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CHANGES OF PELVIC FLOOR MUSCLE FUNCTION DURING PREGNANCY

HOCK MÁRTA[1,*], TARDI PÉTER[1], AMBRUS ESZTER[2], TÓVÁRI ANETT[3], HAJNAL BRIGITTA[4], SZILÁGYI BRIGITTA[1], LEIDECKER ELEONORA, MOLICS BÁLINT[1], JÁROMI MELINDA[1], KRÁNICZ JÁNOS[1], BÓDIS JÓZSEF[5], ÁCS PONGRÁC[1]

ABSTRACT. ***Objective:*** It is known, that incontinence rarely develops during pregnancy. The authors examined pelvic floor muscle function changes during pregnancy. ***Study Design*:** Authors examined 156 women and performed vaginal squeeze pressure measurements. Statistical data were analyzed by *t*-test, differences were considered to be significant at $p<0.05$. ***Results**:* Significant difference was found concerning maximum voluntary contraction ($p=0.002$) and duration of maximum muscle contraction ($p=0.012$) in young nulliparous women compared to average results of pregnant women. This result can be proved in young nulliparous women and among pregnant women in the 2nd ($p=0.045$), and 3rd trimesters ($p=0.005$). Comparing only the results of pregnant women a significantly decreased pelvic floor muscle strength was observed ($p=0.032$) in women exercising occasionally. Significantly weaker muscle strength was demonstrated in those young nulliparous women ($n=21$) who experienced vaginal wind ($p=0.003$) than in young nulliparous women without symptoms. ***Conclusions*:** Vaginal contraction strength decreases during pregnancy.

Keywords: *pelvic floor muscle strength, endurance, vaginal wind, pregnancy*

Introduction

Pelvic floor muscles (PFM) may be exposed to alterations during the different phases of a woman's life, such as pregnancy, postpartum period, and menopause. These factors can impair the integrity of the PFM and lead to urinary incontinence (UI) (Amaro, Moreira, Gameiro et al., 2005). Vaginal delivery is the

[1] *University of Pécs, Institute of Physiotherapy and Sport Sciences, Faculty of Health Sciences, Pécs, Hungary*
[2] *Thermal Rehabilitation Center Harkány, Division of Physiotherapy, Hungary*
[3] *Railway Occupational Health Public Non-Profit Company, Harkány, Hungary*
[4] *University of Pécs, Department of Languages for Specific Purposes, Faculty of Medicine, Pécs, Hungary*
[5] *University of Pécs, Pécs, Department of Obstetrics and Gynaecology, Faculty of Medicine, Hungary*
[*] *Corresponding Author: hock.marta@etk.pte.hu*

most important risk factor and it has been associated with a decrease in PFM strength of 22-35%, after delivery (Sampselle, 1990). Numerous articles deal with the different types of childbirth (Caesarean section, spontaneous vaginal-, forceps- or vacuum assisted delivery) and their results show that spontaneous vaginal- and instrument assisted deliveries increase the frequency of incontinence (Farrell et al, 2001; Peschers et al., 2003; Arya et al.,2001; Rortveit et al., 2003).

Burgio et al. found on the basis of a prospective non-randomized trial results that incontinence rarely develops during the postpartum period and incontinence problems do not start after delivery but actually during the pregnancy (previous) and endures also after delivery (Burgio, Zyczynski, Locher et al, 2003). In the other study group urinary incontinence during pregnancy with a range of 18.7-22.6% was reported (Borello-France, Burgio, Richter et al., 2006). Meyer et al. found 31% of stress urinary incontinence (SI) frequency during pregnancy and in 60% of it SI already occurred during the 2nd trimester (Meyer, Schreyer, De Grandi et al., 1998). The prevalence of incontinence before pregnancy increased from 26% to 58% in the 30th week of pregnancy. Stress urinary incontinence was the most common type of incontinence in the 30th week of gestation, experienced by 31% of nulliparous and 42% of parous women (Vesnes, Rortveit, Bo et al., 2007).

The subjective evaluation of PFM showed a significant decrease in muscular strength during pregnancy but in the objective evaluation there was a not significant decrease of PFM strength compared to healthy nulliparous subjects (Amaro, Gameiro, Sousa et al., 2010). According to Scheer the support of the pelvic organs significantly weakens following the first vaginal delivery, but not during pregnancy (Scheer, Thakar, Sultan et al., 2007). In contrast, according to Gameiro, transvaginal digital palpation evaluation showed significant impairments of the pelvic floor muscle strength at the 36th week of gestation (Gameiro, Sousa, Gameiro et al., 2011). Not enough exact information is available about pelvic floor muscle function changes during pregnancy (Manson, Rose, Wrong et al., 2010).

