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The influence of various risk factors on the strength of pelvic floor muscle in women

Uticaj različitih faktora rizika na jačinu mišića poda karlice kod žene

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Abstract

Background/Aim. Damage of any element of pelvic floor leads to its functional damages, reflected in the occurrence of urinary incontinence, prolapse of pelvic organs, fecal incontinence and sexual dysfunction. Basic aim of our paper was to investigate the influence of various risk factors on pelvic floor muscle strength in women. **Methods.** The study included 90 female patients and examined how age, job, body weight and height, number of deliveries, sports activities, incontinence occurrence, previous prolapse-caused gynecological surgeries, other gynecological surgeries and other conservatively treated gynecological diseases influence the value of pelvic floor muscle strength. Pelvic floor muscle strength was measured using vaginal dynamometer. **Results.** Univariate regression analysis showed that parameters such as age, demanding job, body height, number of deliveries, sports activities, prolapse-caused gynecological surgeries, other gynecological surgeries and other gynecological diseases were in positive correlation with the values of pelvic floor muscle strength. In multivariate regression model, incontinence and gynecological operation of prolapse were singled out as independent risk factors. **Conclusion.** If risk factors that cause damage to pelvic floor muscle are known, it is possible to prevent the damages and improve the quality of women's life.

Key words:
pelvic floor; muscle tonus; women; risk factors; pelvic organ prolapse; pelvic inflammatory disease; urinary incontinence; physical and rehabilitation medicine.

Apstrakt

Uvod/Cilj. Slabost mišića poda karlice dovodi do funkcionalnih oštećenja, uključujući urinarnu i fekalnu inkontinenciju, prolaps organa karlice i seksualnu disfunkciju. Cilj našeg istraživanja bio je ispitivanje uticaja različitih faktora rizika na slabost mišića poda karlice kod žena. **Metode.** U studiju je bilo uključeno 90 žena. Ispitivana je kako starosna dob, težina posla kojim se bave, telesna masa i visina, broj porođaja, bavljenje sportskim aktivnostima, prisutnost inkontinencije, prethodne ginekološke intervencije i lečenje prolapse organa male karlice, kao i druge bolesti, utiču na snagu mišića poda karlice. Snaga mišića poda karlice merena je vaginalnim dinamometrom. **Rezultati.** Univarijantnom regresionom analizom pokazano je da su faktori kao što su starost, težina posla, telesna visina, broj porođaja, bavljenje sportskim aktivnostima, prethodno ginekološko lečenje uzrokovano prolapsom organa male karlice i druge ginekološke intervencije i bolesti, u pozitivnoj korelaciji sa slabošću mišića poda karlice. Multivarijantnom regresionom analizom pokazano je da su ginekološke operacije prolapsa organa karlice i inkontinencija nezavisni faktori rizika. **Zaključak.** Poznavanjem faktora rizika koji dovode do slabosti mišića poda karlice mogu se prevenirati oštećenja i poboljšati kvalitet života žena.

Ključne reči:
karlica, pod; mišići, tonus; žene; faktori rizika; karlični organi, prolaps; karlični organi, zapaljenske bolesti; inkontinencija, urinarna; medicina, fizikalna i rehabilitacija.

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Introduction

One in four American women has moderate to severe symptoms of at least one pelvic floor disorder [1]. Up to one in seven undergoes surgery for pelvic organ prolapse and/or urinary incontinence in her lifetime [2–4]. Advancing age, childbirth, obesity and race are associated with both pelvic organ prolapse and urinary incontinence [5–10]. Other risk factors, such as hysterectomy, hormone therapy and family history, have been less well explored. The rate of pelvic floor disorders is expected to increase dramatically with the aging of the American population [11]. Understanding modifiable risk factors is crucial. Preventing 25% of women from developing pelvic floor disorders would save 90 000 women *per* year from experiencing prolapse or incontinence. “Pelvic floor disorders”, a term used to describe conditions related to changes in anatomy or functioning of the pelvic organs, include urinary incontinence, pelvic organ prolapse (when one or more of the pelvic organs fall into the vagina) and fecal incontinence. Pelvic floor in women consists of muscles, ligaments, fascia and nerves that are mutually connected into a complex, dynamic and coordinated system. The protection of integrity of this complex system provides performance of basic functions of pelvic floor such as supportive function for the organs of pelvic floor, function of urination, defecation as well as sexual function [1]. The damage of any segment of pelvic floor will lead to the damage of its functioning, which is manifested in occurrence of urinary incontinence, vaginal prolapse, fecal incontinence and sexual dysfunction [2]. The damage of connective-muscular fibers *musculus levator ani*, i.e. *pubis-rectal* muscle is considered the first and most significant event in the occurrence of pelvic floor dysfunction due to weakening of its strength and opening urinary-genital hiatus and lowering the uterus and vaginal walls. The causes can be very different [3, 4]. However, there may be a threshold for the pelvic floor at which physical activity’s benefit is negated. Mild or moderate activity and strenuous activity may impact pelvic floor disorders differently, and in a bidirectional manner. Regular low impact activity, like walking, is associated with a lower prevalence of stress incontinence [12–14]. However, many young women report stress urinary incontinence during high-impact, vigorous intensity activities: 28% of college varsity athletes, 41% of elite athletes and 43% of women participating in club sports [15–17]. Some particularly strenuous activities may damage the pelvic floor. Nulliparous military women that completed paratrooper training were more likely to have stage II pelvic organ prolapse than women undergoing regular summer training [18]. Women may stop exercising because of urinary incontinence or fear that such activity will promote pelvic floor disorders [19, 20]. Of 60% of women that are employed, 9.8% are engaged in repeated strenuous physical activity for four or more hours each day [21]. Some data indicate that women with prolapse or incontinence are more likely to report strenuous jobs than women without such disorders [22–26]. However, these studies are variably limited by poorly defined occupational and activity histories, non-standardized outcome assessment, and lack of consideration for confounders.

