations in order to standardize, standardize and maximize the accuracy of measurements.

AIM OF THE WORK

The aim of the study was to assess the influence of age, selected anthropometric data (body weight, body height, BMI (Body Mass Index), external dimensions of the pelvis), and the parameters included in the questionnaires on the bioelectric activity of PFM. It was assumed that lower values of PFM activity and lower pelvic mobility would be observed in subjects with higher values of the parameters assessed.

Detailed research question and hypotheses:

Does the bioelectric activity of PFM depend on age, anthropometric parameters, and data included in the questionnaires?

H_0 – Age, anthropometric data, and data obtained on the basis of questionnaires do not affect the bioelectric activity of PFM.

H_1 – Age, anthropometric data, and data obtained on the basis of questionnaires negatively correlate with the bioelectric activity of PFM.

MATERIAL AND METHOD

A prospective, cross-sectional observational study investigating the effect on the resting and functional bioelectric activity of PFM in menopausal women. The research received a positive opinion of the Bioethics Committee operating at the Medical University of Silesian Piasts in Wroclaw and on this basis, on July 5, 2012, consent to carry out these tests was given (Bioethics Committee opinion number: KB - 611/2012). The target group of the discussed studies was women in the menopausal period. Women were recruited for the study from among patients of the Clinic and Department of Urology and Urological Oncology, University Clinical Hospital in Wroclaw, and volunteers in response to advertisements in the media. All recruited women were assessed according to the inclusion and exclusion criteria in order to qualify for the appropriate study group. The sEMG measurements were made using the MyoSystem 1400L eight-channel electromyography apparatus (Noraxon, Scottsdale, Arizona, USA) with compatible surface and endovaginal electrodes. The Menopause Rating Scale (MRS) was used to assess the symptoms of menopause. Additionally, the symptoms of urinary incontinence were measured using the International Consultation on Incontinence Questionnaire - Urinary Incontinence Short Form (ICIQ - UI).

Statistical analysis was performed using the Statistica 12 program (StatSoft, Inc., USA) licensed from the Medical University of Wroclaw. For measurable variables, arithmetic means, standard deviations, variances, range of variability (extreme values), and skewness were calculated. All investigated quantitative variables were checked with the Shapiro-Wilk test to establish the type of distribution. The correlation was assessed using the Pearson correlation coefficient or the Spearman's rank depending on the fulfillment of the assumptions. The level of $\alpha = 0.05$ was assumed for all comparisons.

RESULTS

The target group was women in the menopausal period. 131 participants were registered, of which 82 were qualified for the measurements on the basis of the inclusion and exclusion criteria. Table 4 presents the characteristics of the stu-

Table 4 Characteristics of the study group (n=82)

	Number of valid cases (n)	Mean ($\bar{x}$)	Minimum (min)	Maximum (max)	Standard deviation (s)
Age [years]	82	65.3	50.0	74.0	5.7
Body weight [kg]	82	69.0	51.0	101.0	10.6
Body height [m]	82	1.61	1.46	1.72	0.05
BMI [kg / m²]	82	26.6	18.8	36.9	3.9
Number of births	82	1.7	0.0	6.0	1.0
Menopausal age [years]	82	50.8	40.0	60.0	4.9

Source: Own study

Table 5 Assessment of the correlation between sEMG PFM activity and the results concerning the group characteristics (Pearson correlation coefficient or Spearman's rank)

	sEMG PFM activity			
	Resting [μV]	Functional [μV]	Resting [μV]	Functional [%]
Age [years]	r=-0.27*	r=-0.28*	r=0.06**	r=-0.08**
	p=0.1451	p=0.1393	p=0.7381	p=0.6602
Body weight [kg]	r=0.13*	r=0.14*	r=-0.23**	r=-0.24**
	p=0.4862	p=0.4697	p=0.2283	p=0.2035
Body height [m]	r=-0.06*	r=-0.02*	r=-0.29**	r=-0.35**
	p=0.7374	p=0.9216	p=0.1202	p=0.0592
BMI [kg / m²]	r=0.38*	r=0.30*	r=0.18**	r=0.28**
	p=0.0565	p=0.1104	p=0.3461	p=0.1345
Number of births	r=0.07*	r=0.08*	r=-0.17*	r=-0.20*
	p=0.7176	p=0.6622	p=0.3619	p=0.2905
Menopausal age [years]	r=0.44*	r=0.50*	r=-0.11**	r=0.10**
	p=0.0161	p=0.0051	p=0.5745	p=0.6035
MRS overall score [points]	r=-0.04*	r=-0.01*	r=-0.10**	r=-0.06**
	p=0.8452	p=0.9632	p=0.6180	p=0.7443
ICIQ-UI Short Form Total Score [points]	r=-0.03*	r=0.03*	r=-0.40**	r=-0.35**
	p=0.8653	p=0.8584	p=0.0301	p=0.0553

