CLINICAL SCIENCE

Comparison of pelvic floor muscle strength evaluations in nulliparous and primiparous women: a prospective study

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OBJECTIVE: This study aimed to compare the pelvic floor muscle strength of nulliparous and primiparous women.

METHODS: A total of 100 women were prospectively distributed into two groups: Group 1 (G1) (n = 50) included healthy nulliparous women, and Group 2 (G2) (n = 50) included healthy primiparous women. Pelvic floor muscle strength was subjectively evaluated using transvaginal digital palpation. Pelvic floor muscle strength was objectively assessed using a portable perineometer. All of the parameters were evaluated simultaneously in G1 and were evaluated in G2 during the 20th and 36th weeks of pregnancy and 45 days after delivery.

RESULTS: In G2, 14 women were excluded because they left the study before the follow-up evaluation. The median age was 23 years in G1 and 22 years in G2; there was no significant difference between the groups. The average body mass index was 21.7 kg/m^2 in G1 and 25.0 kg/m^2 in G2; there was a significant difference between the groups ($p = 0.0004$). In G2, transvaginal digital palpation evaluation showed significant impairments of pelvic floor muscle strength at the 36th week of pregnancy ($p = 0.0006$) and 45 days after vaginal delivery ($p = 0.0001$) compared to G1. Objective evaluations of pelvic floor muscle strength in G2 revealed a significant decrease 45 days after vaginal delivery compared to nulliparous patients.

CONCLUSION: Pregnancy and vaginal delivery may cause weakness of the pelvic floor muscles.

KEYWORDS: Musculature Strength; Nulliparous; Pelvic Floor Muscle; Primiparous.

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INTRODUCTION

The pelvic floor muscles (PFM) may be exposed to alterations during different phases of a woman's life, such as pregnancy, the postpartum period, and physiological aging (menopause). These factors can impair the integrity of the PFM and lead to urinary incontinence (UI).[1]

During pregnancy, the female body undergoes several adaptive modifications. Mechanical and hormonal factors due to pregnancy can predispose women to UIs, which increase the number of micturitions and worsen urinary urgency and any preexisting stress urinary incontinence (SUI).[2] The effects of normal gestation on the physiology of the urinary tract have not been completely elucidated. The prevalence of UIs ranges from 23% to 67% during gestation and 6% to 29% after delivery.[3,4] The evaluation of the PFM is important to provide prophylaxis and improve treatment of PFM dysfunctions.[5]

The function of the PFM is evaluated using a simple, well-tolerated and minimally invasive method that identifies whether there is correct muscular recruitment and predicts PFM dysfunction.[6,7] However, the correlation of this method with objective evaluation methods and its reproducibility remain questionable.[1,8] Several classifications for subjective evaluations of PFM strength have also been proposed.[8,9]

Evaluation with a perineometer is a reliable method to objectively assess the strength of the PFM.[10] This evaluation is frequently performed in the supine or semi-sitting position to improve the comfort of the patient and the clinician.[11] However, these positions may not be relevant to daily activities.

Frawley et al.[12] found that both although manometry and digital muscle testing were reliable tools for measuring the maximum voluntary contraction in lying and upright positions, manometry exhibited a greater reliability.

The identification and standardization of PFM strength in nulliparous women of different ages can help predict urinary and fecal incontinence as well as sexual dysfunction in a woman's first pregnancy. However, this correlation is not well established because there have been few studies describing reference values for PFM strength.[13]

Because there is little information on this subject in the literature, we compared the PFM strength of nulliparous and primiparous women using subjective and objective evaluation methods.

MATERIALS AND METHODS

A total of 100 healthy women aged 20-30 years were evaluated and divided into two groups. Group 1 (G1) was composed of 50 nonpregnant nulliparous women, and Group 2 (G2) was composed of 50 primiparous women. This study was approved by the Ethical Research Committee of Medical School of Botucatu - UNESP (protocol no. 375/2007). All of the participants understood and signed an informed consent form.

