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JOINT TORQUE PRODUCTION AND MUSCLE TIMING ACTIVATION AT THE KNEE AND ANKLE OF OLDER WOMEN FALLERS AND NONFALLERS

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SUMMARY

When comparing the motor response and the ability to develop joint torque at the knee and ankle between young women, older women fallers and nonfallers was found that older fallers presented a greater decline in ability to produce maximum joint torque of knee extension and flexion compared to nonfallers and also a muscle recruitment slowed, especially in the knee flexion and ankle dorsiflexion. Also, it was evidenced that ageing has a strong effect on the ability to develop joint torque rapidly at the knee and ankle.

INTRODUCTION

The ageing process is associated to several physiological and biomechanical changes that leads to the impairment of the neuromuscular system, exposing the elderly to a greater propensity to falls with several consequences on health [1,2,3,4].

Muscular weakness has been one of the major risk factors of falls in elderly population. Nevertheless, falling episodes appear to be more related to the ability to respond rapidly to a postural imbalance than to the maximum strength isolated [2,3], since the greater the delay in motor response the greater is the neuromuscular demand required for torepositioning the center of mass on the support base [5].

Thus, the aim of the present study was to evaluate the motor response and the joint torque development capacity in the knee and ankle of older women with and without fall history, as well as to investigate the effect of ageing on these capacities.

METHODS

The participants of this study were eighteen young women (21.79 ± 2.12 years), twenty-two older women nonfallers (66.14 ± 6.10 years) and twenty-one fallers (69.62 ± 7.16 years). Fall classification was based on their report of having fallen or not fallen during a period of one year before the study. There were no significant differences in body mass, age and stature between older groups. All subjects were classified as physically active.

Strength parameters were obtained using an isokinetic dynamometer. For knee flexion and extension assessment, the knee joint was positioned at 30° of flexion and for plantarflexion and dorsiflexion the ankle joint was positioned at 90°. The protocol consisted of three 5s maximal voluntary isometric contractions with an interval of 30s between them. Subjects were instructed to initiate contraction immediately after a luminous stimulus (LS).

Surface EMG signal was recorded during the strength test at a sample frequency of 2000 Hz from the rectus femoris (RF), vastus lateralis (VL), biceps femoris (BF), tibialis anterior (TA) and gastrocnemious lateralis (GL) muscles.

Torque curve was smoothed with a low pass filter (4th order and cut-off of 3 Hz) to obatain the peak torque (PT) and the peak rate of torque development (RTD) for each joint action. This last one was calculated by computing the variation of torque divided by correspondent time variation, using windows of 100 samples, from the onset of torque ($\geq$ 5% of actual PT value) until 200ms of contraction. Also, torque parameters were normalized to the body mass of each individual.

The EMG signal was full-wave rectified and low pass filter (4th order and cut-off of 3 Hz), and peak rate of EMG rise (REMGR) was determined for each muscle by computing the variation of EMG divided by correspondent time variation, using windows of 100 samples, from the onset of EMG ($\geq$ 5% of actual EMG peak value) until 200ms of contraction. The REMGR was normalized by the peak activation of each muscle.

Reaction time (RT), premotor time (PMT) and motor time (MT) were determined by time interval from the LS until onset of torque, LS until onset of EMG, onset of EMG until onset of torque, respectively.

After testing for normality (Shapiro-Wilk) and homogeneity variance (Levene test) of data, were conducted analyzes of variance (ANOVA) one-way with post-hoc tests of Bonferroni, Gabriel and Games-Howell or, when appropriate, Kruskal-Wallis ANOVA followed by Mann-Whitney test with Bonferroni correction. The significance level was set at $p < 0.05$.

RESULTS AND DISCUSSION

Strength and temporal parameters of muscle contraction are shown in Table 1. Knee flexion and extension PT was lower in the older fallers than in nonfallers, and lower in both older groups than young. Ankle plantarflexion was lower in both older groups than young. Knee extension and flexion and ankle plantarflexion and dorsiflexion RTD was lower in both older groups than young. Only the older fallers showed lower REMGR of the BF than the young. Furthermore, the MT of RF, VL, BF and GL muscles was higher in both older groups than young and the MT of the TA was higher only in older fallers than young.

Therefore, maximal muscle strength is essential to maintaining the functional independence, as well as for preventing falls [2,5]. Also, in accordance with the present study there are evidences that older fallers have slowed MT [2], which may represent an impairment in muscle excitation-contraction coupling and/or reduced stiffness in the muscle-tendon complex [6]. Furthermore, it was observed that ageing has a strong effect on the ability to develop joint torque rapidly and consequently on the ability to achieve maximum strength as fast as possible in the lower limbs.

