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Assessment of pelvic floor of women runners by three-dimensional ultrasonography and surface electromyography. A pilot study.

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Abstract

Aim: To evaluate female runners' pelvic floor muscles using three-dimensional ultrasonography (3DUS) and surface electromyography (SEMG). **Material and methods:** A cross-sectional study was conducted on 24 female runners. SEMG was performed using surface electrodes inserted in the vagina. 3DUS was performed using perineal convex transducer. SEMG was evaluated at rest and with maximum voluntary contraction (MVC) and slow contraction. Levator ani muscle thickness, levator hiatus area and the angle between the levator muscles at rest and with MVC and Valsalva were evaluated using 3DUS. The women were divided into two groups (women running ≤ 25 km/week; women running > 25 km/week). Means, standard deviations and non-paired t tests were used for both groups. **Results:** Among the 24 women, 11 ran ≤ 25 km/week (16.91 ± 4.13 km/week) and 13 ran > 25 km/week (40.77 ± 1.15 km/week). The mean SEMG at rest and with MVC and slow contraction were 16.25, 65.86 and 71.41 mV, respectively. For the levator hiatus area at rest and with MVC and Valsalva, the means were 12.54, 10.06 and 16.57 cm2, respectively. Correlations between 3DUS and SEMG showed significant differences in SEMG at rest and levator thickness with Valsalva ($r = 0.46$; $p = 0.04$). **Conclusions:** 3DUS and SEMG are two feasible methods for evaluating female runners' pelvic floor. Correlations between 3DUS and SEMG showed significant differences in SEMG at rest and levator thickness with Valsalva.

Keywords: pelvic floor, women runners, three-dimensional ultrasound, surface electromyography.

Introduction

Urinary incontinence and genital prolapses are conditions commonly associated with giving birth, especially vaginally, although efficient systems for maintaining intraurethral pressure and supporting the female pelvic organs exist to prepare for the intra-abdominal pressure increase. Computer models show that during vaginal delivery, the levator ani muscle reaches three times its original size, while the pudendal nerve is extended by 33%. Age is also important, since the urethral striated muscle loses up to 70% of its fibers over the course of life [1,2]. Levator ani muscle defects can be palpated with the fingers, but specific training is needed in order to detect such trauma, and a learning curve may be necessary [3,4].

Recent studies using magnetic resonance imaging (MRI) and ultrasonography have shown levator ani muscle trauma in 15 to 30 % of vaginal deliveries [5,6]. Studies have shown that high-impact sports can lead to development of urinary incontinence among women who have competed for long periods of time, thus suggesting that functional changes to the pelvic floor occur in athletic women [7,8]. Three-dimensional ultrasonography (3DUS) is a non-invasive technique that has been used over the past seven years to evaluate gynecological and

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obstetrical patients' pelvic floor, with accuracy similar to MRI [9] and with proven intra and inter-observer reproducibility [10,11].

Surface electromyography (SEMG) is a diagnostic method for neurological disorders, and has been used for evaluating neuromuscular diseases, low abdominal pain and motor control disorders [12]. SEMG has been used to evaluate pelvic muscle activation patterns in women with urinary incontinence and genital prolapse, both in maximum voluntary contraction (MVC) and in Valsalva [13,14]. However, there are no studies in the literature comparing 3DUS and SEMG for pelvic floor evaluations on female runners.

The objective of this study was to compare the measurements obtained from 3DUS (levator hiatus area, levator ani muscle thickness and angle between the levator muscles) with the pelvic muscle activation patterns obtained through SEMG (at rest and with MVC and slow contraction), between short-distance female runners (≤ 25 km/week) and long-distance female runners (> 25 km/week).

Material and methods

A cross-sectional prospective study was conducted between January and July 2011, on 24 female runners. This study was approved by the Research Ethics Committee of the Federal University of São Paulo (UNIFESP). The women who agreed to voluntarily participate in the study signed a consent form. The inclusion criteria were: 1) capacity to perform correct pelvic floor muscle contraction; and 2) a weekly running practice of 15 to 60 km. The exclusion criteria were: 1) presence of any disease that could interfere with adequate contraction of the pelvic muscles, such as a neuromuscular disease; and 2) previous urogynecological surgery.