The sample size was established by considering a confidence level of 95%, a test power of 80% (based on comparisons in the literature) and a maximum estimated error of 5 cmH_2O (based on pilot studies assessing objective evaluations of PFM strength). According to these calculations, each group consisted of approximately 50 participants.

The exclusion criteria for G1 (nulliparous) were a current UI, neurological diseases, previous pelvic surgeries, diabetes, smoking, and cognitive difficulties. The same criteria were used for G2 (primiparous) in addition to gestational complications, such as diabetes, hypertension, and vaginal and urinary infections.

The subjects were evaluated using a clinical questionnaire. The BMI of G1 was calculated and classified according to the World Health Organization (WHO) criteria.[14] In G2, Atalah's curve[15] was used to evaluate the pregnant women's BMIs at the 20th week of pregnancy.

Subjective and objective PFM evaluations were performed at the initial evaluation in G1 and at the 20th and 36th weeks of pregnancy as well as 45 days after delivery in G2. The G2 subjects were divided into two subgroups according to type of delivery: vaginal (n = 17) and cesarean section (n = 19).

For the subjective evaluations, the volunteers were placed in a supine position, undressed from waist to feet, covered with a sheet with the lower limbs bent and separated and instructed about the correct way to perform PFM contractions. The patients were evaluated by a single examiner, who used bidigital vaginal palpation in the anterior and posterior areas of the vaginal introitus. The patients were also required to contract the perineal muscles and to hold this contraction as long as possible. The degree of contraction strength was classified according to the description of Amaro et al.[8] (Table 1), a system that has not been used prior to the present study.

Table 1 - Subjective classification of different degrees of PFM contraction.[8]

Degree	Digital palpation
0	Absence of Muscular Contraction
1	Light Contraction
2	Mild Contraction – not held longer than 5 seconds
3	Normal Contraction – held longer than 5 seconds

The objective measurements were obtained using a Dynamed portable perineometer (model DM 01) with the volunteers in three different positions: supine with the lower limbs straight (P1), supine with the lower limbs bent (P2) and sitting (P3). After the participants were positioned, the examiner introduced a balloon catheter, sized 11×2.6 cm, into the vagina. The balloon catheter was covered with an unlubricated condom and filled with 60 ml of air using a Plastipack syringe (Becton Dickinson, São Paulo, Brazil), which permitted contact with the vaginal wall. The equipment was immediately zeroed, and the patient was asked to hold three PFM contractions as long as possible, with approximately 30-second rest intervals between them. The maximal peak of each contraction was registered in cmH_2O. The lengths of these contractions in seconds were recorded with a Casio chronometer. The average of the measurements was used to avoid biased results. The vaginal catheters were disinfected after each evaluation by washing with liquid detergent and immersion in peracetic acid for 10 minutes. This procedure was standardized by the Infection Committee of the Clinical Hospital of Botucatu.

The qualitative variables were analyzed using the Goodman Test for contrasts among and within multinomial populations.[16] The Mann-Whitney Test was used for comparisons between quantitative variables and time points, along with a nonparametric variance model for repeated measurements. The Turkey Test and the Kruskal-Wallis nonparametric variance model complemented with the Dunn multiple comparisons test were used to analyze multiple comparisons.[17] Statistical analysis was performed at the 5% significance level.

RESULTS

In G2, 14 women were excluded because they left the study before the follow-up examination. The mean age was 23 years in G1 and 22 years in G2. There was no significant difference between the groups.

The average BMI was 21.7 kg/m^2 in G1 and 25,0 kg/m^2 in G2; there was a significant difference between the groups ($p = 0.0004$).

All of the primiparous women had been continent before the pregnancy; however, 19% reported urinary incontinence episodes at the 20th week, 27% at the 36th week, and 36% at 45 days after delivery ($p<0.05$), which indicated a gradual increase in urinary incontinence episodes throughout the pregnancy.

