EFFECT OF FITNESS LEVEL ON FORCE IMPULSE PATTERNS DURING OBSTRUCTED AND UNOBSTRUCTED WALKING IN ELDER FEMALES

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The aim of this study was to investigate the effect of fitness on foot-ground reaction forces during obstructed walking, by comparing two groups of fit females differing on their age. The gait of ten fit elderly women and the gait of ten skilled young female were analyzed with a two force-platforms system during an unobstructed walking and when stepping on and off a raised surface. The results suggest that older subjects with a high fitness score possess GRF patterns similar to youngsters during unobstructed walking. It can be concluded that senior step exercise programs are capable to improve gait stability in the elderly but this positive effect is lessened in the case of more demanding walking tasks. Stepping off was particularly affected in the elderly and in the future this should be taken into account in the development of senior step exercise programs.

KEY WORDS: elderly, gait impulses, kinetics, fitness programs.

INTRODUCTION: Understanding the effects of aging on movement and function is becoming increasingly important because of longer life span and growing elderly population. There is now an emphasis on determining the changes that occur in gait patterns with aging in order to reduce the number of falls, to identify reliable predictors of fall-prone elderly and ultimately to develop programs for preventing fall accidents (Prince et al, 1997). The collection of gait analysis data of healthy subjects is essential to establish realistic expectations of the elderly population. Although advances in technology have made objective methods of measuring gait more available, there are few studies of gait of healthy elderly.
In recent years, there has been considerable research interest in the way gait is modulated when the walker's path is uneven or obstructed, such as when negotiating obstacles. These investigations are important because in moving around real world our path is obstructed and uneven. When negotiating a raised surface, elder individuals differ from younger subjects in the way they adjust their gait in order to clear the obstacle safely (Begg & Sparrow, 2000). Previous studies demonstrate that older individuals develop lower anterior-posterior peak force during push-off, increase the time of the support phase during obstacle clearance, and have higher braking vertical impulse of the trail foot during stepping off (Begg & Sparrow, 2000; Begg et al, 1998; Sparrow et al, 1996). Patla and colleagues (1991) suggest that during obstructed gait a higher-order parameter such as impulse is modulated in adapting the gait pattern. The capacity to propel the body vertically and horizontally (in the anterior-posterior direction) in order to negotiate an obstacle is dependent on the impulses generated in these two directions of motion (Begg & Sparrow, 2000; Begg et al, 1998; Patla et al, 1991).
Neuromuscular changes, loss of balance and visual and attention deficits may all contribute to age-related changes in gait patterns and stability during obstacle clearance. It is possible that fitness by improving muscle force and co-ordination and/or balance might counteract the effect of aging in the way subjects negotiate obstacles. Therefore the aim of the present study was to investigate the influence of fitness level on foot-ground forces during obstructed walking, by comparing two groups of fit females differing on their age.

METHODS AND PROCEDURES: Ten elderly women (age: 67.60 ± 5.74 yrs, weight: 63.32 ± 9.61 kg, height: 1.54 ± 0.06 m, lower limb height: 0.72 ± 0.04 m, mean ± SD) that regularly participate in a step exercise program and with a score in the Senior Fitness Test (Rikli & Jones, 2001) above the 65 percentile and ten young female (age: 21.70 ± 1.42 yrs, mass: 55.19 ± 3.08 kg, height: 1.61 ± 0.05 m, lower limb height: 0.76 ± 0.04 m) fitness instructors walked along a 10-m pathway. Ground Reaction Forces (GRF) was obtained using two force-platforms positioned mid-way along the walking track. During obstructed walking, subjects stepped on and off a raised surface of 17.5 cm height. GRF were measured directly on the AMTI force plate (mod LG 6-4-2000), and on the Kistler force plate (mod. 928 UO 14) using a sampling rate of

1000 Hz. The outputs from the charge amplifiers were passed through a 16-bit analog to digital converter board (A/D Biopac MP 100) in a PC compatible computer using the Acknowledge software. GRF impulses were expressed relative to each subject's body mass. Impulse is the integral of the force/time curve and represents both the magnitude of force and the duration of force application.

All data expressed as mean S.D. were analyzed using SPSS 11.5. Paired Sample T-Test with a level of confidence of 0.05 was used to compare the mean values of the different dynamic parameter. In the lack of normal distribution, the Wilcoxon Mann-Whitney ($p<0.05$) was used. Within the older group linear regression analysis was used to determine the relationship between age and the gait variables. For all statistical analysis the significance level of $p<0.05$ was considered.

RESULTS AND DISCUSSION: During unobstructed walking, all force impulse values were similar between the two groups, which lead us to think that physical activity may be a protective factor in what concerns the gait changes in elderly.

Table 1 summarizes the results of the analyzed parameters in the three task conditions from a kinetic point of view.

Table 1 Mean values standard deviation for force impulse under the trail and lead foot during unobstructed condition and when subjects negotiate a 17.5 cm raised surface (stepping-on and stepping-off condition) for elderly and young subjects. The force impulse variables are Breaking Horizontal Impulse (BHI), Propulsive Horizontal Impulse (PHI), Breaking Vertical Impulse (BVI) and Propulsive Vertical impulse. Differences between groups significant at * p<0.05, **p<0.01, and ns (not significant).

