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AGE-RELATED ALTERATIONS ON TRUNK AND LOWER LIMB STABILIZER MUSCLES ACTIVATION DURING WALKING

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SUMMARY

This study aimed to compare trunk and lower limb stabilizer muscles activation between young and older women during walking. Fifteen young (22.13 yr) and nineteen older women (68.21 yr) walked on a treadmill at self-select speed, while one minute of surface electromyography (EMG) signal were recorded on multifidus (MU), internal oblique (IO), gluteus maximus (GM), rectus femoris (RF) and biceps femoris (BF). EMG signal was processed and the linear envelope was calculated at initial stance (50 ms before heel contact) and final stance (50 ms after toe-off). ANOVA multivariate analysis showed significant main effect between groups ($F = 6.12$ and $p < 0.01$). Older female adults had lower activation of IO and RF at initial stance ($p = 0.003$; and $p < 0.001$). Also, at the final stance older women had lower activation of IO ($p = 0.04$), MU ($p = 0.023$), GM ($p = 0.021$) and BF ($p = 0.036$). Aging cause decreased trunk and lower limb stabilizer muscles activation and may reduce gait stability and increase the risk of falls.

INTRODUCTION

Aging causes several alterations in walking performance, such as: reduction in gait speed, step height and length and increased step width, which are important factors that determine the risk of falls [1]. However, few studies were focused at age-related alterations at hip and trunk biomechanics while walking [1]. Considering that trunk and lower limb stabilizer muscles have an important role to maintain the postural control and balance, which have clinical applicants to prevent falls in older adults. Our study aimed to compare trunk (internal oblique, IO; and multifidus, MU) and lower limb (rectus femoris, RF; gluteus maximum, GM; and biceps femoris, BF) stabilizer muscles activation between young and older women during walking.

METHODS

Data of thirty-four adults, physically fit, women were considered for this study (Table 1). Fifteen young volunteers (22.13 yr) were recruited from a university setting and nineteen older adults (68.21 yr) were recruited from community-based physical activity groups. Young women group had low age ($p < 0.001$), mass ($p = 0.016$) and body mass index ($p < 0.001$) and higher height ($p < 0.001$) and walking speed ($p < 0.001$).

On the first day of data collection, the preferred treadmill walking speeds (PTWS) were measured. During the second day of data collection, the volunteers were familiarized with

treadmill walking (10 minutes) and after that one-minute of surface electromyography (EMG) signal were recorded.

EMG activity was assessed using eight channels, telemetered electromyogram (Noraxon®, Phoenix, USA). EMG signals were collected at sample frequency of 2000 Hz, using Ag/AgCl disc electrodes (Miotec®, Porto Alegre, Brazil) with an active area of 1 cm and inter-electrode distance of 2 cm arranged in bipolar configuration. The electrodes were positioned on the participants' right side on the muscles: internal oblique (IO); multifidus (MU); gluteus maximus (GM); biceps femoris (BF); and rectus femoris (RF)[2,3].

EMG signal was processed in specific routines developed in Matlab (Mathworks®, Natick, USA) using a band pass filter with cut-off frequency of 20-500 Hz, full-wave rectification and a low pass, fourth order filter with a cut-off frequency of 10 Hz were used to calculated the linear envelope. Then, the mean of the linear envelope of the EMG signal was obtained 50 ms after heel contact (initial stance phase), and before toe-off (final stance phase) of the first ten strides. All the linear envelope values were normalized to the mean activation obtained during the gait.

PASW 18.0 (SPSS inc.) was used for all statistical analyses. We used appropriate descriptive statistics (mean and standard deviation) to summarize participant characteristics. The Shapiro-Wilk test was used to test the normality of the data and MANOVA was used to compare the dependent variables between groups. We computed the Pearson correlation coefficients to quantify the association between age and trunk EMG activity and age, and EMG activity and PTWS. The significance level was set to $p < 0.05$.

RESULTS AND DISCUSSION

ANOVA multivariate analysis showed significant main effect between the groups ($F = 6.12$ and $p < 0.01$). At initial stance, older female adults had 54.49 and 39.95% lower activation of IO ($p = 0.003$) and RF ($p < 0.001$). Also, at final stance, older women had, respectively, 35.98, 37.96, 54.59 and 51.25% lower activation of IO ($p = 0.04$), MU (0.023), GM (0.021) and BF (0.036). Figure 1 shows the group comparison for muscles activation at initial and final stance.

Additionally, IO activation at initial stance ($r = -0.512$ and $p = 0.002$), RF at initial stance ($r = -0.453$ and $p = 0.007$), BF at final stance ($r = -0.346$ and $p = 0.045$) and PTWS ($r = -0.765$ and $p < 0.001$) were negatively correlated with age (Figure 2). IO activation at initial stance ($r = 0.492$ and $p =$

0.005; Figure 3) and GM activation at final stance ($r = 0.367$ and $p = 0.042$; Figure 3) were positively associated with PTWS.