The subjective evaluations of the anterior and posterior regions of the PFM (Table 2) revealed no significant differences between the G1 subjects and the G2 subjects at the 20th week. There were significant reductions in PFM strength in the G2 women at the 36th week and 45 days after delivery compared to the G1 women (Table 2).

The comparison of the groups evaluated objectively in the P1, P2, and P3 positions revealed no significant differences between the nulliparous women and the primiparous women at the 20th and 36th weeks of pregnancy ($p>0.05$) (Table 3). However, 45 days after vaginal delivery, a significant reduction in PFM strength in all the positions was observed in the primiparous women compared to the nulliparous women ($p<0.05$) (Table 4).

There were no significant differences in the contraction time in the P1 position between the nulliparous and primiparous women when delivery type was not considered

Table 2 - Results of a subjective evaluation of anterior PFM strength in the nulliparous compared to the primiparous group at different time points using the classification system of Amaro et al.[8]

Groups	Subjective evaluation of PFM			
	1 (light) % (n)	2 (mild) % (n)	3 (normal) % (n)	Total
Nulliparous	0,00 (0)	48 (24)	52 (26)	100 (50)
Primiparous 20 weeks	5.55 (2)	55.55 (2)	38.88 (14)	100 (36)
Primiparous 36 weeks*	19.44 (7)	58.33 (21)	22.28(8)	100 (36)
Primiparous 45 days postpartum**	30.55 (11)	44.44 (16)	25 (9)	100 (36)

*$p = 0.0006$.
**$p = 0.0001$.

or when vaginal and cesarean deliveries were compared (Table 5). However, the contraction time in the P2 position was significantly lower in the primiparous women after cesarean deliveries compared to the nulliparous group (6.0 ± 1.8 seconds *vs.* 7.1 ± 1.3 seconds, respectively; $p = 0.021$), and it was also significantly lower in the P3 position when women with vaginal and cesarean deliveries were compared (8.6 ± 2.9 seconds *vs.* 7.1 ± 1.3 seconds, respectively; $p = 0.016$). There were no significant differences between nulliparous and primiparous women after vaginal delivery in the P2 or P3 positions (Table 5).

DISCUSSION

The average BMI was significantly higher in the primiparous group compared with the nulliparous group, which suggests that obesity influenced the participants. A previous study[18] has demonstrated that overweight and obesity are important risk factors for UIs.

Alterations in the genital and urinary tracts may occur during pregnancy, delivery, and the puerperium. Mechanical and hormonal factors may influence urinary symptoms, e.g., by increasing the voiding frequency and worsening urge incontinence.[19,20] The primiparous women in this study were continent prior to pregnancy and showed a gradual increase in urine loss episodes throughout the pregnancy.

Amaro et al.[8] validated PFM evaluation methods using digital vaginal palpation with a four-degree scale with an intensity range of 0-3. Bo et al.[21] concluded that vaginal palpation was not a reproducible and valid method of measuring PFM strength. Despite the controversies and its low reproducibility, the vaginal palpation method of PFM evaluation is considered easy to use and minimally invasive in daily clinical practice. By using this evaluation, we observed significant reductions in the PFM strength of primiparous women at the 36th week of pregnancy and 45 days after delivery compared to the nulliparous group. The prevalence of UIs increases as pregnancy progresses and is highest in the third trimester.[22] This change is due to the increased concentration of relaxin hormone, which promotes the relaxation of the pelvic floor organs and reduces the resistance to stress on the perineum muscles. Simultaneously, high levels of progesterone cause hypotonicity, which has a relaxing effect on smooth muscles and can lead to urinary frequency and incontinence.[22]

Although the objective evaluation of PFM strength using a perineometer has been validated by the International Continence Society (ICS),[10] there are several devices available with different strength units and probe sizes, which makes concordance among studies difficult.[23] Furthermore, the effects of pregnancy, body weight, and body position on PFM strength have not been totally elucidated.