Various methods, both subjective and indirect, such as the method of digital palpation [5], perineometer measurements [6, 7], the application of perineal ultrasound [8, 9], vaginal balloon [10] and surface electromyography [11] can be used for measuring the strength of pelvic floor in women as well as the estimation of therapy effects. Direct and precise measurement of pelvic floor muscle strength is possible using vaginal dynamometer a newly designed device for measuring and monitoring the pelvic floor muscle strength in women. This modern device works on the principle of measurement ribbons and Winston bridge. Physical effect of the pelvic floor muscle is transmitted to the dynamometer where it is transformed into an electric signal proportional to the magnitude of strengths [12, 13].

The aim of this study was to examine the effect of various risk factors on the strength of pelvic floor muscle in women.

Methods

Prospective clinical study was carried out at Clinic of Gynecology and Obstetrics, Clinical Center Kragujevac, in 2012/2013 after Ethic Committee of Clinical Centre Kragujevac approved the study and oral and written approval of the patients were obtained. The study included 90 women aged 20–58 (on average 41.53 ± 10.35) years. The pelvic floor muscle strength of all examinees was measured using vaginal dynamometer, a device for measuring and monitoring the pelvic floor muscle in women, presented in the previous paper [12, 13]. The influence of age, physically exhausting work, body weight and height, number of vaginal deliveries, sports activities (at least twice weekly one-hour exercise), occurrence of urinary incontinence with or without disturbances of static of genital organs, previous gynecological surgeries of prolapse, other gynecological surgeries, such as abdominal hysterectomy, and other conservatively treated gynecological diseases, such as urinary incontinence, on the strength of pelvic floor muscle was examined. The patients with caesarean section, and those who suffered from cardio-vascular, endocrine, neurological, malignant and other acute gynecological diseases (pelvic inflammation, bleeding) were not included in the study.

Results

The characteristics of the examined group are presented in the Table 1. In this group of patients, the greatest number had two deliveries, 35.56% (χ^2 test: $p = 0.001$). According to physically exhausting work, 27.78% of patients worked hardly, 24.44% worked with medium efforts, while 47.78% had physically easy work. About two thirds of the patients did not have any sports activities (66.89%) which is statistically significantly different in comparison to those who did some kind of recreation (χ^2 test: $p = 0.000$). Problems of urinary incontinence were found in 55.56% of the patients, while 44.44% of examinees did not reveal any data about the occurrence of incontinence. The frequency of patients with urinary incontinence was not statistically significantly different in comparison to the number of patients without these problems (χ^2 test: $p = 0.292$). Only 16% of the patients had previous surgery due to prolapse of uterus, which was sig-

Table 1

General characteristics of the examinees (n = 90)

