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ORIGINAL ARTICLE

Parity: a risk factor for decreased pelvic floor muscle strength and endurance in middle-aged women

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Abstract

Introduction and hypothesis The incidence of pelvic floor muscle (PFM) dysfunction increases rapidly with menopause and aging. Despite the raised magnitude and prevalence of pelvic floor disorders in middle-aged women, the risk factors underlying PFM dysfunction still remain to be identified. PFM function can be clinically measured as the maximum strength and endurance using manometry. The aim of this study was to evaluate PFM function in terms of strength and endurance by perineometer and to assess the risk factors that decrease PFM strength and endurance in middle-aged women.

Methods This was a cross-sectional study. Overall, 125 parous women (age 40–60 years) completed the study. A questionnaire was used to collect information on several demographic and obstetric variables. The Peritron perineometer measured PFM strength and endurance. Multiple linear regression analysis was used to evaluate the effects of sociodemographic variables on PFM function.

Results Both average strength of PFMs and maximum muscle strength significantly reduced as the number of parity increased. Average and maximum strength of PFMs showed a significant difference between women with parities of two and one ($\beta = -0.435$, $p < .001$; $\beta = -0.441$, $p < 0.001$, respectively). Both were even more influenced in women with parity of three ($\beta = -0.503$, $p < .001$; $\beta = -0.500$, $p < .001$). However, PFM endurance did not decrease with increasing parity number until the parity of two; however, it decreased in women with parity of three ($\beta = -0.302$, $p < 0.05$).

Conclusion Parity appeared to have a dominant influence on weakness of PFM, and strength was more significantly associated with parity than endurance in middle-aged women.

Keywords PFM endurance · PFM strength · Pelvic floor muscle · Perineometer

Introduction

With the increase in both the absolute and relative number of elderly women, pelvic floor muscle (PFM) dysfunction is becoming a major health problem because the most affected women experience a significant change in quality of life (QoL). Estimates show that more than one third of the female population suffers from PFM dysfunction of various severity levels in their lifetime. In particular, one third of premenopausal and one half of postmenopausal women are estimated to be affected by some type of pelvic floor disorder, and 25% of women are at a risk of needing surgery due to pelvic floor dysfunction [1, 2]. Despite the magnitude and prevalence of pelvic floor disorders in middle-aged women, identifying risk factors for undermining PFM function remains unresolved. Previous studies suggested many factors that affect strength and endurance, such as age, ethnicity, pregnancy, mode of delivery, parity, medical history, family history, gynecological surgeries, and obesity [3, 4]. However, even a well-known risk factor affecting PFMs, such as vaginal delivery, remains a part of an ongoing debate, because several cases do not show a correlation with this issue [5].

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The pelvic floor is an anatomical complex comprising the pelvic diaphragm muscles, urogenital diaphragm muscles, ligaments, and connective tissue, which are interconnected in a three-dimensional arrangement [6]. PFMs support the pelvic organs and are important in maintaining their position and function by contraction [7]. Information on the severity of PFM weakness was obtained by evaluating PFM strength and endurance [8, 9]. PFM function can be clinically quantified as maximum strength and endurance measured using manometry [10].

The aim of this study was to evaluate PFM function in terms of strength and endurance and to assess the risk factors that decrease those functions in middle-aged women.

Materials and methods

Participants

This was a cross-sectional study performed in a public hospital evaluating 125 parous women aged 40–60 years who appeared for periodic medical checkups between July and October 2012. The ethics committee of the Hanmaeum Changwon Hospital granted approval for the study. Each participant granted their informed consent to participate and completed a questionnaire before enrollment that provided information on baseline characteristics and obstetric and medical histories. Patients undergoing fecal or urinary incontinence treatment, having undergone a previous urogynecological surgery, having chronic cough, and having anorectal and/or neuromuscular disease were excluded.

