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Static balance, quadriceps strength and ankle dorsiflexor torque in fertile and post-menopausal women

Equilíbrio estático, força do quadríceps e torque dos dorsiflexores do tornozelo em mulheres férteis e na pós-menopausa

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Abstract

Introduction: Menopause is the period of life in which women experience progressive changes in their body. Muscular strength and balance are important examples of changes occurring in this group of individuals. **Objective**: Evaluation and correlation of the static balance, quadriceps strength and ankle dorsiflexor torque in fertile (n = 20) and post-menopausal women (n = 45) were studied. **Methods**: A device was used to record the ankle dorsiflexion torque and the quadriceps strength was measured according to the concept of one repetition maximum. The assessment of the static balance was made with the Polhemus system. **Results**: The control group presented ankle dorsiflexor torque and quadriceps strength greater than the post-menopausal women, but the static balance was not different between groups. In control group, correlation was observed only between quadriceps strength and using the fixed platform with eyes closed. In the post-menopausal women there was a correlation between static balance and the ankle dorsiflexor torque in the fixed platform with eyes open ($r = 0.386$; $p = 0.008$); fixed platform with eyes closed ($r = 0.373$; $p = 0.01$) and unstable platform with eyes open ($r = 0.343$; $p = 0.02$). In this group correlation between static balance and quadriceps strength was observed in testing the use of fixed platform with eyes closed ($r = 0.315$; $p = 0.03$). **Conclusions**: The results suggest that the diminished muscular strength after menopause seems to be related to the hypoestrogenism and that the ankle dorsiflexor torque is an important factor for the maintenance of static balance in the first years of menopause.

Keywords: Post-menopause. Balance. Torque. Muscle strength.

Resumo

Introdução*: A menopausa é um período em que a mulher apresenta progressivas alterações em seu organismo. A perda de força muscular e do equilíbrio corporal são importantes exemplos dessas alterações.* ***Objetivo****: Avaliar e correlacionar o equilíbrio estático, a força de quadríceps e o torque dos dorsiflexores de tornozelo de mulheres no período fértil (n=20) e de mulheres na pós-menopausa (n = 45).* ***Métodos****: Foram registrados o torque dos dorsiflexores de tornozelo e a força do quadríceps. O equilíbrio estático foi avaliado utilizando-se o sistema Polhemus.* ***Resultados****: O grupo controle apresentou maior torque dos dorsiflexores de tornozelo e maior força de quadríceps comparado ao grupo pós-menopausa, porém o equilíbrio estático não apresentou diferença entre os grupos. No grupo controle, foi observada correlação somente entre a força de quadríceps com a condição plataforma fixa olhos fechados. No grupo de mulheres na pós-menopausa houve correlação entre torque dos dorsiflexores de tornozelo e equilíbrio estático nas condições plataforma fixa olhos abertos (r = 0,386; p = 0,008), plataforma fixa olhos fechados (r = 0,373; p = 0,01) e plataforma instável olhos abertos (r = 0,343; p = 0,02). Neste mesmo grupo também houve correlação entre força de quadríceps e equilíbrio estático na condição plataforma fixa olhos fechados (r = 0,315; p = 0,03).* ***Conclusões****: Os resultados sugerem que a diminuição da força muscular após a menopausa parece estar relacionada ao hipoestrogenismo e que o torque dos dorsiflexores de tornozelo é um fator importante para a manutenção do equilíbrio estático nos primeiros anos da menopausa.*

Palavras-chave*: Pós-menopausa. Equilíbrio. Torque. Força muscular.*

Introdução

The aging process involves several changes in body, including progressive reduction in muscular strength and of muscular fiber replacement by connective and fatty tissue, combined with a decline in physical activity (1). It is estimated that, after the age of 40 years, about 5% of muscular mass is lost during each decade of life, loss that is faster after 65 years of age, mainly in the lower limbs (2).

Studies have suggested that the decreased muscular strength in women over 50 years of age may be related to a lack of estrogens resulting from menopause, (3). However, the investigations have not evaluated alterations occurring in women experiencing the first years of post-menopause.

There are some studies that assessed the muscular strength in older women, but without taking into account the duration of post-menopause (4, 5) which may potentiate the losses caused by the functional decline related to age. In addition, there are a few studies that specify the post-menopause duration (6, 7), but most of them encompassed long periods (8-11).

Reduction in both muscular strength and joint amplitude as well as an inefficient muscular torque are associated with impaired postural control so that strategies must be developed for keeping and/or recovering balance (12). However, little is known about hypoestrogenism in the first five years of post-menopause and a possible negative influence on muscular strength and postural control.

Therefore, the objective of this investigation was to assess the static balance, quadriceps strength and isometric ankle dorsiflexor torque in fertile and women within 1-5 years of post-menopause. Furthermore, it was investigated some possible correlation between balance, ankle torque and muscular strength.