* Spearman's rank correlation coefficient
** Pearson's correlation coefficient

Source: Own study

Table 6 Assessment of the correlation between sEMG PFM activity and the results of external pelvic measurements (Spearman's rank correlation coefficient)

	sEMG PFM activity			
	Resting [µV]	Functional [µV]	Resting [%] x	Functional [%]
ASISs [cm]	r=-0.12*	r=-0.12*	r=-0.01*	r=0.01*
	p=0.5392	p=0.5166	p=0.9621	p=0.9866
Intercostal [cm]	r=0.11*	r=0.03*	r=0.10*	r=0.02*
	p=0.5525	p=0.8735	p=0.5992	p=0.9115
Intertrochanteric [cm]	r=0.02*	r=0.04*	r=-0.03*	r=0.03*
	p=0.9147	p=0.8232	p=0.8675	`p=0.8884
External coupler [cm]	r=-0.02*	r=-0.05*	r=-0.03*	r=-0.13*
	p=0.9122	p=0.7921	p=0.8921	p=0.5111
* Spearman's rank correlation coefficient				

Source: Own study

dy group. It contains basic information, such as age, height and weight, body mass index BMI (Body Mass Index).

Below there is an assessment of the influence of age, selected anthropometric measurements (body weight, height, BMI), and the results of questionnaires (MRS, ICIQ - UI Short Form, questions from the personal questionnaire, regarding menopausal age and number of deliveries) on the activity of sEMG PFM (table 5) and the angle of the pelvis (table 6).

In the case of sEMG PFM activity, a positive, statistically significant correlation was observed between resting and functional voltage [µV] and menopausal age ($r = 0.21$; $p = 0.044$; $r = 0.21$; $p = 0.044$) and a negative correlation between sEMG activity at rest [%] PFM and the result of the ICIQ questionnaire - UI Short Form ($r = 0.21$; $p = 0.044$) (Table 5). There were no statistically significant correlations with the other variables in table 5 and with the results of external pelvic measurements (table 6).

DISCUSSION

In this study, the impact of age, selected anthropometric parameters (body weight, height, BMI, external pelvic measurements), and data from the conducted questionnaires (i.e. MRS, ICIQ - SF) on the bioelectric activity of PFM was assessed. Although there were numerous studies devoted to the assessment of the impact on PFM: age [8, 30, 31], body weight [32, 33], BMI [34, 35], or pelvic dimensions [36, 37], this study did not present statistically significant correlations between the bioelectric activity of PFM and the above variables were observed.

However, the above study showed a relationship between the resting and functional activity of sEMG PFM and menopausal age. PFM activity increased in women who were long after menopause. Based on the work of other scientists [27, 38, 39], it can be concluded that higher bioelectrical activity of PFM results in the occurrence of fewer ailments related to the lower urinary tract (eg SUI). According to Lee et al. [6] or Trutnovsky et al. [40], increased symptoms related to the lower urinary tract occur during menopause. The above information could explain the lower sEMG PFM value in the initial postmenopausal period shown in this study.

Another noteworthy result of the analysis is the relationship between lower PFM resting activity and worse, subjective assessment of symptoms related to urinary incontinence. This result confirms numerous scientific reports [27, 38, 39] about the influence of weakened PFM on the increase of symptoms related to abnormal urinary incontinence.

CONCLUSIONS

Postmenopausal women achieve higher values of sEMG PFM resting and functional activity, indicating that PFM function improves with the passing of the postmenopausal years. Women who report significant symptoms of urinary incontinence have a lower PFM resting tone. This may prove vital functions of PFM, mainly during their resting activity. However, this requires further verification based on a larger study group with the use of specialized methods to assess the degree and type of urinary incontinence.

