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ETHNIC DIFFERENCES IN PELVIC FLOOR MUSCLE STRENGTH AND ENDURANCE IN SOUTH AFRICAN WOMEN

Ina van der Walt
Pelvic Floor Physiotherapist, Physiotherapy Division, Department of Interdisciplinary Health Sciences, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town South Africa

Kari Bø
Professor, Physiotherapist and Exercise Scientist, Norwegian School of Sport Sciences, Department of Sports Medicine, University of Oslo, Oslo, Norway

***Susan Hanekom**
Senior Lecturer, Physiotherapy Division, Department of Interdisciplinary Health Sciences, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town South Africa

Gunter Rienhardt
Consultant Urogynaecologist, Urogynaecology Unit, Tygerberg Hospital and Stellenbosch University, Cape Town, South Africa Present address: Urogynaecology Unit, Princess Anne Hospital, Southampton, United Kingdom.

I van der Walt: Project development, Data Collection, Data Analysis, Manuscript writing
K Bo: Project development, Manuscript writing
S Hanekom: Project development, Data Collection, Data Analysis, Manuscript writing
G Rienhardt: Project development, Manuscript writing

*Corresponding Author: (E-mail) sdh@sun.ac.za

Abstract:

Introduction: Limited knowledge exists about pelvic floor muscle (PFM) function in ethnic groups. The aim of this study was to compare PFM strength and endurance in a group of black, white and mixed-race women.

Methodology: Cross-sectional study. Maximum voluntary contraction (MVC) and endurance were measured with a perineometer and vaginal balloon sensor. Two sets of 3 MVC of the PFM were recorded; resting phase five minutes. Demographic variables and factors associated with PFM strength were assessed.

Results: 122 nulliparous Black (n = 44), White (n = 44) and Mixed-race (n = 34) students participated. PFM of Black women were stronger than that of White ($p = 0.02$) or Mixed-race ($p < 0.01$) women. The MVC of PFM in black women decreased ($p=0.02$) between first and second set of contractions.

Conclusion: Ethnic differences were found. Further clinical studies are needed to confirm an association between PFM function and pelvic floor disorders.

Key words: ethnicity, muscle endurance, pelvic floor, strength

Brief summary: Comparison of pelvic floor muscle strength and endurance in a volunteer university student sample of black, mixed-race and white woman

Introduction:

An estimated 250 million women worldwide suffer from urinary incontinence (UI) [1]. It is a distressing condition with significant social, psychosexual and economic implications [2].

Ethnic differences have been reported in the prevalence of UI [3]. There is an indication that White women may be more at risk of stress urinary incontinence (SUI) [1] and that Black South African women have a higher prevalence of overactive bladder [4]. The etiology of ethnic differences in the prevalence of urinary incontinence is still controversial and is most likely multifactorial, including inherent structural and physiological factors.

The pelvic floor muscles (PFM) form an integral part of the continence mechanism [5, 6]. Decreased PFM strength has been associated with stress urinary incontinence [7, 8] and strength training of the PFM has been found to increase muscle volume, reduce muscle length, reduce the levator hiatus and lift the bladder and rectal ampulla[9]. Investigating PFM strength and endurance may contribute to the understanding of the reported differences in ethnic prevalence of different types of UI.

A search of the literature revealed only two older studies comparing PFM strength between ethnic groups. In 1963 Skinner and Crichton [10], using a Kegel perineometer, compared PFM strength of black African and Indian nulliparous and multiparous female nurses and reported

that black African women have 72% stronger PFM than Indian women. In 1975, Knobel [11] reported that in a small sample of 10 black women and 10 Indian women, the PFM strength of the black women was 56% stronger than that of the Indian women.

To date, there is equivocal evidence for normal values of PFM function and Dietz et al [12] encouraged investigators to reproduce and extend findings on normal pelvic floor values in nulliparous women. The aim of the current study was to assess ethnic variation of PFM strength and endurance between nulliparous women in the black, white and mixed-race ethnic groups.

Materials and Methods

This cross-sectional study assessed the PFM strength and endurance of nulliparous student volunteers studying at the three universities in Cape Town. Data collection was performed between July and October 2007. Ethics approval was granted by the Human Research Committee at Stellenbosch University, Cape Town, South Africa (N06/03/058). Informed consent was obtained from all participants prior to study commencement.