Observed parameters	Obtained values
Age (years), x̄ ± SD (median; min-max)	41.53 ± 10.35 (44; 20–58)
Work, n (%)	
exhausting	25 (27.8)
medium effort	22 (24.4)
easy	43 (47.8)
Body height (cm), x̄ ± SD (median; min-max)	165.23 ± 5.53 (165.5; 155–175)
Body mass (kg), x̄ ± SD (median; min-max)	64.04 ± 8.88 (63.5; 47–92)
Delivery, n (%)	
yes	59 (65.6)
no	31 (34.4)
Number of deliveries, n (%)	
0	31 (34.4)
1	8 (8.9)
2	32 (35.6)
3	19 (21.1)
Sport activities, n (%)	
yes	28 (31.1)
no	62 (68.9)
Urinary incontinence, n(%)	
yes	40 (44.4)
no	50 (55.6)
Gynecological surgeries – prolapse, n (%)	
yes	15 (16.7)
no	75 (83.3)
Gynecological surgeries – others, n (%)	
yes	13 (14,4)
no	77 (85.6)
Other gynecological diseases, n (%)	
yes	18 (20)
no	72 (80)
Values of muscle strength (daN), x̄ ± SD (median, min–max)	1.14 ± 0.48 (1.10; 0.33–2.30)

x̄ – mean; SD – standard deviation; daN – decaNewton.

nificantly lower when compared to the number of patients who did not have this kind of surgery (χ^2 test: $p = 0.000$). Other gynecological surgeries were in the history of 14.44% of patients (χ^2 test: $p = 0.000$). About 20% of patients were previously treated using conservative methods for various gynecological diseases, which is significantly lower in comparison to the number of patients without any treatment for gynecological diseases (χ^2 test: $p = 0.000$).

Mean values of muscle strength were measured by vaginal dynamometer and analyzed in relation to the examined parameters (Table 2).

The average value of muscle strength in the examined patients, measured using vaginal dynamometer was 1.14 daN (decaNewton). The lowest measured value was 0.33 daN, while the highest was 2.30 daN. The mean value of muscle force measured using vaginal dynamometer in the patients who had deliveries was 0.959 daN, while in those who did not have any deliveries it amounted 1.477 daN, which was statistically significant ($p = 0.000$).

Independent *t*-test showed that the difference in the values of muscle strength between the patients who had and did not have any deliveries was statistically significant ($p = 0.000$). The patients who had a delivery had on average weaker muscles. In relation to the number of deliveries, the strongest muscle strength was found in women who had only one delivery, followed by those with two deliveries, while the weakest pelvic floor muscle was found in the women who had three deliveries. Bonfferoni test for multiple comparison showed that the difference in muscle strength was statistically signi`ficant different between the patients who did not have deliveries and those with two deliveries ($p = 0.000$), as well as between the patients who had no deliveries and those with three deliveries ($p = 0.000$), while being not proved between those without deliveries and those with one vaginal delivery. According to variant analysis, differences in values of muscle strength among the patients with physically exhausting jobs and those whose jobs required moderate or no physical efforts, were statistically significant ($p = 0.029$) (Table 2). The women who did physically hard work had, on average, the weakest muscle, followed by women who made medium efforts, while those who had physically easy job had the strongest muscle strength. Bonfferoni test for multiple comparison showed that only the difference between physically hard and easy work was statistically significant ($p = 0.029$).

Independent *t*-test showed that the difference in muscle strength values between the patients who did sports and who did not was statistically significant ($p = 0.000$). The women who did some sport had, on average, stronger muscle strength (Table 2).

Table 2

Mean values of muscle strength measured by vaginal dynamometer and analyzed in relation to the examined parameters (n = 90)

Risk factor	Values of muscle strength (daN), x̄ ± SD	*p*
Delivery		
yes	0.959 ± 0.432	0.000
no	1.477 ± 0.385	
Physical effort at work		
hard	0.956 ± 0.384	0.029
medium	1.085 ± 0.434	
easy	1.269 ± 0.527	
Sports activities		
yes	1.495 ± 0.401	0.000
no	0.976 ± 0.429	
Urinary incontinence		
yes	0.780 ± 0.318	0.000
no	1.422 ± 0.396	
Vaginal prolapse surgery		
yes	0.558 ± 0.152	0.000
no	1.253 ± 0.441	
Gynecological surgeries		
yes	0.762 ± 0.260	0.000
no	1.201 ± 0.484	
Gynecological diseases		
yes	0.916 ± 0.277	0.003
no	1.193 ± 0.509	

x̄ – mean; SD – standard deviation; daN – decaNewton.

Independent *t*-test showed that the difference in the values of muscle strength in the patients with and without urinary incontinence was statistically significant ($p = 0.000$). The women with incontinence had, on average, weaker muscle.

Statistically significant difference ($p = 0.000$) in the values of muscle strength in the patients who previously had gynecological surgery of prolapse of uterus and/or vagina and those who did not have the surgeries and without vaginal prolapse are presented in Table 2. The patients who had the surgery for genital prolapse had, on average, weaker muscle (0.558 ± 0.152 daN).