It is known, that stress incontinence more often appears in women who perform strenuous physical activity (Nygaard et al., 1994; Thyssen et al., 2002; Bo, Borgen, 2001). But it is unknown, what effect the moderate physical activity on the strength of PFM during pregnancy.

Question to be answered is: is there a change and how intense it is among the results of pregnant women of the 2nd and 3rd trimesters. Besides, to reveal how PFM strength changes are influenced by physical activity during pregnancy.

Material and methods

Participants

To be eligible, participants had to be younger than 35 years, at least in the 12th week of the present gestation and willing to participate in the study.

Altogether, 156 examinations were carried out among young nulliparous-, and pregnant women, measurement data were processed in the current article. The catchment areas involved only Caucasian women to participate if 18 or over, nulliparous with a known singleton pregnancy and no previous symptoms of stress incontinence.

In the current study excluding factors were as follows: smoking, allergy, pulmonary diseases, previous surgery, radiotherapy, chronic urinary tract infection, severe neurology disease e.g. multiple sclerosis, muscular dystrophy, psychiatric disease, or major medical condition, regular pelvic floor exercise, inability to contract the pelvic floor muscle, strenuous physical work and multipara women. Women with pregnancy complications (twin gestation, diabetes, preterm labour, and haemorrhage from low-lying placenta) were also excluded. All subjects of the study were voluntaries and provided informed consent.

The intervention

Vaginal squeeze pressure measurement was performed with Gynopress (Frytech Ltd., Budapest, Hungary) to determine the muscle function; women were in lithotomy position during the examination. The intravaginal air-inflated balloon catheter used for the examination had the following parameters: length 75mm, diameter 15mm, connected to a microtip transducer. The balloon catheter was covered with a non-lubricated condom and with the help of a syringe filled with 35 ml air. Subjects were well-informed about the procedure before the examination and visual control of techniques was ensured during the examination. The pressure balloon was inserted into the vagina until the full extent of the compressible portion of the device was above the level of the hymeneal ring. The perineometer was connected to a handheld microprocessor with latex tubing, allowing the readings of pressure values in centimetres of water (cmH_2O). On examination of the muscle group the results of maximum muscle strength and duration of maximum muscle strength were processed. For each squeeze, a maximum pressure and duration of squeeze were considered as strength and endurance of the PFM. Patients were instructed to contract their PFM and to squeeze with maximum effort. They were asked to pull the PFM in and up as much as possible. Three adequate squeezes were recorded with 60-second rest intervals between efforts. The peak of the three successful contractions was recorded as maximum strength of PFM. The examination of endurance indicated the duration of maximum muscle contraction. In order to measure the endurance, 75% of maximum perceived strength was calculated. Patients were then instructed to maintain this squeeze pressure until fatigue developed or the squeeze pressure returned to

75% of the primary effort. The same person performed the examination under undisturbed conditions in every case. On examination of muscle strength, the maximum voluntary contraction was examined and results of not satisfactory measurements were closed out which involved breathing manoeuvres (Vasalva manoeuvre or voluntary apnoea) and contracting the gluteal, hip adductor, or abdominal muscle instead of the pelvic floor muscle.

Questionnaires were always filled in by the same person before the survey started. The first part of the questionnaire included demographic data, obstetric and gynaecological history and current medication, the second part involved questions related to lifestyle and risk factors. The third part dealt with exercise habits. The exercise type was asked and recorded according to frequency. Physical exercise at least 2 times/1hour was considered to be regular, less frequent exercise was considered to be occasional (once a week, or less and less than 1 hour).

The whole examination period involved 13 months. The examinations were carried out at the Department of Obstetrics and Gynaecology, Faculty of Medicine, University of Pécs, and Institute of Physiotherapy and Sport Sciences, Faculty of Health Sciences, University of Pécs.

Procedure

Ethical considerations

The study was approved by the appropriate research ethics committee in University of Pécs. (Licence No. 4590) Women received an information sheet prior to attending their vaginal squeeze pressure measurement. If they were interested in participating in the research, the physiotherapist provided a detailed explanation. Those who agreed to participate signed an informed consent.