To perform SEMG, an eight-channel electromyograph (model 810, EMG System of Brazil®) was used. The patient was put into a supine position, with knee and hip flexion. A vaginal transducer with two opposing metal parts (Chantanooga Group®) was inserted up to the middle third of the vagina, using lubricant gel. The women were instructed to do three maximum voluntary contractions (MVC) with 10 seconds of rest between contractions. The best MVC was used for statistical analysis, with subsequent root mean square analysis. All SEMG examinations were performed by a single examiner (CDP).

Perineal 3DUS was performed using the Voluson 730 Expert machine (General Electric Medical Systems, Zipf, Austria) equipped with a convex volumetric transducer (RAB 4-8). The transducer was covered with a sterile latex preservative and was inserted in the vagina, without too much pressure, by opening the labia minora, guided in a median-sagittal plane that allowed, from right to left, viewing of the pubic symphysis, bladder neck, urethra, vagina length, distal portion of the rectum with the anorectal junction and the proximal part of the anal canal. The opening angle was standardized at 85º. After an automated sweep (4 seconds), the image was shown on the screen of the apparatus in multi-plane form (axial, sagittal and coronal planes) and rendered form. The volumes were acquired at rest and with MVC and Valsalva, and were stored in the memory of the apparatus. Volumetric acquisitions were performed by only two examiners (EAJ and ZIKJB). Later, these volumes were transferred to compact discs (CDs) and analyzed off-line on a personal computer (PC) by means of the 4D Views software version 9.0 (General Electric Healthcare, Zipf, Austria). The lengths of the levator ani muscle and levator hiatus and the angle between the levator muscles were measured in the rendered plane. The image was displayed on the screen (1 x 1), with magnification of 1.20 and transparency of 50. The rendering consisted of a mixture of the surface and maximum transparency modes (70% and 30%, respectively), and the gamma curve was adjusted in such a way as to obtain the best image possible. Measurements were obtained using the MEASURE button, with the options of generic distance between two points, generic area by means of a manual line and generic angle by means of two lines (fig 1). The off line evaluations were performed by two examiners (MDZ, ZIKJB).

The data were transferred to a spreadsheet in the Excel 2007 software (Microsoft Corp., Redmond, WA, USA). For statistical analysis, the following software was used: SPSS (version 18.0, SPSS Inc. Chicago, IL, USA) and GraphPad Prism (version 5.0, GraphPad Software, San Diego, CA, USA). Initially, the variation between observed values at rest and with MVC (MVC-Resting) and between observed values at rest and with slow contraction (Slow-Resting) was calculated for variables relating to SEMG. For variables relating to 3DUS, the variation between observed values at rest and with MVC (MVC-Resting) and between observed values at rest and during the Valsalva maneuver (Slow-Resting) was calculated. The Kolmogorov-Smirnov test was used to ascertain whether the quantitative parameters presented normal distribution. Considering that the distribution did not differ significantly from normal distribution, means and standard deviations (SD) of the parameters evaluated were calculated. The values observed for age, body mass index (BMI), SEMG and pelvic 3DUS were compared between the groups (women who run ≤ 25 km/week vs. women who run > 25 km/week) using the non-paired t

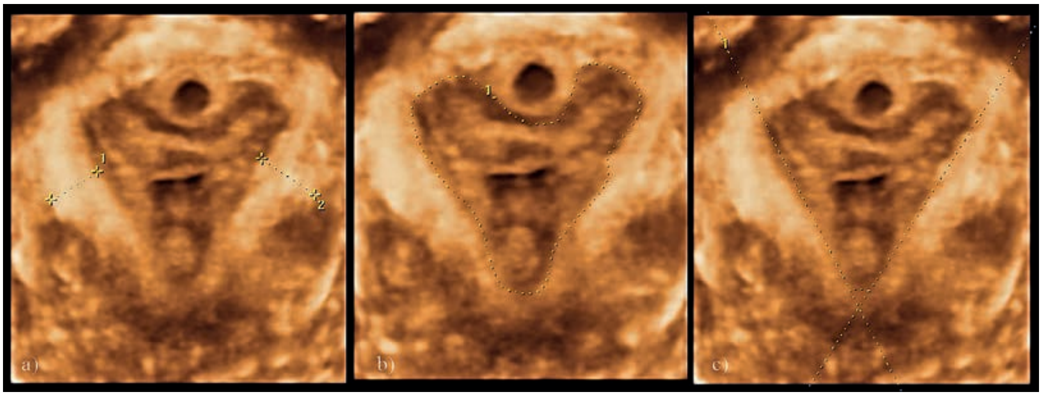

Fig 1. (A) measurement of the levator ani muscle thickness; (B) measurement of the levator hiatus of the anus; (C) measurement of the angle between the levator muscles of the anus.