Methods

Participants

This research study was approved by the Human Research Ethics Committee of the Ribeirão Preto School of Medicine, University of São Paulo. All participants were recruited from the community and the

Centre of Health at the Ribeirão Preto School of Medicine (CSE-FMRP-USP). It was classified as post-menopause women those who had not menstruated within the previous one year (13).

The volunteers went through an interview that contained questions about the criteria for inclusion in the research. Forty-five healthy women with 52,13 ± 4,19 years old in post-menopause during 1-5 years participated in this study. Twenty women with 22,42 ± 2,44 years old, with regular menstrual cycles and not on oral contraceptives were included in the control group (fertile women).

Exclusion criteria were hysterectomy, use of hormone therapy, smoking and clinical conditions that could interfere in the postural control, such as cardiorrespiratory, neurological or rheumatic disease, orthopaedic conditions, vestibulopathy and diabetes mellitus.

In the post-menopausal women, the inclusion criterion was based on the time after menopause (between 1 and 5 years of menopause) of natural cause. All women had estradiol levels < 20 pg/mL.

Static balance

Static balance was assessed in a system based on electromagnetic sensors (Polhemus, PATRIOT™). A transmitting coil captures postural oscillation through a sensor positioned on the seventh cervical vertebra. During 90 seconds the maximum antero-posterior dislocation was measured in four situations:

1) participants standing on a fixed platform (50.0 x 50.0 cm) with eyes open (FPEO);
2) participants standing on a fixed platform with eyes closed (FPEC);
3) participants standing on an unstable platform-foam surface of 30 g/dm³ density and 5.0 cm thick (14) with eyes open (UPEO);
4) participants standing on an unstable platform with eyes closed (UPEC). For testing with the eyes open a 5.5 cm in diameter circular marker was attached on a wall 150 cm away from the participant was used as visual reference.

Ankle Toque and Quadriceps Strength

The analyses of isometric ankle torque and quadriceps strength were performed only in the dominant lower limb. Isometric ankle dorsiflexor torque evaluation was done with the participant seated on a 43.0 cm height chair, keeping the ankle in neutral position. Isometric torque was assessed by a digital torque device (30 Nm) adapted to a loading device, both attached to a wooden base. For the torque analysis it was performed three maximal voluntary contractions and that of the highest value was considered as valid.

Concentric muscular strength of quadriceps was measured using a knee extensor test according to the concept of one repetition maximum (1-RM) which is defined as the highest load lifted along a full range of motion before two failed attempts at a given load. Before testing, the individual was asked to perform a series of 8-12 repetitions without any load to become familiar with the test technique. Next, progressive loading repetition test was performed at 90-120 second intervals of rest. This 1RM test has been widely used because it is safe and valid even for old people (15, 16).

Statistical analysis

The Kolmogorov-Smirnov test showed that all variables presented a normal distribution. Therefore, the Pearson's correlation test was used to assess the relationship between ankle torque, quadriceps strength and static balance. Difference between groups was evaluated using the Student's t-test. All statistical analyses were obtained with the SPSS™ software (SPSS for Windows™, V10.0 – SPSS Inc., USA), with significance level set at 0.05.

Results

The control group presented ankle dorsiflexor torque ($p = 0.003$) and quadriceps strength ($p < 0.0001$) greater than the post-menopausal women, while the static balance was not different between control and the test group ($p > 0.05$; Table 1).

In younger women, correlations were not observed between ankle dorsiflexor torque and static balance. However, in this group, correlation was observed between quadriceps strength and FPEC ($p = 0,04$).

In post-menopausal women, correlations were observed between ankle dorsiflexor torque and FPEO ($p = 0.008$), dorsiflexor torque and FPEC ($p = 0.01$), dorsiflexor torque and UPEO ($p = 0.02$), but not between dorsiflexor torque and UPEC ($p = 0.32$). Correlation was also observed between quadriceps strength and static balance only for FPEC ($p = 0.03$), whereas FPEO ($p = 0.59$), UPEO ($p = 0.49$) and UPEC ($p = 0.41$) showed no correlation with the quadriceps strength. These data are listed in Table 2.

Discussion

In the literature, studies showed that hormonal reposition has a positive effect on the postural balance (17) and possibly on the muscular strength (18) of post-menopausal women. For that reason our test group was composed by post-menopausal women who had never been subjected to hormone therapy.