Procedure

Participants completed a questionnaire regarding sociodemographic data, such as age, parity, delivery mode, contraception, menopause, education level, job, disease, alcohol use, and body mass index (BMI) [9]. All were examined by a physical therapist experienced in PFM evaluation. During examination, participants lay in a supine position with a pillow under their head, knees straight, and legs abducted. To reduce the effect of abdominal pressure, they were instructed before starting the procedure to not apply abdominal pressure during measurement. An objective perineal muscle strength evaluation was made using a digital perineometer (Peritron 9300, Cardio Design Pty Ltd. Oakleigh, VIC, Australia) [11] connected to a balloon catheter (11 × 2.6 cm), which was inserted into the vagina. The balloon was located 1 cm from the outside of the vaginal canal, positioning the middle of the balloon 3.5 cm inside the vaginal introitus, and the device was calibrated to zero before each measurement. Women were asked to contract PFMs to the maximum possible extent three times and hold their contraction for 5 s; a 10-s interval was kept between the three contractions. The peak of the three successive contractions was recorded as the maximum measured strength of the PFM. Mean strength was calculated as the average of three maximum voluntary contractions. Visible or palapable contraction of the rectus muscle or gluteal muscles was minimized. Perineometer pressure was recorded as centimeter of water (cmH_2O). Technical validity of the perineometer was supposed correct to ±1 cm of water [12].

An endurance test was performed after the maximum voluntary contraction test. Participants were asked to hold a PFM contraction for as long as they could. They were not interrupted unless the pressure measurements reached zero or they reported not being able to hold the contraction any longer. Contraction holding time was measured in seconds and used for data analysis.

Statistical analysis

The sociodemographic mean differences in terms of the maximum PFM strength, endurance, and average strength were analyzed using the t -test and one-way analysis of variance (ANOVA), and the post hoc comparison test was performed using Duncan's multiple-range test). Multiple regression statistical models were used to determine the relationship between data variables and PFM function. The variance inflation factor was calculated to confirm co-linearity, and autocorrelation was examined. Stepwise regression was used to determine an appropriate model for these data. Significance level was set at $P < 0.05$, and all data were analyzed using the Statistical Package for the Social Sciences Version 19 (SPSS Inc., Chicago, IL, USA). In the final model, we included parity, age, job, alcohol intake, and BMI.

Results

A total of 125 women were included in the study, and all successfully underwent perineometer. There were 11 patients with one parity, 98 with two, and 16 with three. Mean age at the time of examination was 47.78 ± 3.49 years; 72.0% had normal spontaneous vaginal delivery (NSVD), 24.0% had Cesarean section (CS), and 4.0% had deliveries by both CS and NSVD. Baseline demographic features and obstetric outcomes are summarized in Table 1.

PFM strength was associated with parity, and the average strength significantly decreased as the number of parities increased. Maximum PFM strength was inversely related with the number of parities, and other variables showed no significant association with the PFM strength and endurance. In contrast to average and maximum strength, there was no significant association between parity and endurance (Table 2.).

Multivariate regression analysis showed that the number of parities exhibited a negative linear relation with average and maximum PFM strength (Table 3). Women with parity of two had a greater effect on average vaginal strength and exhibited

Table 1 General characteristics of research participants

Variables	Group	Number (%)	Mean ± SD (median)
Age (year)	≤ 45	37 (29.6)	47.78 ± 3.49 (48.00)
	46–49	52 (41.6)	
	≥ 50	36 (28.8)	
Parity	1	11 (8.8)	
	2	98 (78.4)	
	3	16 (12.8)	
Delivery mode	NSVD	90 (72.0)	
	CS	30 (24.0)	
	NSVD+CS	5 (4.0)	
Contraception	No	68 (54.4)	
	Yes	57 (45.6)	
Menopause	No	85 (68.0)	
	Yes	40 (32.0)	
Education level	≤ High school	81 (64.8)	
	≥ College	44 (35.2)	
Job	No	16 (12.8)	
	Yes	109 (87.2)	
Disease	No	65 (52.0)	
	Yes	60 (48.0)	
Alcohol	< Once a month	75 (60.0)	
	1–3/month	26 (20.8)	
	≥ 1/week	24 (19.2)	
Height			158.62 ± 5.14 (159.00)
Weight			58.25 ± 7.72 (58.00)
BMI (kg/m^2)	< 23	61 (48.8)	23.16 ± 2.83 (23.05)
	23 ≤ BMI < 25	30 (24.0)	
	≥ 25	34 (27.2)	