Recruitment of participants: A lecture on pelvic floor anatomy, function and dysfunction and rehabilitation was offered by the principal investigator (PI) to students registered at the physiotherapy and nursing schools of the different universities. The study was explained, the balloon catheter was shown to the students and volunteers for the study were recruited. In addition students from other university departments, waiting to be seen at the University of the Western Cape Student Health Clinic, were also recruited after detailed explanation and counseling. Students were included if they were nulliparous and aged between 18 and 45. Exclusion criteria were: previous gynaecological surgery (i.e. pelvic floor surgery), pregnancy, menstruation on the day of the test, inability to understand the instructions given in English, inability to contract the PFM (as assessed by observing inward movement of the perineum while contracting), participation in an active pelvic floor strengthening program for longer than two weeks, low back pain sufferers with radiating pain, or any participant who had a neurological condition that would affect the pelvic floor function, radiotherapy to pelvis/pelvic organs, diabetes mellitus, suspected urinary tract infection on the day of the test, previous spinal surgery and vaginal infection on the day of the test. Participants were required to classify themselves as part of a Black, Mixed-race or White ethnic group.

Instruments: A questionnaire was developed to assess the demographic variables and factors which may be associated with PFM strength. The questions were compiled according to the risk factors identified in the literature for the development of pelvic floor dysfunction [13]. These were: age, BMI, frequency of low back pain, medication usage (i.e. oral contraceptives, progestogen injection, anti-depressants, muscle relaxants, thyroid medication), chronic respiratory conditions, previous PFM training, UI status, frequency of bowel motion, straining at stool, perineal pain, participation in physical activity, smoking and menstrual status. The face validity of questionnaire was established in a pilot trial before data collection commenced. We recruited eight women from the family planning clinic to determine whether they understood the questions. The sample consisted of four mixed-race, three black Xhosa-speaking and one white woman. Six were nulliparous and two were parous. The mean age of the sample was 22 years (range 21-26 years) and had a mean BMI of 21 kg/m2 (range 18-25 kg/m2) [14]

PFM strength was measured as maximum voluntary contraction (MVC). Strength and vaginal resting pressure (cmH_2O) were measured with the Peritron ™ 9300 (Cardio Design, Australia) used with the Camtech AS vaginal balloon sensor (Sandvika, Norway) with the participant in the crook-lying position. A standardised test procedure as described by Bo et al [15] was used. The balloon catheter was compressed by an estimated 10% to allow for air expansion at body temperature and then connected to the silicon tubing of the Peritron[16]. The participant inserted the balloon sensor up to a mark, so that the middle of the balloon sensor was 3.5 cm from the introitus [17]. The participant was instructed to contract the PFM as hard as possible and then to relax without pressing the perineum downwards. Contractions were accepted as correct, when the PI assessed that no visible co-contraction of hip adductor, gluteal or rectus abdominus muscles (posterior pelvic tilt) took place and the catheter was drawn inwards while the participant performed the PFM contraction [16]. The method has been tested for intra-tester reproducibility and has been found to be reliable*i* [14, 18]

Procedure: Two sets of 3 maximum voluntary contractions of the PFM were recorded. The participants were instructed to maintain three PFM contractions up to 10 seconds with a rest period of 20 seconds between each contraction. Resting pressure and peak pressures of repeated contractions were registered on the Peritron™ 9300. A resting phase of five minutes was allowed between the sets. Endurance was calculated by comparing the difference in strength between the first and second set of contractions.

Sample size calculation: Initial sample size calculation was based on data of a study conducted by Frawley et al [19]. They used the Peritron perineometer with its standard vaginal probe, and reported a standard deviation of 15 cmH2O. We calculated that a total sample of 75 participants would be needed to detect a difference of 15cm H2O in PMF strength between the groups with 90% power and a two sided p-value <0.05. We did an interim analysis after 50 participants were included. Using ANOVA we then calculated that a sample size of 37 in each ethnic group would detect a mean difference of 8 cmH2O between the three groups of participants with 90% power and a two sided p-value <0.05.

Statistical analysis: PFM data was recorded and analysed in Microsoft Excel by the PI. The PI was blind to group classification. A graph was constructed of the data captured by the Peritron™ 9300. Using the graph, baseline and peak measurements were plotted for each contraction. The baseline measurement was then subtracted from the peak measurement to obtain the measurement of the pressure increase with a MVC. The mean of the 3 contractions were then calculated for each set.