REFERENCES / LITERATURA

1. Harlow SD, Gass M, Hall JE, et al. Executive summary of the Stages of Reproductive Aging Workshop + 10: addressing the unfinished agenda of staging reproductive aging. *Menopause N Y N*. 2012;19(4):387-395. https://doi.org/10.1097/gme.0b013e31824d8f40
2. Aguilar-Zavala H, Pérez-Luque EL, Luna-Martínez F, et al. Symptoms at postmenopause: genetic and psychosocial factors. *Menopause N Y N*. 2012;19(10):1140-1145. https://doi.org/10.1097/gme.0b013e3182503bde
3. Bauld R, Brown RF. Stress, psychological distress, psychosocial factors, menopause symptoms and physical health in women. *Maturitas*. 2009;62(2):160-165. https://doi.org/10.1016/j.maturitas.2008.12.004
4. Newton KM, Buist DSM, Keenan NL, et al. Use of alternative therapies for menopause symptoms: results of a population-based survey. *Obstet Gynecol*. 2002;100(1):18-25.
5. Moilanen J, Aalto A-M, Hemminki E, et al. Prevalence of menopause symptoms and their association with lifestyle among Finnish middle--aged women. *Maturitas*. 2010;67(4):368-374. https://doi.org/10.1016/j.maturitas.2010.08.007
6. Lee J. The menopause: effects on the pelvic floor, symptoms and treatment options. *Nurs Times*. 2009;105(48):22-24.
7. Nygaard CC, Betschart C, Hafez AA, et al. Impact of menopausal status on the outcome of pelvic floor physiotherapy in women with urinary incontinence. *Int Urogynecology J*. 2013;24(12):2071-2076. https://doi.org/10.1007/s00192-013-2179-7
8. Tinelli A, Malvasi A, Rahimi S, et al. Age-related pelvic floor modifications and prolapse risk factors in postmenopausal women. *Menopause N Y N*. 2010;17(1):204-212. https://doi.org/10.1097/gme.0b013e3181b0c2ae
9. Berg JA, Larson CA, Pasvogel AE. Menopausal symptom perception and severity: results from a screening questionnaire. *J Clin Nurs*. 2008;17(7):940-948. https://doi.org/10.1111/j.1365-2702.2007.02112.x
10. Conboy L, Domar A, O'Connell E. Women at mid-life: symptoms, attitudes, and choices, an internet based survey. *Maturitas*. 2001;38(2):129-136.
11. Dennerstein L, Dudley EC, Hopper JL, et al. A prospective population-based study of menopausal symptoms. *Obstet Gynecol*. 2000;96(3):351-358.
12. Hsieh C-H, Su T-H, Chang S-T, et al. Prevalence of and attitude toward urinary incontinence in postmenopausal women. *Int J Gynaecol Obstet Off Organ Int Fed Gynaecol Obstet*. 2008;100(2):171-174. https://doi.org/10.1016/j.ijgo.2007.08.013