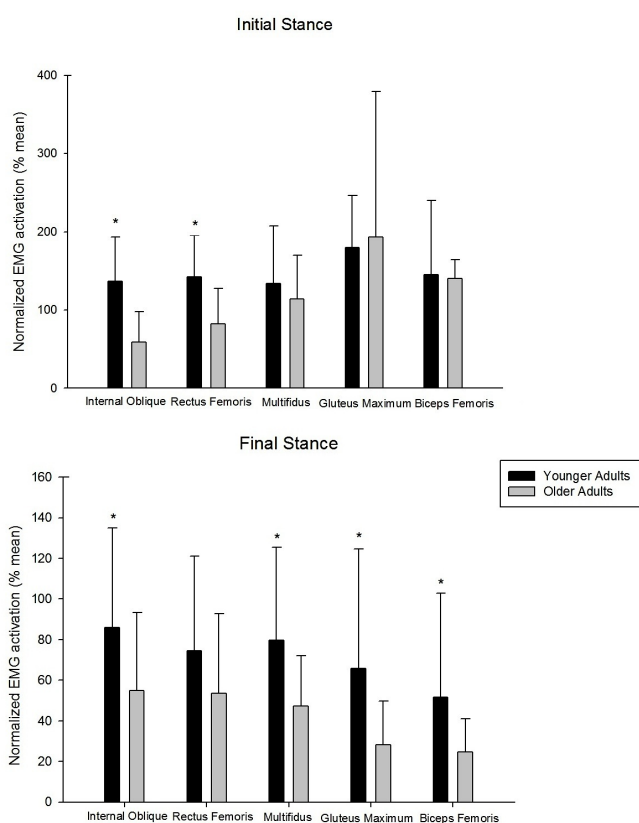


Figure 1: Comparison between younger and older adults for normalized EMG activation (% mean).

Trunk muscles activation is the major neuromuscular response to provide trunk stability during dynamic tasks [4]. Trunk muscles can be classified into two systems: local system muscles, which are permanently active at low levels and have the function to stabilize each intervertebral joint; and global system muscles, which can be subdivided in global stabilizing system muscles, which control and limit movements and global mobilizing system muscles, which initiate the movements [4]. During walking, IO and MU have mobilizing and stabilizing characteristics [4], both have a similar pattern, which is characterized by two peaks of activation, the first at initial stance (heel strike) and the second at final stance (push-off phase). The same EMG pattern (two peaks of activation) is also observed in hip stabilizer muscles activation, such as RF, GM and BF, at initial and final stance [5].

At the heel strike, leg, hip and trunk stabilizer muscles have to be activated when work absorption the ground reaction force and stabilize each joint [5,6]. For IO and RF muscles the walking speed has an important contribution on the amount of EMG activation during this phase. According to Anders et al (2007), IO activation pattern is mixed by a continuous activation at low walking speed (0.55-0.83 m.s⁻¹) and phasic activation at high speeds (1.11-1.66 m.s⁻¹) [4]. Also, the eccentric contraction of RF at heel contact has a very important role to decelerate the anterior displacement of the center of mass. In addition, there is a positive association between walking speed and weight acceptance force at heel strike, which leads increasing the amount of the RF recruited motor units [6].

During the final stance, the plantarflexors are highly activated to push the foot against the ground while knee flexors and hip extensors are also activated to promote anterior acceleration of the body [6]. Thus, higher activation of plantarflexors, knee flexors and hip extensor at the final stance may leads to higher acceleration of the body, which contributes to increase the walking speed.

CONCLUSIONS

Older female adults had decreased trunk and lower limb stabilizer muscles activation during the stance phase of the gait. In addition, aging is related with a reduced walking speed, which may be influenced the amount of EMG activation during walking. Aging cause decreased trunk and lower limb stabilizer muscles activation and may reduce gait stability and increase the risk of falls.

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Table 1 Subjects characteristics.

Variables	Younger Women Group (n = 15)	Older Women Group (n = 19)	P-value
Age (years)	22.13 (2.58)	68.21 (7.44)	$p < 0.001^\dagger$
Mass (kg)	59.62 (3.6)	64.94 (7.75)	$p = 0.016^*$
Height (m)	1.63 (0.06)	1.53 (0.04)	$p < 0.001^\dagger$
BMI (kg m ⁻²)	22.44 (1.39)	27.69 (3.73)	$p < 0.001^\dagger$
Walking speed (m s ⁻¹)	1.42 (0.07)	1.08 (0.19)	$p < 0.001^\dagger$

† = difference between groups, $P < 0.01$; * = difference between groups, $P < 0.05$; BMI = body mass index; PTWS = preferred treadmill walking speed.