test. The proportions of the women with previous pregnancies, previous vaginal deliveries, menopausal status, urinary incontinence and pelvic floor exercise practice were compared between the groups using Fisher's exact test. Additionally, the correlations between weekly distance covered and parameters relating to SEMG and pelvic 3DUS were evaluated using Pearson's correlation coefficient. This coefficient was also used to correlate between the SEMG and pelvic 3DUS parameters. The statistical significance level was taken to be $p < 0.05$.

Results

Twenty-four female runners aged between 28 and 56 years were evaluated. Of these women, eleven ran ≤ 25 km/week (16.91 ± 4.13 km/week, mean ± SD) and thirteen ran > 25 km/week (40.77 ± 1.15 km/week). Comparing these two groups, significant differences could only be seen with regard to age and angle variation between resting and MVC (table I, table II).

The weekly distance covered did not present any significant correlation with any of the parameters relating to SEMG or pelvic 3DUS. Correlations between SEMG and pelvic 3DUS showed significant differences only in relation to SEMG at rest and levator thickness during the Valsalva maneuver ($r = 0.46$; $p = 0.04$); in the SEMG variation observed between slow contraction and resting, and in levator thickness variation between Valsalva and resting ($r = -0.46$; $p = 0.04$).

Discussion

Sport is beneficial for women of all ages and is associated with health benefits and enhanced wellbeing. Nevertheless, active women are at risk from conditions resulting from continuous high-impact exercise, such as pelvic floor dysfunction. Genital prolapse, urinary incontinence and anal incontinence are the most common diagnoses. Jumping, high-impact landings and running have been associated with the highest prevalence of urinary incontinence, even in young women [15].

The electrical activity of the pelvic floor muscles, especially the pubovisceral muscle, was measured using SEMG in all the female runners, and we were unable to observe any difference between the two groups. This was probably because the group that ran more than 25 km/week also undertook moderate-impact physical activities, rather than exhausting activities (the longest distances were equivalent to approximately six practices per week of 7 km, which on average corresponded to 45 minutes duration for each session).

SEMG indirectly infers muscle function, since all muscle work generates electrical activity, while completely atrophic muscles or those without tonus would not generate electrical activity [16]. This method for assessing the pelvic floor musculature remains little used in routine practice, although it is inexpensive and pain-free. In turn, although 3DUS is also not routinely performed, it has been shown to be a very useful tool for information on the pelvic floor musculature. Furthermore, it assists in diagnosing diverticulosis and urethral cists, and also in detecting complications resulting from urogynecological surgery, especially in procedures using a polypropylene mesh [17].

Although the group of runners from more than 25 km per week were older than the other group, the functional differences (at SEMG) and anatomical (at 3DUS) were not statistically significant. As stated previously, the electrical activity of muscle is directly related to pelvic floor muscle strength. Few runners practiced exercises to

Table I. Comparison of the parameters evaluated between the women who ran ≤ 25 km/week and the women who ran > 25 km/week: age, body mass index and parameters relating to surface electromyography and three-dimensional ultrasonography.