13. Jędrzejczyk S, Lau K, Wieczorek M, et al. Effects of selected obstetric-gynaecological surgery on female urinary incontinence in pre- and postmenopausal patients. *Menopause Rev*. 2008;(2):91-95.
14. Larson B, Collins A, Landgren BM. Urogenital and vasomotor symptoms in relation to menopausal status and the use of hormone replacement therapy (HRT) in healthy women during transition to menopause. *Maturitas*. 1997;28(2):99-105.
15. Schnatz PF, Banever AE, Greene JF, O'Sullivan DM. Pilot study of menopause symptoms in a clinic population. *Menopause N Y N*. 2005;12(5):623-629. https://doi.org/10.1097/01.GME.0000156347.54144.AC
16. Mannella P, Palla G, Bellini M, Simoncini T. The female pelvic floor through midlife and aging. *Maturitas*. 2013;76(3):230-234. https://doi.org/10.1016/j.maturitas.2013.08.008
17. Cody JD, Jacobs ML, Richardson K, et al. Oestrogen therapy for urinary incontinence in post-menopausal women. *Cochrane Database Syst Rev*. 2012;10:CD001405. https://doi.org/10.1002/14651858.CD001405.pub3
18. Canderelli R, Leccesse LA, Miller NL, Unruh Davidson J. Benefits of hormone replacement therapy in postmenopausal women. *J Am Acad Nurse Pract*. 2007;19(12):635-641. https://doi.org/10.1111/j.1745-7599.2007.00269.x
19. Menezes M, Pereira M, Hextall A. Predictors of female urinary incontinence at midlife and beyond. *Maturitas*. 2010;65(2):167-171. https://doi.org/10.1016/j.maturitas.2009.10.004
20. Basha ME, Chang S, Burrows LJ, et al. Effect of estrogen on molecular and functional characteristics of the rodent vaginal muscularis. *J Sex Med*. 2013;10(5):1219-1230. https://doi.org/10.1111/jsm.12088
21. Lara LA da S, Montenegro ML, Franco MM, et al. Is the sexual satisfaction of postmenopausal women enhanced by physical exercise and pelvic floor muscle training? *J Sex Med*. 2012;9(1):218-223. https://doi.org/10.1111/j.1743-6109.2011.02516.x
22. Petros PE, Ulmsten UI. An integral theory of female urinary incontinence. Experimental and clinical considerations. *Acta Obstet Gynecol Scand Suppl*. 1990;153:7-31.
23. Dimpfl T, Jaeger C, Mueller-Felber W, et al. Myogenic changes of the levator ani muscle in premenopausal women: the impact of vaginal delivery and age. *Neurourol Urodyn*. 1998;17(3):197-205.
24. Abdool Z, Shek KL, Dietz HP. The effect of levator avulsion on hiatal dimension and function. *Am J Obstet Gynecol*. 2009;201(1):89.e1-5. https://doi.org/10.1016/j.ajog.2009.02.005
25. Nelson HD. Menopause. *Lancet Lond Engl*. 2008;371(9614):760-770. https://doi.org/10.1016/S0140-6736(08)60346-3
26. Enck P, Vodusek DB. Electromyography of pelvic floor muscles. *J Electromyogr Kinesiol Off J Int Soc Electrophysiol Kinesiol*. 2006;16(6):568-577. https://doi.org/10.1016/j.jelekin.2006.08.007
27. Aukee P, Penttinen J, Airaksinen O. The effect of aging on the electromyographic activity of pelvic floor muscles. A comparative study among stress incontinent patients and asymptomatic women. *Maturitas*. 2003;44(4):253-257.
28. Voorham-van der Zalm PJ, Voorham JC, van den Bos TWL, et al. Reliability and differentiation of pelvic floor muscle electromyography measurements in healthy volunteers using a new device: the Multiple Array Probe Leiden (MAPLe). *Neurourol Urodyn*. 2013;32(4):341-348. https://doi.org/10.1002/nau.22311
29. Bø K, Raastad R, Finckenhagen HB. Does the size of the vaginal probe affect measurement of pelvic floor muscle strength? *Acta Obstet Gynecol Scand*. 2005;84(2):129-133. https://doi.org/10.1111/j.0001-6349.2005.00676.x
30. Rett MT, Simoes JA, Herrmann V, et al. Management of stress urinary incontinence with surface electromyography-assisted biofeedback in women of reproductive age. *Phys Ther*. 2007;87(2):136-142. https://doi.org/10.2522/ptj.20050318
31. Jundt K, Kiening M, Fischer P, et al. Is the histomorphological concept of the female pelvic floor and its changes due to age and vaginal delivery correct? *Neurourol Urodyn*. 2005;24(1):44-50. https://doi.org/10.1002/nau.20080
32. Greer WJ, Richter HE, Bartolucci AA, Burgio KL. Obesity and pelvic floor disorders: A review of the literature. *Obstet Gynecol*. 2008;112(2 Pt 1):341-349. https://doi.org/10.1097/AOG.0b013e31817cfdde
33. Rasmussen KL, Krue S, Johansson LE, et al. Obesity as a predictor of postpartum urinary symptoms. *Acta Obstet Gynecol Scand*. 1997;76(4):359-362. https://doi.org/10.1111/j.1600-0412.1997.tb07993.x
34. Wasserberg N, Haney M, Petrone P, et al. Morbid Obesity Adversely Impacts Pelvic Floor Function in Females Seeking Attention for Weight Loss Surgery. *Dis Colon Rectum*. 2007;50(12):2096-2103. https://doi.org/10.1007/s10350-007-9058-6
35. Subak LL, Wing R, West DS, et al. Weight Loss to Treat Urinary Incontinence in Overweight and Obese Women. *N Engl J Med*. 2009;360(5):481-490. https://doi.org/10.1056/NEJMoa0806375
36. Bogusiewicz M, Rosińska-Bogusiewicz K, Drop A, Rechberger T. Anatomical variation of bony pelvis from the viewpoint of transobturator sling placement for stress urinary incontinence. *Int Urogynecology J*. 2011;22(8):1005-1009. https://doi.org/10.1007/s00192-011-1421-4
37. Handa VL, Lockhart ME, Kenton KS, et al. Magnetic resonance assessment of pelvic anatomy and pelvic floor disorders after childbirth. *Int Urogynecol J Pelvic Floor Dysfunct*. 2009;20(2):133-139. https://doi.org/10.1007/s00192-008-0736-2
38. Bø K. Pelvic floor muscle training is effective in treatment of female stress urinary incontinence, but how does it work? *Int Urogynecol J Pelvic Floor Dysfunct*. 2004;15(2):76-84. https://doi.org/10.1007/s00192-004-1125-0
39. Dannecker C, Wolf V, Raab R, et al. EMG-biofeedback assisted pelvic floor muscle training is an effective therapy of stress urinary or mixed incontinence: a 7-year experience with 390 patients. *Arch Gynecol Obstet*. 2005;273(2):93-97. https://doi.org/10.1007/s00404-005-0011-4
40. Trutnovsky G, Guzman-Rojas R, Martin A, Dietz HP. Pelvic floor dysfunction – does menopause duration matter? *Maturitas*. 2013;76(2):134-138. https://doi.org/10.1016/j.maturitas.2013.06.012

otrzymano / received: 07.12.2021 | poprawiono / corrected: 22.12.2021 | zaakceptowano / accepted: 15.01.2022