CONCLUSIONS

Older fallers presented a greater decline in ability to produce maximum torque at the knee joint and also a muscle recruitment slowed, especially in the knee flexors and ankle dorsiflexors. This may increase the risk of falls in this individuals. Furthermore, it was evidenced that ageing has a strong effect on the ability to develop joint torque rapidly in the lower limbs.

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Table 1: Comparisons between young women, older women fallers and nonfallers for peak torque (PT), peak rate of torque development (RTD) and reaction time (RT) and peak rate of EMG rise (REMGR), premotor time (PMT) and motor time (MT) of the rectus femoris (RF), vastus lateralis (VL), biceps femoris (BF), tibialis anterior (TA) and gastrocnemious lateralis (GL).

Variable	Young	Older Nonfallers	Older Fallers
Knee extension PT ($N.m.kg^{-1}$)	2.61 (0.46)$^{**\,\dagger\dagger}$	1.52 (0.28)*	1.31 (0.27)
Knee flexion PT ($N.m.kg^{-1}$)	1.24 (0.27)$^{**\,\dagger\dagger}$	0.66 (0.16)**	0.52 (0.09)
Ankle plantarflexion PT ($N.m.kg^{-1}$)	1.35 (0.31)$^{**\,\dagger\dagger}$	0.76 (0.22)	0.75 (0.28)
Ankle dorsiflexion PT ($N.m.kg^{-1}$)	0.47 (0.11)$^{**\,\dagger}$	0.39 (0.08)	0.35 (0.08)
Knee extension RTD ($N.m.kg^{-1}.s$)	8.31 (3.41)$^{**\,\dagger\dagger}$	3.43 (1.13)	2.98 (1.35)
Knee flexion RTD ($N.m.kg^{-1}.s$)	4.18 (1.54)$^{**\,\dagger\dagger}$	1.47 (0.67)	1.11 (0.58)
#Ankle plantarflexion RTD ($N.m.kg^{-1}.s$)	2.62 (5.29)$^{**\,\dagger\dagger}$	1.34 (1.78)	1.06 (3.22)
Ankle dorsiflexion RTD ($N.m.kg^{-1}.s$)	1.79 (0.47)$^{**\,\dagger\dagger}$	1.05 (0.41)	1.01 (0.42)
Knee extension RT (s)	0.432 (0.097)	0.451 (0.184)	0.444 (0.131)
#Knee flexion RT (s)	0.356 (0.635)	0.430 (0.938)	0.402 (0.616)
#Ankle plantarflexion RT (s)	0.395 (0.452)	0.491 (0.677)	0.453 (0.888)
Ankle dorsiflexion RT (s)	0.402 (0.117)	0.379 (0.091)	0.418 (0.100)
#RF REMGR ($\%EMG_{peak}.s^{-1}$)	277.84 (597.98)	255.20 (455.83)	242.78 (568.26)
#BF REMGR ($\%EMG_{peak}.s^{-1}$)	301.06 (380.82)*	248.64 (404.20)	198.19 (428.11)
#VL REMGR ($\%EMG_{peak}.s^{-1}$)	325.37 (518.85)	216.88 (485.68)	267.57 (569.95)
TA REMGR ($\%EMG_{peak}.s^{-1}$)	381.23 (140.20)	316.91 (135.08)	371.93 (132.36)
#GL REMGR ($\%EMG_{peak}.s^{-1}$)	375.17 (609.52)	297.27 (522.47)	238.71 (549.04)
RF PMT (s)	0.319 (0.103)	0.307 (0.174)	0.283 (0.099)
#BF PMT (s)	0.288 (0.605)	0.269 (1.001)	0.319 (0.595)
#VL PMT (s)	0.322 (0.458)	0.326 (0.704)	0.259 (0.631)
TA PMT (s)	0.285 (0.112)	0.232 (0.094)	0.282 (0.103)
#GL PMT (s)	0.263 (0.496)	0.345 (0.642)	0.276 (0.875)
RF MT (s)	0.111 (0.021)$^{**\,\dagger\dagger}$	0.150 (0.038)	0.145 (0.030)
#BF MT (s)	0.115 (0.071)$^{**\,\dagger\dagger}$	0.161 (0.366)	0.165 (0.164)
#VL MT (s)	0.104 (0.176)$^{**\,\dagger\dagger}$	0.138 (0.111)	0.147 (0.106)
#TA MT (s)	0.108 (0.108)**	0.130 (0.100)	0.144 (0.281)
#GL MT (s)	0.139 (0.070)$^{*\,\dagger}$	0.163 (0.118)	0.158 (0.138)

†($p < 0.05$); ††($p < 0.01$): Difference in relation to the nonfallers. *($p < 0.05$); **($p < 0.01$): Difference in relation to the fallers. #: Non normally distributed data. Data are reported as mean (SD) for normally distributed data and median (range) for non normally distributed data.