N (%), Mean ± SD, (N=125) *BMI* body mass index, *NSVD* normal spontaneous vaginal delivery, *CS* cesarean section, *SD* standard deviation

higher maximum strength than women with one parity ($\beta = -0.435$, $p < .001$; $\beta = -0.441$, $p < 0.001$, respectively). Both factors showed even greater values in women with parity of three ($\beta = -0.503$, $p < .001$; $\beta = -0.500$, $p < .001$). In contrast to the average and maximum strength measurements, PFM endurance was not inversely related with parity number but showed a significant association only in woman with parity of three ($\beta = -0.302$, $p < 0.05$). Average and maximum vaginal pressure strengths were not correlated with age, job, alcohol consumption, or BMI. In addition, age, job, and BMI were not associated with endurance.

Discussion

PFM maximum and average maximum strength was significantly lower in the multiparous than in the primiparous group and decreased inversely according to number of parities. This finding is consistent with results of previous studies showing an association between increasing parity and changes in PFM strength [13]. The influence of pregnancy remains poorly understood, but the mechanical pressure and variations in circulating levels of hormones during pregnancy are expected to have a significant role.

In mechanical terms, the pelvic floor structure is under long-term, continuous pressure due to uterine growth during pregnancy, particularly in the third trimester. The increased abdominal pressure results in the downward compression and stretching of the PFMs, and the change of gravity axis may affect the integrity of the pelvic floor [14]. Additionally, the increased levels of steroid hormones, such as estrogen and progesterone, cause muscle relaxation and bring about hypotonicity of smooth muscles, possibly leading to PFM dysfunction. Relaxin, a peptide hormone of the insulin-like growth factor family, may affect the relaxation of pelvic floor organs and cause pelvic floor dysfunction by leading to connective tissue remodeling during pregnancy [15].

Many authors have studied the effects of changes in PFM strength according to type of delivery modes [vaginal (VD) and cesarean section (CS) deliveries]; however, it remains controversial whether delivery mode itself affects PFM. One study reported that all PFM parameters showed significant differences when comparing VD and CS. Analyzing data for different delivery modes, a significant PFM strength reduction was reported in the VD but not the CS group [16, 17]. Hilde et al. [12] presented data on 55 parous women studied from late pregnancy (36th to 42nd week), 3–8 days after delivery, and 6–10 weeks postpartum. However, Siqurdardottir et al. [16] found that voluntary contraction of the levator ani muscle, a major PFM, was decreased shortly after VD; restoration in most patients was reported at 6–10 postpartum weeks [5]. Another study reported that PFM strength was decreased shortly after childbirth but recovered by 1 year postpartum, irrespective of delivery mode [18]. In the long-term, it would be interesting to know how much PFM strength recovers over 1-year postpartum. One hypothesis is that the levator ani muscle has strong potential for recovery from pregnancy- and delivery-induced damage in most women. According to one study, most of this recovery occurs in varying degrees during the first 6 months postpartum, with no significant difference in the extent of recovery observed between delivery modes [18]. Although several long-term postpartum follow-up studies of pelvic floor disorders have been conducted, PFM strength assessment results with direct force measurement have been sparse. Our findings indicate that delivery type does not affect PFM strength in middle-aged women. A recent study also assessed the influence of delivery type on PFM function in postmenopausal women [19]. We suggest that, irrespective of delivery mode, there is a trend toward PFM recovery over the long term.

Table 2 Changes in pelvic floor muscle (PFM) strength and endurance according to participant general characteristics in univariate analysis