Data were analyzed with Statistica software version nine by Statsoft TM in consultation with a statistician. Central tendencies and data variability were reported as means / standard deviations if data was distributed normally; and medians / inter-quartile range when not. One-way ANOVA, cross tabulation and chi-square tests were used as indicated to test homogeneity of the different ethnic groups. One-way ANOVA was used to analyze differences in PFM strength between two sets of contractions. Repeated measures of ANOVA were used to compare the first and second set of contractions between two ethnic groups. Two-way ANOVA and Spearman's correlations were used to establish if ethnicity is independently associated with PFM strength. Significance was established at $p<0.05$.

Results

One hundred and thirty-five women volunteered for the study, but 122 were included (Figure 1). The sample included students from physiotherapy (n=46), nursing (n=32) and other study areas (n=45). Participants classified themselves as Black (n=44 36%), White (n=44 36%) and Mixed-race (n=34 28%).

Participants ages ranged between 18 and 45 years of age, with a mean of 22 (SD=3.54) Participants who classified themselves as White were significantly older (p=0,02) than participants from the other two groups. The Body Mass Index (BMI) of the sample ranged between 16 and 38 with a mean of 23 (SD=4.16) The BMI of participants who classified themselves as Black was higher than participants from the other two groups. Differences between the groups were also noted in their participation in physical activities, smoking habits, medication usage, amenorrhoea, previous attempts to contract the PFM, perineal pain and straining at stool Table 1.

In the first and second set of PFM contractions, black women had significantly higher MVC values than the white (p=0.02) and mixed-race (p<0.01) women (Figure 2). No significant difference in strength between the white and mixed-race women (p=0.78) were noted (Table 2). A significant (p=0.02) decrease in the MVC squeeze pressure of PFM were observed in black women from the first to the second set of contractions (Figure 3). The other two groups had no significant (p=1.0) decrease in MVC squeeze pressure between the first and second set of contractions (Table 2).

Despite ethnic differences observed in various variables (Table 1), a decreased bowel motion frequency and BMI were the only two variables associated with PFM strength. Women who had a bowel motion less than three times a week had significantly (p=0.01) lower MVC values (12.9 cmH_2O) compared to women who had more regular bowel motions (21 cmH_2O). A weak positive correlation (Spearman r = 0.19 p=0.04) between BMI and MVC values was also observed. Following an analysis of covariance, ethnic grouping was independently associated (p< 0.01) with PFM strength

Discussion

Significantly stronger PFM were observed in black women when compared to white or mixed-race women. This is in agreement with the two previous reports [10, 11] . In the present study, PFM strength of black women was found to be 26% stronger than white women and 37% stronger than mixed-race women. It must be taken into account, that comparison to the studies of Skinner and Crichton [10] and Knobel [11] is hampered by the fact that different measuring devices and probes were used and different ethnic groups had been compared.

Ethnical differences have also been found in other studies reporting on the cross-sectional area of the PFM. The maximal force potential of a muscle is proportional to the sum of the cross-sectional areas of all the fibres, therefore the thicker the muscle, the greater the force potential [20]. With MRI studies, Duong and Korn [21] found that the PFM in nulliparous black women are thicker than in white women, which also confirm the results of two other morphological studies [22, 23]. Hence, it is expected that black women would have stronger PFM than white women. The findings in this paper therefore add weight to the belief that black women have PFM that

are better equipped to withstand the effect of intra-abdominal forces on the urinary tract and thus are less likely to experience SUI [1]

Similar results were found if the PFM strength of the white students of this study when compared to strength measurements of continent physiotherapy students in Norwegian studies [24-27]. Moreover, other studies evaluating vaginal squeeze pressure in continent women reported values in the same area, which compares favourably with values of mixed-race and white women in the present study[18, 28]. However, caution must be exercised when direct comparisons are made as measurements have been done with different measuring apparatus [15]

Mean maximal contraction values for women with SUI or mixed incontinence have much lower reported values (5-16.2 cmH_2O) [16, 26, 26, 29-31]. Mixed-race students had the lowest maximal pressure readings (15.6 cmH_2O) in this study and can be compared to the bottom range of values reported by healthy women and the upper range of values of women with SUI. In studies [7, 32] with samples consisting of women who completed a PFM strengthening program for SUI, higher mean values were reported (19.2-26.6 cmH_2O). It seems, therefore, that women on an active training protocol may have stronger pelvic floor muscles, than the general population of white women. These values of women on a strengthening program compared well with the values of the black women in this study.