There were no significant differences in PFM strength in any of the three different positions among the nulliparous and pregnant primiparous women. According to Scheer,[24] the support of the pelvic organs weakens significantly following the first vaginal delivery, but not during pregnancy. However, the evaluation performed 45 days after delivery in the present study showed a significant decrease in muscular strength in all of the body positions in women who had undergone vaginal delivery. Baytur et al.[25] evaluated nulliparous and primiparous women and observed reduced PFM strength after vaginal compared to cesarean delivery. Baessler and Schuessler[26] also reported that the strength of this musculature was not changed in women who underwent cesarean delivery. This study is in agreement with the results of most research, which have associated vaginal delivery with PFM weakness.

Using digital palpation, perineometry, and electromyography, Marshall et al.[27] compared the PFM strength of nulliparous and primiparous women ten months after vaginal delivery and observed significantly higher muscular strength and endurance in the nulliparous women.

In terms of the different body positions and time points, there were no significant differences in the PFM contraction time between the primiparous patients after vaginal

Table 3 - Maximum amplitude of PFM contraction (cmH_2O) (median and range) in the nulliparous compared to the primiparous group at 20 weeks and 36 weeks of gestation measured using a perineometer in different positions: supine with the lower limbs straight (P1), supine with the lower limbs bent (P2), and sitting (P3).

Positions	Groups			
	G1 (n = 50)	G2 (n = 36) at 20 weeks of gestation	G2 (n = 36) at 36 weeks of gestation	Statistical results
P1	16.3 (6.6-55.3)	17.6 (3.0-55.3)	11.8 (4.0-66.7)	$p > 0.05$
P2	15.6 (7.0-59.0)	15.8 (8.0-59.0)	11.8 (5.3-43.3)	$p > 0.05$
P3	19.3 (3.6-87.3)	19.0 (6.0-87.3)	16.5 (5.3-57.3)	$p > 0.05$

Table 4 - Maximum amplitude of PFM contractions (cmH_2O) (median and range) in the nulliparous compared to the primiparous 45 days postpartum group according to the type of delivery measured using a perineometer in different positions: supine with the lower limbs straight (P1), supine with the lower limbs bent (P2), and sitting (P3). Different lower-case letters indicate significant differences between groups at the same time point.

Positions	Groups		
	G1 (n = 50)	G2 (n = 36)	Statistical results
P1	16.3 (6,6-55.3)[b]	VD 8.3 (3.6-32.6)[a]	$p = 0.012$
		CD 11.0 (4.7-46.3)[ab]	$p > 0.05$
P2	15.6 (7.0-59,0)[b]	VD 8.3 (4.6-23.7)[a]	$p = 0.011$
		CD 13.7 (5.3-39.3)[ab]	$p > 0.05$
P3	19.3 (3.6-87.3)[b]	VD 10.3 (6.6-26.3)[a]	$p = 0.002$
		CD 16.0 (5.3-43.3)[ab]	$p > 0.05$

VD = Vaginal delivery (n = 17).
CD = Cesarean delivery (n = 19).

delivery and the nulliparous women. However, we observed a significantly shorter contraction time in the primiparous women who underwent cesarean deliveries compared to the nulliparous women. One possible explanation is that compromising the rectus abdominis muscle during cesarean delivery impairs the sustained contraction of the PFM and reduces the contraction time. Other authors[28,29] have suggested that the synergistic activity of the abdominal muscles and the PFM is important for maintaining adequate urethral closing pressure.

Despite all of the limitations and difficulties in performing this type of study, further research is necessary to provide more information about the PFM strength in pregnant women compared to a control group, such as nulliparous women.

CONCLUSION

During pregnancy and after vaginal delivery, women demonstrated weaker PFM compared to nulliparous controls.

Table 5 - Length of PFM contractions (cmH_2O) (seconds) (mean and standard deviation) in the nulliparous group compared to the primiparous 45 days postpartum group according to the type of delivery, measured using a perineometer in different positions: supine with the lower limbs straight (P1), supine with the lower limbs bent (P2), and sitting (P3). Different lower-case letters indicate significant differences between the groups at the same time point.