	Unobstructed Walk			Stepping-on			Stepping-off		
	Elderly	Young	p	Elderly	Young	p	Elderly	Young	P
LeadFoot									
BHI	0.97±0.15	0.88±0.21	ns	0.96±0.17	0.88±0.22	ns	1.22±0.21	1.07±0.12	Ns
PHI	0.85±0.03	0.86±0.03	ns	0.82±0.16	0.95±0.18	ns	1.29±0.12	1.16±0.16	Ns
BVI	1.00±0.17	0.95±0.17	ns	0.89±0.03	0.86±0.03	**0.03***	0.67±0.02	0.83±0.02	**0.00****
PVI	0.80±0.02	0.90±0.03	ns	0.91±0.04	0.90±0.03	ns	0.70±0.03	0.71±0.04	Ns
Trail Foot									
BHI				0.98±0.11	0.85±0.13	ns	1.32±0.25	1.26±0.20	Ns
PHI				1.02±0.09	1.08±0.18	ns	1.05±0.17	1.20±0.17	Ns
BVI				0.82±0.04	0.80±0.06	ns	1.22±0.11	1.13±0.09	Ns
BVI				0.77±0.04	0.78±0.03	ns	0.72±0.06	0.78±0.04	**0.01****

Vertical and horizontal Impulses for both the stepping-on and the stepping-off phases were also analyzed as impulse ratios by dividing by the force impulse values during the unobstructed walking and calculated for both the braking and the propulsive phases of foot-ground contact. The lead and the trail-foot data were considered separately (Figure 1).

When stepping-on the lead-foot breaking vertical impulse (BVI) was higher in the elder group ($p=0.03$) in accordance with the results found by Begg and Sparrow (2000). The linear regression studies allow us to verify the effect of age on gait parameters. For the elderly, age appears as a predictor factor in the lead-foot propulsive vertical impulse (PVI) and ratio (PVIR) with $r2=0.70$ and 0.60, respectively. The same was observed for the trail-foot propulsive horizontal impulse (PHI) ($r2=0.80$).

During stepping-off, both BVI and BVI ratio were higher and lower, respectively for the trail-foot ($p=0.002$ for both) and lead-foot ($p=0.014$ and 0.010 respectively) in the elderly. A negative association was also found between age and trail-foot PHI ($r2=0.50$).

The differences in gait characteristics between young and older individuals when negotiating a raised surface are suggestive of a different strategy used by the elderly, based on increased breaking before accelerating to step on the obstacle. These results are strengthened by the observed higher lead-foot BHI during obstacle approach relatively to the unobstructed walking, demonstrating higher gait breaking demands.

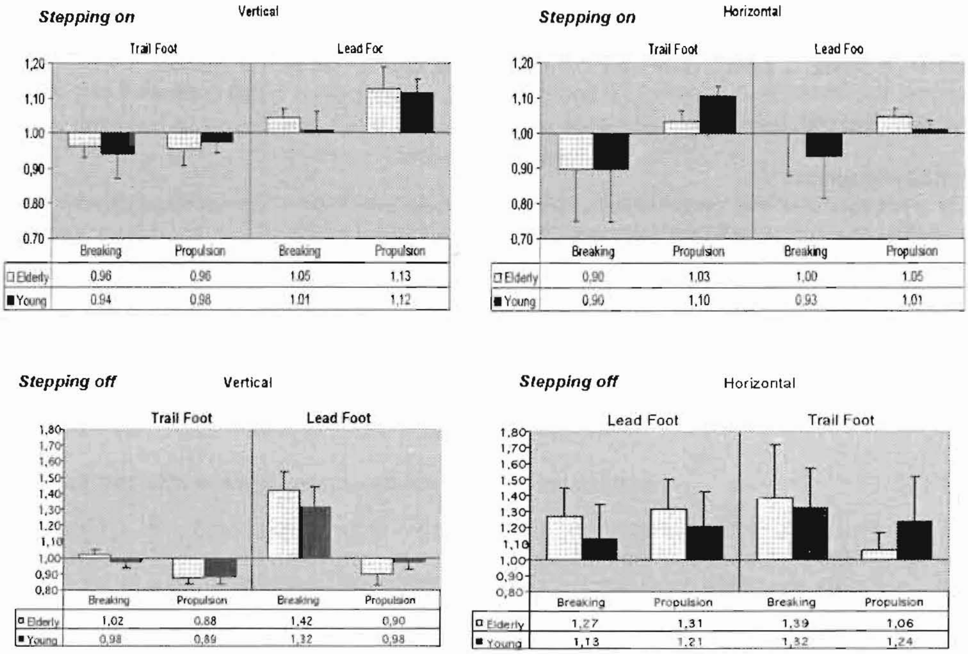

Figure 1: Force impulse ratios (relative to unobstructed condition) under the trail and the lead feet during stepping-on (the two graphs above) and stepping-off (the two bellow) conditions. The data in the bar graphs indicate group mean standard deviation. These impulse ratios have been shown during the breaking and the propulsive phases of the support phase. Note different scaling in horizontal impulse values for the stepping-off condition that are due to large mean and SD values.

CONCLUSION: Despite the small number of subjects, the results suggest that older subjects with a high fitness score, as assessed by the Senior Fitness Test, possess ground reaction force patterns similar to youngsters during unobstructed walking. It is important to refer that the present group of elderly women were involved in a bench stepping exercise program for at least 2 years with a 3 hour-week periodicity. Our results suggest that the involvement on these exercises program could explain the lack of disturbances in the gait parameters associated with age.

However, age significantly affects some force impulses when negotiating an obstacle. It can be concluded that senior step exercise programs are capable to improve gait stability in the elderly, but this positive effect is lessened in the case of more demanding walking tasks. Stepping off was particularly affected in the elderly and in the future this should be taken into account in the development of senior step exercise programs.

It allows also to conclude that step-seniors exercise programs could have a positive impact on the aging delay, with repercussions on the prevention of osteoporosis and reducing the risk of making them prone to falling or to other accident related injuries(6), in spite of the improvement of the well-being and quality of life.

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