Independent *t*-test showed that the difference in muscle strength values between the patients who previously had other gynecological surgeries and those who did not have any ones was statistically significant ($p = 0.000$). The patients who had other gynecological surgeries had, on average, weaker muscle (0.762 ± 0.26 daN) (Table 2). Independent *t*-test showed that the difference in muscle strength values between the patients who previously had other gynecological diseases and those who did not have any such diseases was statistically significant ($p = 0.000$). The patients who had other gynecological diseases had, on average, weaker muscle (0.916 ± 0.277 daN) (Table 2).

Univariate regression analysis (Table 3) showed that parameters such as age, physically exhausting work, body height, vaginal delivery, number of deliveries, sports activities, gynecological surgeries of prolapse, other gynecological surgeries and other gynecological diseases significantly correlated with the values of pelvic floor muscle strength. All these parameters were included in multivariate regression model. In multivariate regression model, urinary incontinence and gynecological surgery of prolapse singled out as independent risk (Table 4) for lower strenght of pelvic floor muscle factors.

Table 3

Results of univariate regression used in the analysis of influence of the observed factors on the strength of pelvic floor muscle

Observed parameters	Regression coefficient	Non-standardized coefficient B	*p*
Age	0.538	-0.025	0.000
Body height	0.271	0.024	0.010
Body weight	0.064	-0.003	0.549
Delivery	0.512	0.518	0.000
Number of deliveries	0.531	-0.219	0.000
Exhausting work	0.279	0.158	0.008
Sport activities	0.500	-0.519	0.000
Gyn. surgeries of prolapse	0.539	0.695	0.000
Other gynecological surgeries	0.321	0.438	0.002
Other gynecological diseases	0.231	0.277	0.029

Table 4

Results of multivariate regression used in the analysis of influence of the observed factors on the strength of pelvic floor muscle in women

Observed parameters	Non-standardized	*p*
Age	-1.558	0.070
Exhausting work	-0.008	0.494
Body height	0.007	0.279
Vaginal delivery	0.332	0.055
Number of deliveries	0.130	0.087
Sport activities	-0.164	0.078
Urinary incontinence	0.420	0.000
Gynecological surgery of prolapse	0.309	0.005
Other gynecological surgeries	0.115	0.298
Other gynecological diseases	0.082	0.396

Discussion

The use of vaginal dynamometers to measure pelvic floor muscle function is recent and there are only few studies, including our studies comparing the muscle strength in women with or without urinary incontinence [12–17]. Pelvic organ prolapse is a common condition characterized by descent of the vaginal wall or vault, and the uterus [18]. Data show that 75% of women aged 45–85 years had some degree of prolapse [19]. The prevalence of typical signs, vaginal bulge, reported to be about 3–12% [19, 20]. Moreover, other symptoms, such as pelvic pressure/heaviness or pelvic pain and urinary or bowel symptoms may occur [21].

The most important factors that lead to pelvic organ prolapse, primarily vagine, are aging and the forthcoming menopause which is followed by the changes in hormonal status of a woman [22]. Although the damages of connective and muscular structures of pelvic floor and their denervation occur during vaginal delivery, symptomatic vaginal prolapse does not appear immediately after the delivery, but usually after a few decades [22]. On the other side, it could be explained by the fact the damaged muscular and connective tissue of the pelvic floor (during reparation of connective tissue the predominant collagen of the type I is replaced with less valuable collagen of the type III) additionally weakens (decompensates) after menopause due to the lack of estrogen stimulation [19]. On the other hand, during the physiological process of ageing after the menopause, the contents of collagen are reduced in the connective tissue [20]. In menopause, the lack of estrogen stimulation leads to reduced synthesis of the collagen type I, which results in the reduction of its content in the connective tissue, thus causing the decrease of the connective tissue strength and occurrence of clinically manifested vaginal prolapse [22].

The damage of cross-striated pelvic floor fibers leads to urinary and fecal incontinence, vaginal prolapse and sexual dysfunction [2]. The patients with such disorders have hygienic and social problems and feel humiliated [23]. One of the problems which are found in practice is measuring the pelvic floor muscle strength aimed at selection of the mode of treatment, either surgical or kinesthetic as well as objective measuring of the effects of the application of pelvic floor muscle exercise program [13]. The number of studies regarding the evaluation of pelvic floor muscle function is growing [5–11]. With this paper, we tried to make contribution to better knowledge and understanding of causes that led to dysfunction of pelvic floor muscle.

Our study showed that the strength of pelvic floor muscle declines with the number of deliveries. The difference in the pelvic floor strength was statistically significantly between the women who did not have any deliveries and those with two deliveries, as well as between the women who did not have any deliveries and those with three deliveries. The difference was not proved for the women with one delivery and those without any deliveries.