Table 1 - Variables with respective means and standard deviations (SD) for post-menopausal and fertile women

Variables	Post-menopause Group		Control Group	
	Mean	SD	Mean	SD
Age (years)	52.13	4.19	22.42	2.44
Mass (kg)	71.18	13.84	54.61	5.30
Height (m)	1.56	0.07	1.63	0.05
BMI (kg/m²)	29.13	5.36	20.55	2.12
Duration of menopause (months)	42.50	15.63	—	—
FSH levels (mlU/mL)	78.37	41.66	—	—
Static balance (cm)				
FPEO	1.31	0.51	1.34	0.46
FPEC	1.53	0.46	1.55	0.42
UPEO	1.66	0.52	1.99	0.83
UPEC	2.43	0.65	2.47	0.78
Ankle dorsiflexor torque (Nm)	16.75	5.29	21.90*	7.70
Quadriceps strength (kg)	7.73	2.99	11.59*	3.86

FPEO = fixed platform with eyes open ; FPEC = fixed platform with eyes closed; UPEO = unstable platform with eyes open; UPEO = unstable platform with eyes closed.

* $p < 0.05$ (post-menopausal group versus control group).

Table 2 - Correlation between ankle torque, quadriceps strength and static balance

Groups	Variables	FPEO	FPEC	UPEO	UPEC
Post-menopause Group	Ankle torque (Nm)	0.386**	0.373*	0.343*	-0.152
	Quadriceps strength (Kg)	-0.082	0.315*	-0.105	0.205
Control Group	Ankle Torque (Nm)	-0.161	-0.327	-0.085	-0.100
	Quadriceps strength (Kg)	0.300	0.465*	0.175	0.237

Data represent Pearson's correlation coefficient (r). *p<0.05 or **p<0.01.

People with 52,13 ± 4,19 years old formed our test group and, according to Bonasera & Nichols (19) the decrease in muscular strength secondary to aging occurs more rapidly after 65 years, particularly in the lower limbs. Therefore, according to the aforementioned authors, the decrease in muscular strength in post-menopausal women should be attributed to the estrogen deprivation.

Our results showed that fertile women had muscular strength of ankle dorsiflexors and quadriceps greater than post-menopausal women. However, there was no difference in the static balance comparing both groups. Therefore, other mechanisms may be involved to compensate the diminished muscular strength.

Tinetti, Speechlev e Ginter (20) believe that the foot biomechanics is the most important aspect to keep body balance, and any limitation in force, motion, or even presence of pain, will impair the equilibrium.

There are three strategies that can be used by an individual to maintain the upright posture and/or recover the balance: hip, ankle, and stepping strategy (21). Ekblad et al. (22) suggested that the normal body oscillation has two main strategies. One of them is called ankle strategy, when body acts as an inverted pendulum, which is very common in small movements. Our findings showing a correlation between static balance (FPEO, FPEC and UPEO) and the ankle dorsiflexor strength in the post-menopausal women corroborate such ideas and suggest that the ankle dorsiflexors become an important component of balance in that age group. In control group, the dorsiflexor strength had no association with the balance, meaning that other biomechanical aspects may be more significant.

When oscillation is greater, faster, or when the bearing surface is smaller than the foot area, the pattern of oscillation encompass the hip strategy (22, 23). The greater the body perturbation, the more people tend to decrease the ankle response and increase the hip response (24). This condition probably occurred in situation 4 (UPEC) in the post-menopausal group, where the subjects had a decreased ankle response and other muscular groups may be activated to keep posture.

Different perturbations can result in a variety of posture responses depending on the biomechanical context (25, 26), as different situations require different strategies. The several responses result from the relationship between joint movement and torque produced by the moving joint or surrounding joints (19). Standing on a foam surface not only impairs the proprioceptive information, but also modifies the mechanical characteristics of the bearing surface, decreasing the ankle torque efficiency and increasing the use of hip strategy for postural control (27).

In our study, we observed no correlation between static balance and quadriceps strength in FPEO, UPEO and UPEC situations for both groups, suggesting that this muscular group may be related to the dynamic equilibrium as shown by Carter et al. (8) who found a correlation between dynamic balance and strength of knee extensor ($r = 0.51$; $P < 0.001$) in osteoporotic women aged 65-75 years.

Our results reinforce the importance of exercising the dorsiflexor muscles for balance rehabilitation in the post-menopausal women, since they seem to contribute to a greater postural stability. In addition, among the muscular strength related to movements of hip, knee, and ankle, only the ankle dorsiflexor strength has prognostic value of fall risk (28).

Conclusions

In summary, the results suggested that the hypoestrogenism in the first years of menopause has more impact in the muscular strength than in the postural control, since premenopausal individuals had greater muscular strength than post-menopausal women, without differences in balance between groups. In the control group, there was no correlation between ankle dorsiflexor and static balance. Conversely, in post-menopausal women, correlations were observed in the FPEO, FPEC and UPEO conditions. Possibly, due to the functional changes that occur with aging, the ankle dorsiflexors have to increase their performance to keep balance.

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