Statistical Methods

The study was a prospective, observational and a controlled trial with non-random sampling. Variables are described by frequencies and mean and standard deviation or mean and range.

Statistical data were analyzed by *t*-test or nonparametric Mann-Whiney *U*-test was used to compare the difference between groups. Differences between nonmetric variables were analyzed using Fisher's exact test. A p value <0.05 was interpreted as statistically significant. Statistical analysis was performed using SPSS 15.0.1 for Windows (SPSS Inc, 1989–2006).

Results

Statistical Characteristics of the Participants

Demographic parameters of surveyed women were as follows: the first group involved young nulliparous women: number of examined women 52, the second group involved pregnant women in the 2nd (13-26 weeks) and 3rd (26-39 weeks) trimesters. The number of examined pregnant women is 104, average week of pregnancy: 28.6 weeks (13-39 weeks).

Table 1. Statistical Characteristics of the Participants

	Age (years)	BMI (kg/m^2)
Young Nulliparous Women (n=52)	23.38 ±2.52 (21-30)	21.22±1.8(17.78-25.8)
Young Nulliparous Women (n=21) with the complaint	21.38 ±2.33(21-27)	20.11±1.6(17.78-22.8)
Pregnant Women (n=104)	28.84±2.89 (22-35)	23,33±2.6(18.98-26.8)
2nd trimester (n=52)	26.8±1.89 (23-35)	21.03±1.79(18.98-22.01)
3rd trimester (n=52)	27.01±2.99 (22-33)	24.67±3.11(19.92-26.8)

Findings of PFM function

A significant decrease could be observed between mean muscle strength and duration of maximum muscle contraction of young nulliparous women compared to average muscle strength (p=0.002) and duration of maximum muscle contraction (p=0.012) during pregnancy. This is also verified by the results of the current study regarding muscle strength and muscle strength of young nulliparous women (p=0.005) as they showed a significant decrease in pregnant women during the 3rd trimester.

Table 2. Values of PFM strength and duration in the third trimester and in nulliparous women

	Third trimester patients (n=52)	Nulliparous controls (n=52)	p value
Maximum contraction strength (cmH$_2$0)	mean 64.6±SD 42.98 range 6-150	mean 93.13 ±SD 43.12 range 19-180	0.005
Maximum contraction duration (sec)	mean 3.65±SD 1.93 range 1-10	mean 6.33±SD 3.89 range 1-13	0.003

Further analysis of the results of young nulliparous women and the 2nd trimester a significant decrease of muscle strength (p=0.045) was proved even in this trimester.

Table 3. Values of PFM strength and duration in the second trimester and in nulliparous women

	Second trimester patients (n=52)	Nulliparous controls (n=52)	p value
Maximum contraction strength (cmH_2O)	mean 79.58±SD 35.82 range: 4-160	mean 93.13±SD 43.12 range 19-180	0.045
Maximum contraction duration (sec)	mean 5.47±SD 5.8 range 1-17	mean 6.33±SD 3.89 range 1-13	0.122

In the 3rd trimester not only muscle strength but also duration of maximum muscle contraction (p=0.003) showed essential differences compared to duration of maximum muscle contraction of young nulliparous women while in the 2nd trimester duration of maximum muscle contraction did not show any significant differences (p=0.122). Comparing the data of the 2nd and 3rd trimesters the following can be concluded: average muscle strength in the 2nd trimester is higher than in the 3rd but no significant difference could be defined (p=0.441). Duration of maximum muscle contraction was better by 0.831 sec (p=0.516) but statistically it was not significant.

Table 4. Values of PFM strength and duration in the second and third trimesters

	Second trimester patients (n=52)	Third trimester patients (n= 52)	p value
Maximum contraction strength (cmH_2O)	mean 79.58±SD 35.82 range: 4-160	mean 64.6±SD 42.98 range 6-150	0.441
Maximum contraction duration (sec)	mean 5.47±SD 5.8 range 1-17	mean 3.65±SD 1.93 range 1-10	0.516

When habits of exercise were taken into consideration in the analysis the following results were obtained: further on much better results of muscle strength (p=0.03) were obtained if young nulliparous women performed regular exercises when compared to pregnant women. The pelvic floor muscle strength (p=0.029) of those young nulliparous women who occasionally did exercise and the duration of maximum contraction (p=0.018) of young nulliparous women who regularly did exercise showed a significantly better result when compared to those pregnant women who regularly or occasionally did exercise. Comparing only the results of pregnant women a significantly decreased pelvic floor muscle strength was observed (p=0.032) in women exercising occasionally versus regularly. Subjects of this study preferred the following exercise types: running, ball games, aerobic, maternity exercise, aqua-fitness and jogging. Due to the small case number the effects of physical activity types on pelvic floor muscle strength was not examined in further.