Variables	Group	M-A		Maximum		E-A	
		Mean ± SD	*P*	Mean ± SD	*P*	Mean ± SD	*P*
Parity	1	43.82[b] ± 16.21	.000	46.86[b] ± 17.43	.000	24.27 ± 12.41	.210
	2	28.28[a] ± 14.22		30.37[a] ± 14.69		18.01 ± 16.93	
	3	22.31[a] ± 9.36		24.48[a] ± 9.45		13.27 ± 8.61	
Age (year)	≤45	29.54 ± 17.02	.876	32.09 ± 18.03	.806	15.62 ± 10.21	.553
	46–49	29.13 ± 13.19		31.24 ± 13.54		19.27 ± 15.40	
	≥50	27.84 ± 14.52		29.76 ± 14.77		18.46 ± 20.76	
Delivery mode	NSVD	28.29 ± 14.83	.478	30.45 ± 15.21	.432	17.93 ± 16.39	.996
	CS	31.40 ± 14.49		33.78 ± 15.60		18.13 ± 15.55	
	NSVD+CS	24.43 ± 13.74		25.80 ± 13.80		17.43 ± 8.88	
Contraception	No	30.23 ± 15.74	.348	32.62 ± 16.40	.299	18.79 ± 14.31	.595
	Yes	27.75 ± 13.76		29.77 ± 14.19		17.26 ± 17.14	
Menopause	No	27.41 ± 15.09	.444	29.38 ± 15.73	.397	16.45 ± 19.42	.469
	Yes	29.57 ± 14.53		31.86 ± 15.03		18.67 ± 13.97	
Education level	≤ High school	30.40 ± 15.02	.396	32.68 ± 15.72	.385	18.53 ± 12.61	.767
	≥ College	28.06 ± 14.53		30.19 ± 15.00		17.65 ± 17.46	
Job	No	29.51 ± 14.88	.209	31.73 ± 15.40	.206	19.01 ± 16.54	.053
	Yes	24.56 ± 12.86		26.56 ± 13.69		10.81 ± 7.01	
Disease	No	28.37 ± 14.74	.712	30.50 ± 14.87	.689	17.26 ± 16.19	.641
	Yes	29.35 ± 14.74		31.59 ± 15.67		18.60 ± 15.66	
Alcohol	< Once a month	28.85 ± 13.22	.985	30.92 ± 13.54	.967	20.14 ± 17.96	.126
	1–3/month	29.39 ± 14.75		31.84 ± 15.17		13.99 ± 9.26	
	≥ 1/week	28.73 ± 19.26		31.02 ± 20.47		14.47 ± 13.02	
BMI (kg/m^2)	< 23	26.30 ± 12.95	.156	28.22 ± 13.10	.121	17.58 ± 12.61	.347
	23 ≤ BMI < 25	30.95 ± 16.38		33.27 ± 17.07		15.28 ± 12.16	
	≥ 25	31.69 ± 15.67		34.23 ± 16.58		21.00 ± 22.61	

post-hoc test: a < b, *M-A average of PFMl strength, E-A average of PFM endurance, NSVD* normal spontaneous vaginal delivery, *CS* cesarean section, *BMI* body mass index

Another important aspect related to PFM function is endurance, defined as the ability to hold isometric contractions. Little is known on the factors affecting endurance, and our study did not report results related to this aspect in perimenopausal women. One study recruited ten nulliparous and ten primiparous patients (9–10 months after the birth of the first child), demonstrating the significantly lower endurance in the primiparous than the nulliparous group; however, the number of participants was small [20]. A study focusing on the impact of delivery mode reported a pronounced reduction in endurance after vaginal and cesarean deliveries (53 and 65%, respectively), and there was no change in the cesarean group [16]. Another study assessed changes in PFM function after the first childbirth by measuring endurance at 20–26 weeks of gestation and at 6–12 weeks postpartum. Endurance was significantly reduced in all participants because of the first childbirth but was not significantly influenced by delivery mode [17]. To our knowledge, there are no long-term studies on endurance that assesses direct measurement in perimenopausal women. Although our study found that endurance decreased according to parity, it showed no association between endurance and mode of delivery. No significant difference in endurance time was observed between women with parities one and two paraties; however, a significant decrease was found in women with parity three compared with parities one and two. Our study suggested that although it decreased with increasing parity, endurance was less influenced by parity number than by PFM strength. This is the first report exploring the association between endurance and parity in middle-aged women.