The protocol utilized to assess endurance in this study was two sets of three MVCs with a 5 minute rest period between sets. Black women in this study had a significant decrease in PFM strength between the first and second set of contractions, whereas no significant decreases were found between the first and second set of contractions in the white and mixed-race women. This could imply that the PFM in black women develop fatigue more easily than in the other ethnic groups and therefore have decreased endurance.

During daily activities, the PFM needs constant tension to support pelvic organs and inhibit detrusor contractions through the perineo-detrusor inhibitory reflex [33]. This reflex works on the principle that a contraction of the PFM would decrease detrusor contraction and so inhibit urinary urge. Therefore, if the PFM develops fatigue, it could possibly result in decreased inhibition and therefore increased excitation of the detrusor, resulting in overactive bladder (OAB) symptoms. Thus, the fact that the PFM of black women develops fatigue more easily could be an indication of why there is an increased prevalence of overactive bladder symptoms in this group.

The method of endurance measurement in this study has not been validated and therefore the results have to be interpreted with caution. No reliable protocol for PFM endurance testing using vaginal pressure measurement is described in literature. There is also no consensus on the method used to measure endurance. Frawley et al [19] did not find their endurance test protocol, consisting of one set of twenty fast contractions, to be reproducible. In the literature, two different protocols to assess endurance were described, one being time of sustained contraction and the other, two or three sets of three maximal contractions. These two protocols have shown conflicting results on endurance regarding parity and continence [8, 34]. In future studies it would be valuable to establish a validated protocol to determine endurance and to investigate the interaction between PFM endurance and overactive bladder syndrome.

Ethnic differences in the sample were noted in the variables such as age, BMI, student discipline, physical activity participation, smoking, usage of progestogen injection as contraceptive method, amenorrhoea, previous attempt to contract the PFM, perineal pain and straining at stool. In this sample, the BMI in the black group was significantly higher than in the other ethnic groups and is consistent with findings in other studies [35, 36]. The questionnaire had been validated with a pilot study and expert review, but reliability of the instrument has however, not been established with testing and re-testing.

In the present study increased BMI and decreased frequency of bowel motion was associated with PFM strength. Women with increased BMI had stronger PFM. This is not consistent with the literature, where increased BMI is a known risk factor in the development of UI [2]. In the covariate analysis of BMI and ethnicity, ethnicity was still independently associated with PFM strength. Women who had decreased frequency of bowel motion (less than three times a week) had significantly weaker PFM than those with normal bowel frequency, which is consistent with findings in the literature [37, 38] Decreased frequency of bowel motion may indicate straining on stool which is considered a risk factor for weakening of the pelvic floor [37, 38].

A non-probability sampling method with an absence of randomization was used. This weakens the generalization of the sample and increases sampling error. The results of this study can therefore only be generalized to nulliparous black, white and mixed-race urban women, of 18-45 years undergoing tertiary education. In observational research there is no randomization of groups that could ensure that the groups are equal, but there are statistical methods to determine if a variable is independently associated with an outcome. Therefore, all efforts have been made to exclude all known factors that would influence PFM strength and to include analysis of all other factors that might influence PFM strength or be associated with PFM strength, in order to verify if ethnicity is independently associated with strength. However, the study still has a self-selected sample and there may therefore be sampling bias.

Conclusion

This paper established differences in PFM strength and endurance of nulliparous women of different ethnical groups in a volunteer university student sample. The results of the cross-sectional study indicate that black women had stronger PFM than white and mixed-race women. In addition black women had decreased endurance compared to white and mixed-race women. However, no significant differences regarding PFM strength and endurance were found between white and mixed-race women. Further clinical studies are needed to confirm an association between PFM function and pelvic floor disorders.