Positions	Groups		
	G1 (n = 50)	G2 (n = 36)	Statistical results
P1	7.3 ± 1.7^{a}	VD 7.3 ± 1.6^{a}	$p > 0.05$
		CD 6.7 ± 2.0^{a}	$p > 0.05$
P2	7.1 ± 1.3^{b}	VD 7.3 ± 2.0^{b}	$p > 0.05$
		CD $6.0 \pm 1.8^{a*}$	$p = 0.021$
P3	7.7 ± 1.7^{ab}	VD 8.6 ± 2.9^{b}	$p > 0.05$
		CD $7.1 \pm 1.3^{a**}$	$p > 0.05$

VD = Vaginal delivery (n = 17).
$^{*}p = 0.045$.
$^{**}p = 0.016$.
CD = Cesarean delivery (n = 19).

REFERENCES

1. Amaro J, Moreira E, Gameiro M, Padovani C. Pelvic floor muscle evaluation in incontinent patients. Int Urogynecol J Pelvic Floor Dysfunct. 2005;16:352–4, doi: 10.1007/s00192-004-1256-3.
2. Morkved S, Bø K. Prevalence of urinary incontinence during pregnancy and postpartum. J Pelvic Floor Dysfunc. 1999;10:394–8, doi: 10.1007/s001920050067.
3. Hong P, Leong M, Selzer V. Uroflowmetric observation in pregnancy. Neurourol Urodyn. 1988;7:61–70, doi: 10.1002/nau.1930070107.
4. Goldberg R, Kwon C, Gandhi S, Atkuru L, Sand P. Urinary incontinence after multiple gestation and delivery: impact on quality of life. Int Urogynecol J Pelvic Floor Dysfunct. 2005;16:334–6, doi: 10.1007/s00192-004-1252-7.
5. Peschers U, Fanger G, Schaer G. Bladder neck mobility in continent nulliparous women. Br J Obstet Gynecol. 2001;108:320-4, doi: 10.1016/S0306-5456(00)00066-8.
6. Thompson J, O'Sullivan P, Briffa N, Neumann P. Assessment of voluntary pelvic floor muscle contraction in continent and incontinent women using transperineal ultrasound, manual muscle testing and vaginal squeeze pressure measurements. Int Urogynecol J Pelvic Floor Dysfunct. 2006;17:624–30, doi: 10.1007/s00192-006-0081-2.
7. Hundley A, Wu J, Visco A. A comparison of perineometer to brink score for assessment of pelvic floor muscle strength. Am J Obstet Gynecol. 2005;192:1583-91, doi: 10.1016/j.ajog.2004.11.015.
8. Amaro J, Gameiro M, Padovani C. Treatment of urinary stress incontinence by intravaginal electrical stimulation and pelvic floor physiotherapy. Int Urogynecol J Pelvic Floor Dysfunct. 2003;14:204–8, doi: 10.1007/s00192-003-1061-4.
9. Ortiz O, Nunez F, Ibãnez G. Evaluation funcional del piso feminino (Classificacion Funcional). Bol Soc Latinoam Uroginecol Cir Vag. 1996; 1:5-9.
10. Messelink B, Benson T, Berghmans B, Bø K, Corcos J, Fowler C, et al. Standardization of Terminology of Pelvic Floor muscle function and dysfunction: report from the pelvic floor clinical assessment group of the International Continence Society. Neurourol Urodyn. 2005;24:374–80, doi: 10.1002/nau.20144.
11. Bø K, Finckenhagen HB. Is there any difference in measurement of pelvic floor muscle strength in supine and standing position? Acta Obstet Gynecol Scand. 2003; 82:1120-4, doi: 10.1046/j.1600-0412.2003.00240.x.
12. Frawley HC, Galea MP, Phillips BA, Sherburn M, Bo K. Reliability of pelvic floor muscle strength assessment using different test positions and tools. Int Urogynecol J Pelvic Floor Dysfunct. 2006;25:236–42.
13. Rosenbaum T. Pelvic floor involvement in male and female sexual dysfunction and the role of pelvic floor rehabilitation in treatment: a literature review. J Sex Med. 2007;4:4-3, doi: 10.1111/j.1743-6109.2006.00393.x.