	≤ 25 km/week (N = 11)		**> 25 km/week (N = 13)**		
	Mean	**SD**	**Mean**	**SD**	**p**
Age (years)	38.27	10.11	46.08	7.34	0.04
BMI (kg/m²)	23.12	2.72	23.69	2.89	0.62
SEMG at rest (mV)	16.25	6.31	13.40	7.34	0.36
SEMG with MVC (mV)	65.86	41.08	91.08	40.29	0.17
SEMG with slow contraction (mV)	71.47	56.48	85.12	36.79	0.50
SEMG variation (MVC-resting) (mV)	49.62	41.14	77.68	39.41	0.12
SEMG variation (slow-resting) (mV)	55.23	57.09	71.72	34.98	0.41
Hiatus at rest (cm2)	12.54	2.63	14.93	3.96	0.11
Hiatus with MVC (cm2)	10.06	2.81	10.53	3.39	0.72
Hiatus with Valsalva (cm2)	16.57	4.56	18.55	5.43	0.36
Hiatus variation (MVC-resting) (cm2)	-2.49	1.73	-4.40	2.98	0.08
Hiatus variation (Valsalva-resting) (cm2)	4.02	3.27	3.62	3.39	0.77
Thickness at rest (mm)	12.16	4.79	10.45	2.91	0.31
Thickness with MVC (mm)	11.06	4.62	10.21	3.64	0.63
Thickness with Valsalva (mm)	10.85	3.79	11.34	2.41	0.72
Thickness (MVC-resting) (mm)	-1.10	4.76	-0.25	3.83	0.64
Thickness (Valsalva-resting) (mm)	-1.31	5.47	0.89	2.49	0.22
Angle at rest (degrees)	49.74	10.93	57.00	9.60	0.10
Angle with MVC (degrees)	54.73	10.47	52.10	9.36	0.53
Angle with Valsalva (degrees)	48.06	13.18	50.73	10.62	0.60
Angle (MVC-resting) (degrees)	4.99	10.12	-4.89	8.93	0.02
Angle (Valsalva-resting) (degrees)	-1.68	13.57	-6.26	8.26	0.33

P values obtained through the non-paired t test; BMI = body mass index; SEMG = surface electromyography; MVC = maximum voluntary contraction.

Table II. Comparison of the parameters evaluated between the women who ran ≤ 25 km/week and the women who ran > 25 km/week: observed proportion of the women who presented previous pregnancies, previous vaginal deliveries, menopausal status, urinary incontinence and pelvic floor exercise practices.

	≤ 25 km/week (N = 11)		**> 25 km/week (N = 13)**		
	N	**%**	**N**	**%**	**p**
Previous pregnancies	8	72.73	8	61.54	0.68
Vaginal deliveries	1	9.09	1	7.69	1.00
Menopausal status	3	27.27	6	46.15	0.42
Urinary incontinence	2	18.18	1	7.69	0.58
Pelvic floor exercise	3	27.27	4	30.77	1.00

P value obtained using Fisher's exact test.

strengthen their pelvic floor, but still showed good electrical activity in the maximal voluntary contraction. In a study of Resende et al [14], which examined 28 nulliparous volunteers, found MVC 99.8 mV, a result very similar to that of runners from more than 25 km (91.08 mV).

In our sample of runners, no significant differences were observed between the groups in relation to pubovisceral muscle injuries or its thickness. In relation to the angle formed between the muscles during the contraction maneuver, differences between the two groups could be seen. However, from a clinical point of view this difference still needs to be studied, perhaps with a bigger group of marathon runners, in whom the impact of the physical activity on the pelvic floor is more damaging.

There was interest in evaluating these two methods for diagnosing pelvic floor muscle function diagnosis, and in whether there might be any correlation between them, although they are well known to be independent examinations. SEMG analyzes muscle function from its electrical activity [18] and 3DUS provides information on muscle position, thickness and size, i.e. anatomical information [19]. The possibility of dynamic ultrasound studies in real time, also known as four-dimensional ultrasonography (4DUS), through measurements made at rest and during the Valsalva maneuver and maximum contraction maneuver is of particular interest [20]. Moreover, the images are stored and can be analyzed after the examination and by several professionals. For this reason, the assessment of pelvic floor by 3DUS is being increasingly used, both to evaluate the pelvic floor and to diagnose the effects of gestation, delivery and impacts caused by sports.

The limitation of this study was the small sample; however, it was a pilot study without a power sample. The main objective was to compare SEMG and 3DUS parameters of pelvic floor of runner's women. Future studies including large samples are necessary to prove the real correlations between SEMG and 3DUS parameters and the possible clinical practices of these correlations.

Conclusion

In summary, we did not find any correlation between these methods that might have any clinical importance, although statistically there may have been associations relating to SEMG at rest and levator thickness during the Valsalva maneuver, and the SEMG variation observed during slow contraction and at rest versus the variation in levator thickness between the Valsalva maneuver and resting.

Conflict of interest: none

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