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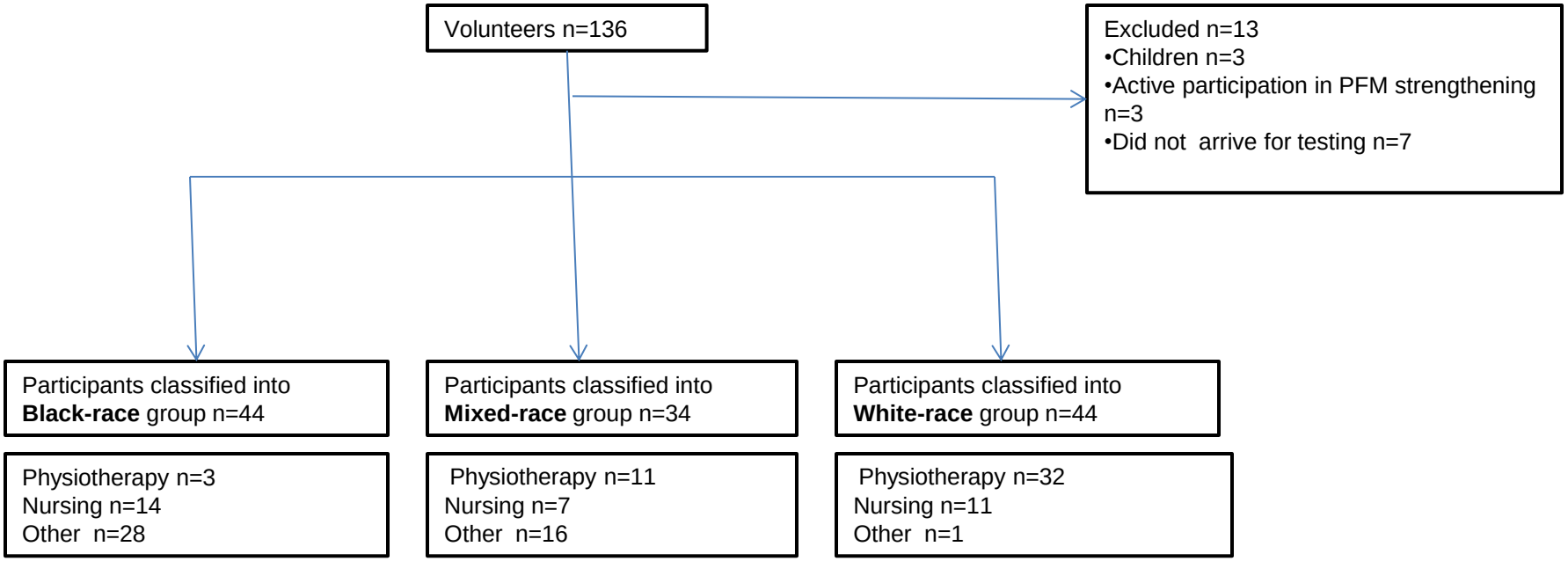