Although it was not the purpose of the investigation, it was found that muscle strength showed a significant difference in young nulliparous women who experienced vaginal wind (p=0.003), compared to those without the complaint.

Discussion

Mechanical and hormonal factors due to pregnancy can predispose women to decrease PFM strength (Gameiro et al., 2011). Summary of present results shows a significant decrease in muscle strength and duration of maximum muscle contraction of pregnant women. Significant change due to physiological changes of the last period in pregnancy is observable when muscle strength of young nulliparous women and pregnant women in the 3rd trimester were compared. It is known, that the growing uterus and foetus weight on PFM, which contributes to chronic stress on PFM throughout pregnancy and results in PFM weakness. Sphincter strength and its supportive function of PFM are at risk. The present findings show, that significant decrease of muscle strength was statistically proven in pregnant women in the 2nd trimester too. When the average results of the two trimesters were compared a smaller but not significant decrease of muscle strength was probably due to displacement of centre of gravity which resulted from the increased lumbar lordosis (Nguyen, Lind, Choe, et al., 2000). The intense growth of the foetus in the 3rd trimester may cause an increased lordosis and the downward force loads not only the pelvic floor muscle but the pubic bone and the abdominal muscles as well (Capson, Nashed, Mclean, 2011). The effect of hormonal changes may be more significant in the PFM strength maintaining, as to mechanical stresses during pregnancy (Hvidman, Foldspang, Mommsen, et al., 2002).

Change of function is observable when duration of maximum muscle contraction of young nulliparous women and pregnant women in the 3rd trimester was compared. Gameiro et al. observed a significantly shorter contraction time in the primiparous women who underwent caesarean deliveries compared to the nulliparous women. According to the authors one possible explanation is that compromising the rectus abdominis muscle during caesarean delivery impairs the sustained contraction of the PFM and reduces the contraction time (Gameiro, Sousa, Gameiro, et al., 2011). At present, in spite of the accumulating knowledge about the co-coordination between involved muscles (abdominal muscles, deep back muscles, diaphragm and the perineal muscles) (Madill, McLean, 2008) in maintaining continence, little is known about the change of this function during pregnancy, but we know, that the abdominal muscle strengthening can be beneficial (Dimpfl, Jaeger, Mueller-Felber, et al., 1998). The other hand, the pelvic floor is composed of a combination of slow-twitch or type I (66%) and fast-twitch or type II (34%) muscle fibre (Dimpfl, Jaeger, Mueller-Felber, et al., 1998). The slow-twitch fibres are responsible for maintenance of the tone of the levator any muscles, providing support for the pelvic organs at rest. The fast-twitch fibres are mainly activated during stressful periods or sudden increases in intra-abdominal pressure (Dixon, Gosling, 1994). It is known, that type II or fast twitch fibres predominantly generate energy anaerobically for a quick and powerful contraction, and exert 20% more force than slow-fibres (Powers, Howley, 2007). This function may impairment and the pelvic floor muscle strength decreases at the 36th week of gestation (Gameiro, Sousa, Gameiro, et al., 2011). Findings of present study are in accordance with this previous finding. It is known, that PFM has a higher percentage of slow-fibres to maintain its tone and contraction (Peruchini, DeLancey, 2008). Type I fibers are characterized by high endurance. Research has shown that type I or slow-fibers decrease in the levator any after birth (Dimpft, Müller-Felber, Anthuber, 1996). Present result shows decline already during third trimester. Not enough exact information is available, further studies are needed about pelvic floor muscle function changes during pregnancy particular as regards type I or slow-fibres concerned.

Six factors affect the development and maintenance of muscle mass: nervous system activation, environmental factors, endocrine influences, nutritional status, genetics and physical activity. All are relevant to the structure and function of PFM (McArdle, Katch, Katch, 1991).

It is known, that stress incontinence more often appears in women who perform high strain jobs, intense jumping, high-intensity sports and heavy lifting (Nygaard et al., 1994; Thyssen et al., 2002; Bo, Borgen, 2001). The frequency of physical exercise also gives a significant difference in the results between the groups which encourages us to suggest the continuous, regular but not straining physical exercise during pregnancy as well as the Royal College of Obstetricians and Gynaecologists and Guidelines (Royal College of Obstetricians and Gynaecologists, 2008).