Numerous papers show that vaginal delivery leads to weakening of cross-striated pelvic floor muscle structures in women due to the trauma of the muscles and/or their denervation. Sampselle et al. [24] also showed that vaginal delivery had effect on muscle strength. They measured the strength of pelvic floor muscle in 77 women using the palpation method in the 32nd and 35th weeks of pregnancy, as well as after the delivery. Considerable decrease of muscle force was found after the delivery. In the other article Sampselle [25] also concluded that the strength of the pelvic floor muscle declined with the number of deliveries. The women with greater number of deliveries had weaker muscle strength in comparison to those with one delivery only.

Exhausting physical work, hence the increased stress of pelvic floor muscles can also lead to decrease of pelvic floor muscle strength. In Denmark, the study was conducted on 28,000 nurses aged 20–69 who, due to their profession, were exposed to physically exhausting work, such as lifting the patients, the study showed that the risk of their prospective gynecological prolapse surgeries as a result of weakened pelvic floor increased for 1.6 in comparison to other population [26]. According to variant analysis, our results show statistically significant differences in the values of pelvic floor muscle strength ($p = 0.000$) between the women with physically exhausting jobs and those whose jobs require moderate or no physical efforts. The women who perform physically difficult jobs had, on average, the weakest muscle strength, while those with an easy job had the strongest muscles. Bonfferoni test for multiple comparison showed that only the difference between the physically most exhausting and the easiest jobs was statistically significant. It was also found that the difference in the values of muscle strength between the patients who had sports activities and those who did not was statistically significant. The women who did sports activities had, on average, stronger muscle force.

One of clinical manifestations of the weakness of connective-muscular structures of pelvic floor is also the presence of urinary incontinence and vaginal prolapse, i.e. previous treatments using conservation method or surgery due to the stated troubles. In this paper, the mean value of muscle strength in the patients with urinary incontinence, measured with vaginal dynamometer was 0.780 daN, in comparison to 1.422 daN in those without incontinence (p = 0.000), which proved that the women with urinary incontinence showed statistically significant weakness of pelvic floor muscle. FitzGerald et al. [27] also showed the connection between the weakness of pelvic floor muscle and urinary incontinence. The weakness of pelvic floor muscle can also be influenced by previous gynecological surgery of prolapse. The mean value of muscle strength in these patients was 0.558 daN, while those who did not have this surgery it amounted 1.253 daN (P =0.000). In other study, Uma et al. [28] investigated the values of pelvic floor strength after the surgical treatment of prolapse and concluded that pelvic floor muscle was weak even after the surgery; hence, the conducting of kinesis therapeutic program was necessary. We also proved that the occurrence of other gynecological diseases and surgeries in the pelvis has statistically significant effect on weakening of connective-muscular structures of pelvic floor. This is explained with the fact that in the process of wound healing, after trauma (delivery) or surgery (hysterectomy) a minor quality collagen type III is formed, which leads to decrease of total strength and resistance of pelvic floor [24].

Multivariate regression analysis showed that only the urinary incontinence and previous gynecological surgeries of prolapse were independent statistically significant risk factors connected with the decreased strength of connective-muscular pelvic floor structures. This is in accordance with the current knowledge of pathological physiology of vaginal prolapse and urinary incontinence as clinical manifestations of pelvic floor dysfunction, i.e. their occurrence as a result of weak peritoneal muscles. Namely, in the patients in these conditions, the values of measured muscle strength were considerably lower in comparison to those without these kinds of problems. For these patients, the application of physical therapy aimed to improvement of muscle strength values is necessary, as well as the permanent follow-up in order to prevent the occurrence of possible, even more serious aggravation of the current condition [12]. The device is quite simple for application, and the muscle strength is read as a digital record. For that reason, it is most favorable in comparison to all other methods.

Conclusion

The strength of pelvic floor muscle is best to determine by an objective method such as vaginal dynamometer. Using vaginal dynamometer, it is possible to read on display the muscle strength which is weaker in elderly female patients due to several deliveries, physically exhausting work, lack of sports activities or previous surgeries for prolapse of uterus and/or vagina, or other gynecological surgeries. High-risk groups of women are women after abdominal hysterectomy and operation of uterine prolapse, and in these patients the implementation of prevention is recommended.

The knowledge of risk factors that lead to damage of pelvic floor muscle and newly designed dynamometer for objective measuring the muscle strength make it possible to prevent further impair of pelvic floor muscle by applying kinesis therapeutic exercises and thus improve patients' life quality.

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