Figure 1: Consort diagram of participants

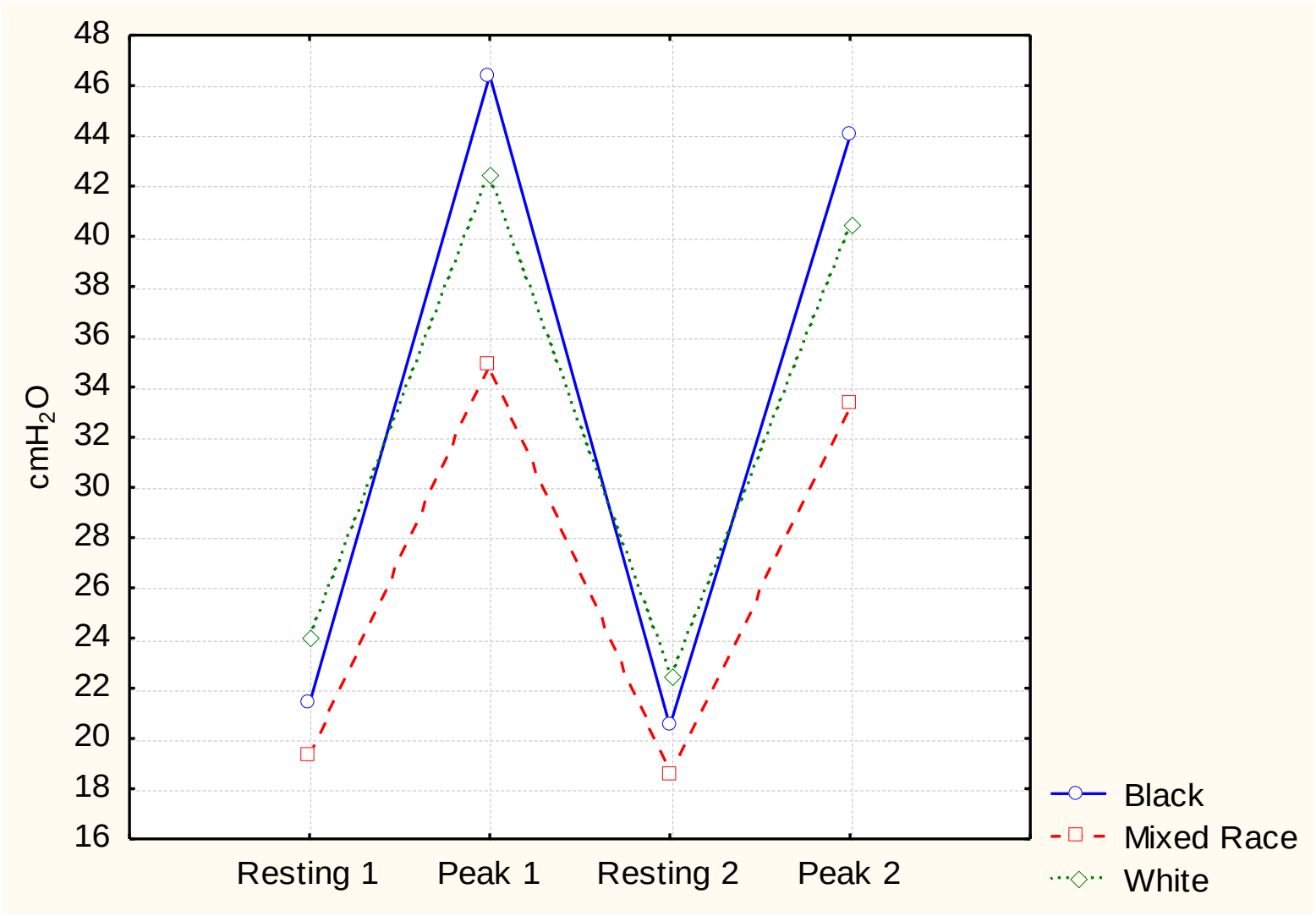

Figure 2: Mean vaginal resting and maximum voluntary contraction values (cmH_2O) of first and second set of contractions