14. World Health Organization [homepage on the Internet] (2006) BMI Classification. Geneva: WHO [cited 2008 nov1 12]. Available from: www.who.int/bmi
15. Atalah. Propuesta de un nuevo estándar de evaluación nutricional en embarazadas. Rev Méd Chile. 1997;125:1429–36.
16. Goodman LA. Simultaneus confidence intervals for multinomial proportions. Technometrics. 1965;7:247–54, doi: 10.2307/1266673.
17. Zar JH. Biostatical analysis. New Jersey : Prentice Hall, 5th Ed., 2009;1-960.
18. Subak LL, Richter HE, Hunskaar S. Obesity and urinary incontinence: Epidemiological and clinical research update. J Uro Dec. 2009;182(6 Suppl):S2-7, doi: 10.1016/j.juro.2009.08.071.
19. Wesnes SL, Rortveit G, Bø K, Hunskaar S. Urinary incontinence during pregnancy. Obstet Gynecol. 2007;109:922–8, doi: 10.1097/01.AOG.0000257120.23260.00.
20. Chin HY, Chen MC, Liu YH. Postpartum urinary incontinence: a comparison of vaginal delivery, elective, and emergent cesarean section. Int Urogynecol J Pelvic Floor Dysfunct. 2006;17:631-5, doi: 10.1007/s00192-006-0085-y.
21. Bo K, Finckenhagen HB. Vaginal palpation of pelvic floor muscle strength: inter-test reproducibility and comparison between palpation and vaginal squeeze pressure. Acta Obstet Gynecol Scand. 2001;80:883-7.
22. Fitzgerald MP, Graziano S. Anatomic and functional changes of the lower urinary tract during pregnancy. Urol Clin N Am. 2007;34:7-12, doi: 10.1016/j.ucl.2006.10.007.
23. Barbosa PB, Franco MM, Souza FO, Antônio FI, Montezuma T, Ferreira CHJ. Comparison between measurements obtained with three different perineometers. Clinics. 2009;64:527-33, doi: 10.1590/S1807-59322009000600007.
24. Scheer I, Thakar R, Sultan AH, Jones PW. Does pregnancy and delivery affect pelvic organ support?Pregnancy and prolapse assessement [PAPA] study. In:37thAnnual Meeting of the International Continence Society (ICS). Rotherdan, Bristol. 2007.
25. Baytur YB, Deveci A, Uyar Y, Ozcakir HT, Kizilkaya S, Caglar H. Mode of delivery and pelvic floor muscle strength and sexual function after

childbirth. Int J Gynecol Obstet. 2005;88:276-80, doi: 10.1016/j.ijgo.2004.12.019.

26. Baessler K, Schuessler B. Childbirth-induced trauma to the urethral continence mechanism: review and recommendations. Urology. 2003; 62:39-44, doi: 10.1016/j.urology.2003.08.001.
27. Marshall K, Walsh DM, Baxter GD. The effect of a first vaginal delivery on the integrity of the pelvic floor musculature. Clin Rehabil. 2002;16:795-9, doi: 10.1191/0269215502cr556oa.
28. Neumann P, Gill V. Pelvic floor and abdominal muscle interaction: EMG activity and intra-abdominal pressure. Int Urogynecol J Pelvic Floor Dysfunct. 2002;13:125-32, doi: 10.1007/s0019202000 27.
29. Maddil SJ, Mclean L. Relationship between abdominal and pelvic floor muscle activation and intravaginal pressure during pelvic floor muscle contractions in healthy continent women. Neurourol Urodyn. 2006;25:722-30, doi: 10.1002/nau.20285.