In a detailed interview, we questioned bladder (stress and urge incontinence, frequency, nocturia, symptoms of voiding dysfunction, and urinary tract infections) and bowel symptoms (straining at stool and chronic constipation), as well as a history of conditions associated with connective tissue dysfunction and pelvic floor muscle exercises. It is not unusual for women to experience vaginal noise (VN) or vaginal wind (VW), especially during posture changes and sexual intercourse. The underlying mechanism of VN is still unknown. It is possible that air becomes trapped in the posterior fornix and that during sudden movements it is released and produces the typical noise (Hadar, Kornreich, Heifettz, et al., 1991). Approximately one out of the eight women in a general population had the symptom of VN. According to Krissi et al. VN is an extremely embarrassing problem (Krissi, Medina, Stanton, 2003). Slieker-ten Hove et al. found no significant differences in the strength and endurance of the pelvic floor musculature between the VN positive and the VN negative women in contrast to the results of present study (Slieker-ten Hove, Pool-Goudzwaard, Eijkemans, Steegers-Theunissen, Burger, Vierhout, 2009). In the present study, the muscle strength showed a significant decrease on examination of pelvic floor muscle strength in young nulliparous women with the complaint of vaginal noise. It is known, that the pregnancy itself and hereditary factors might predispose more than parturition trauma in some women (Demirci, Ozden, Alpay, et al. , 2001; Foldspang, Mommsen , Djurhuus, 1999; Iosif, Batra, et al., 1981; Iosif, 1981) but the exact mechanisms remain uncertain. Initial strength of PFM is another factor that may influence continence status during pregnancy (Morkved, Salvesen, Bo, et al., 2004). Genetic factors and race influence the percentage distribution of type I or II fibres and this differs significantly among individuals, but studies have shown that specific training can convert type I to type II fibres, or vice versa (McArdle, Katch, F., Katch, C., 1991).

Relevance to clinical practice

There is not enough information available on physiological changes of the pelvic floor muscle strength during pregnancy to prevent stress incontinence. These data provide further justification, but on the basis of these present results it is questioned that preventive programmes (pelvic floor exercise) should preferably be started earlier. It appears that healthcare professionals, midwives and physiotherapists should evaluate women in terms of their pelvic floor muscle function already at the beginning of the pregnancy. It is hoped, that this work will eventually lead toward reasonable strategies to reduce the incidence of pelvic floor dysfunction.

Strength and weaknesses of the study

This current study had some limitations which must be considered, firstly, the small number of subjects in each group. Secondly, women were not followed through their pregnancy and the post-partum period. Finally, the methodological weakness in the design of the study was that vaginal squeeze pressure measurement is the most sensitive method of assessing PFM strength although not the most reliable one, but it is the most accessible and affordable currently. A new study should be carried out to compare all periods (before gestation, first, second, third trimesters and the postpartum period) and control other factors, such as lumbar lordosis, abdominal-, gluteal- and back muscle strength, the changes developing during gestation.

The strengths of this study lie in the setting and design. The study was a nonrandomized controlled clinical and population-based cross-sectional study with an age- and sex-matched control group. The strength of the study is the fact that few studies have been made in this area, especially on the state of the perineal muscles during pregnancy. The primary benefit of the research is that not only muscle strength but endurance is investigated during the 2nd and the 3rd trimester. The measurement method has great importance. The patients had received adequate information prior to the examination in order to prevent measurement errors. The measurements were performed by the same experienced colleague. One of the key components of the research is examining physical activity and pelvic floor muscle strength during pregnancy. It has been revealed little in the literature so far. The primary objective of the study did not include the detection of PFM dysfunction for nulliparous women. During the interview, the survey focused primarily on the exclusion and inclusion criteria factors for nulliparous women. However, in the interviews a vaginal noise was mentioned by the participants, which is not among the recognized symptoms so those women were not excluded from the study. Statistical analyses were conducted with the unexpected but significant outcome of the investigation.

Conclusions

Pregnant women had more significant weaker pelvic floor muscle strength in the 2nd and 3rd trimester than young nulliparous women. The continuous and regular, but not strenuous exercise does not impair the strength of the PFM during pregnancy. In young nulliparous women who experienced vaginal wind PFM function may be decreased.

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