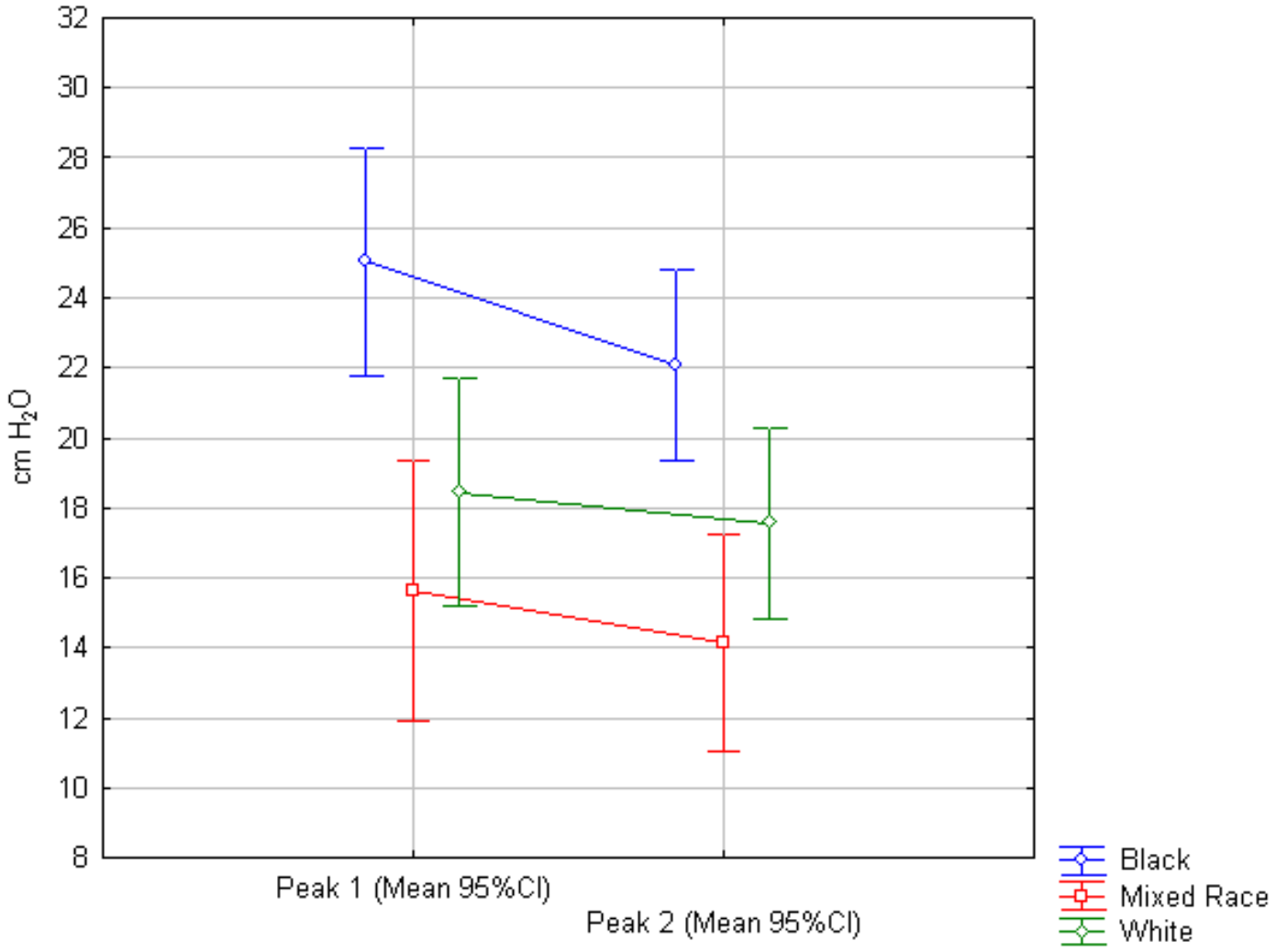

Figure 3: Difference in maximum voluntary contraction pressure **(c**mH_2O**)** between first and second set of contractions

Table 1: Comparison of three ethnic groups

Characteristics	**Subdivision**	**Total n (%)** **n=122**	**Black** **n=44**	**Mixed** **n=34**	**White** **n=44**	**p-value**
Physical activity n(%)	*Regular*	74 (61%)	22 (50%)	15 (43%)	37 (84%)*	<0,01
Smoking n(%)		21 (17%)	5 (11%)	11 (31%)*	5 (11%)	0.04
Regular low back pain n(%)		42 (34%)	10 (23%)	16 (45%)	16 (37%)	0.09
Medication n(%)	*Oral contraceptive*	32 (26%)	8 (18%)	7 (20%)	17 (39%)	0.06
	DPCI	21 (17%)	14 (32%)*	7 (20%)	0 (0%)	<0.01
	Anti depressants	6 (5%)	2 (4.5%)	0 (0%)	4 (10%)	
	Muscle relaxants	1 (1%)	1 (2%)	0 (0%)	0 (0%)	
	Thyroid	2 (2%)	0 (0%)	0 (0%)	2 (4.5%)	
Chronic respiratory conditions n(%)		9 (7%)	2 (4.5%)	4 (9%)	3 (7%)	
Not menstruating / Amenorrhoea n(%)		13 (11%)	7 (16%)*	5 (14%)*	1 (2%)	0,04
Menstruating n(%)		109 (89%)	37 (84%)	30 (86%)	42 (98%)	
Previous PFM training n(%)		69 (57%)	13 (30%)	16 (46%)	40 (91%)*	<0.01
Stress incontinence n(%)		5 (4%)	2 (4%)	2 (6%)	1 (2%)	0.71
Perineal pain n(%)		22 (18%)	13 (30%)*	7 (20%)	2 (5%)	< 0.01
Constipation n(%)	*BM ≤3 day*	14 (12%)	4 (9%)	8 (29%)	2 (4.5%)	
	Straining at stool	29 (24%)	10 (23%)	12 (34%)	7 (16%)	0.16
Age years Mean SD		122 (100%)	22±2.82	21± 1.94	23±4.73 *	0.02
BMI Mean SD		122(100%)	24.45± 4.5 *	22.05± 4.48	22.48±3.11	0.02
LEGEND: DPCI *Depot Progesterone contraceptive injection* BM *Bowel motion Body Mass Index *Significant*						

Table 2: Maximum voluntary contraction (mean value) of set 1 and 2

Group	Set 1		Set 2		P value
	Mean MVC (cmH_2O)	95%CI	Mean MVC (cmH_2O)	95%CI	
Total n=122	20.0	18-22	17.9	16.3 -19.6	< 0.01
Black n=44	25.0	20.9-29.1	23.6	20.7-26.4	0.017
Mixed-race n=34	15.6	12.8-18.4	14.9	11.6-18.1	1.00
White n=44	18.4	15.4-21.4	18.0	15.1-20.8	1.00