To explain this aspect, the composition of muscle fiber type in pelvic muscles needs to be considered. The levator ani muscle comprises slow-twitch type I fiber (66%) and fast-twitch type II fiber (34%) [21]. The latter play a role in more rapid and forceful muscle contraction, and the former have greater endurance because of their fatigue resistance and slower contraction rate. Even though the mechanism of pelvic floor dysfunction is multifactorial and without clear etiology, some studies have suggested a possible pathway of transition of type II fibers into type I fibers that occurs in cases of muscle

Table 3 Stepwise multiple linear regression analysis for the effect of independent variables on pelvic floor muscle (PFM) strength and endurance

Variables	M-A			Maximum			E-A		
	B	β	t	B	β	t	B	β	t
(Constant)	26.024		1.222	28.119		1.276	−1.467		−0.062
Parity									
1	(ref.)			(ref.)			(ref.)		
2	−15.466	−.435	−3.414***	−16.269	−.441	−3.471***	−7.878	−.205	−1.577
3	−22.029	−.503	−3.890***	−22.737	−.500	−3.880***	−14.266	−.302	−2.284*
Age	−0.013	−.003	−0.035	−0.043	−.010	−0.113	0.223	.049	0.546
Job									
No	(ref.)			(ref.)			(ref.)		
Yes	4.067	.093	1.084	4.229	.093	1.089	7.252	.153	1.752
Alcohol									
<1/month	(ref.)			(ref.)			(ref.)		
1–3/month	−1.304	−.036	−0.395	−0.976	−.026	−0.286	−7.168	.181	−1.970
≥ 1/week	−1.074	−.029	−0.323	−0.923	−.024	−0.268	−6.082	.152	−1.659
BMI	0.663	.128	1.483	0.750	.139	1.622	0.563	.100	1.143
F	2.904**			3.013**			2.119*		
R^2	.148			.153			.113		
adj R^2	.097			.102			.059		

BMI body mass index, M-A average of PFMl strength, E-A average of PFM endurance, B unstandardized beta, β standardized beta, t t test statistic
* $p < .05$, ** $p < .01$, *** $p < .001$

trauma. This observation indicates that any damage caused to type II pelvic muscle fibers significantly reduces muscle strength but not endurance because of fiber transition. Muscle endurance is more resistant than muscle strength to the noxious factors provoking pelvic floor damage, which is consistent with our data [14, 22].

Several studies reported age as an important factor associated with a reduced PFM function [14, 23, 24]. One study studied strength and endurance in 28 women aged 19–58 years and reported that strength did not correlate with age. However, age significantly and positively affected endurance, which was greater in women aged ≥40 years than in younger women; this may be explained by pelvic muscle composition transition from type II to type I fibers in the aging process [25]. However, in our study, there was no significant association between endurance and strength and age. As we studied middle-aged perimenopausal women specifically, age may be not a statistically significant risk factor for PFM dysfunction within that age group. We found no factors related to strength or endurance among other variables, such as contraception, menopause, education level, or BMI.

To assess PFM function, reliably determining the strength and endurance of these muscles is of great value [8]. Pressure perineometer, introduced by Kegel in 1950, is a pressure biofeedback device to measure intravaginal pressure. It is a simple, minimally invasive, low cost, and a reliable quantitative method with a reportedly high reproducibility [5, 13].

The limitation of the study was that the distribution of parity subgroups was not even. This study was conducted to investigate whether decrease in PFM function occurs by measuring PFM strength and endurance directly in middle-aged women and identify associating factors with limited a number of patients. Further studies, mainly focused on parity, must be conducted in a larger cohort of samples with the aim at even distribution of subgroups.

Conclusion

The purpose of this study was to investigate the risk factors affecting PFM in middle-aged women. In these women, parity was a major risk factor related with PFM strength and endurance. Strength decreased proportionally with parity number; endurance declined with increasing parity number after the second childbirth independently of delivery mode. Thus, endurance was less associated with the parity number than it was with PFM strength. It is important to assess risk factors for and to prevent symptoms related to PFM function disorders, such as stress incontinence, bladder dysfunction, rectal dysfunction, uterine prolapse, and sexual dysfunction. The study suggests that measuring PFM strength and endurance in high-parity women may be helpful in predicting PFM function disorders.

Compliance with ethical standards

Conflicts of interest None.

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