# CAN STEP EXERCISE PREVENT GAIT IMPAIRMENTS IN ELDERLY WOMEN? A KINETIC ANALYSIS

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This research aimed to investigate lower limb motion while a subject negotiated a raised surface to study the effects of age-related declines in gait. We selected foot-ground force variables to highlight possible differences between the young and elder subjects. The gait of ten post-menopause women that took part in a step exercise program and ten skilled young female were analyzed with a two force-platforms during an unobstructed walking and when subjects were stepping on and off a raised surface of 17.5 cm height. The results suggest that older subjects possess GRF patterns similar to youngsters during unobstructed walking. It can be concluded that senior step exercise programs are capable to prevent gait impairments in the elderly but this positive effect is lessened in the case of more demanding walking tasks which should be taken into account in the development of senior step exercise programs.

**KEY WORDS:** elderly, gait, GRF, kinetics, fitness programs

**INTRODUCTION:** We are living in the age of longevity. Population ageing represents a triumph of social development and public health. Ageing is now the norm rather than the exception, and we can exert crucial influence in increasing awareness and designing broad initiatives to highlight the opportunities brought to individuals and societies by living longer.

There is promising new progress in knowledge of how to prevent and/or deal with problems associated with ageing. Recently it becomes increasingly important to understand the effects of ageing on movement and function in order to reduce disability. From the gerontology literature we find a 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, and it is known that the presence of hazards in the environment contribute significantly to the increase of falls among elderly.

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 and can be quite useful in the analysis of certain aspects of locomotion.

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. Using this kind of biomechanical data, the ultimate purpose is to promote health and well-being throughout the lifespan, thus ensuring the attainment of the best quality of life for a long as possible.

**METHODS:** The gait of 10 post-menopause women (67.60 ± 5.74 yrs; 63.32 ± 9.61 kg; 1.54 ± 0.06 m) that took part in a step exercise program and having achieved above a 65 percentile in the 8-foot-up & go and the chair-stand tests of the Senior Fitness Test (SFT) battery (Rikli & Jones, 2001) and the gait of 10 skilled young female students (21.70 ± 1.42 yrs; 55.19 ± 3.08 kg;

1.61 ± 0.05 m) were analyzed (8 trials) with two force-platforms positioned mid-way along a walking track (6 m long). Ground Reaction Force (GRF) were measured on the AMTI force plate (mod LG 6-4-2000), and on a Kistler force plate (mod. 928 UO 14) using a sampling rate of 1000 Hz. During obstructed walking, subjects stepped on and off a raised surface of 17.5 cm height. The outputs from the charge amplifiers were passed through a 16-bit analogue to digital converter board (A/D Biopac MP100) in a PC compatible computer using Acqknowledge software.

The following kinetic variables extracted from the GRF data for both the lead and trail feet were analyzed: vertical and anterior-posterior ground reaction force peaks (VGRF, A-PGRF) of the braking (B), and propulsive (P) phases; duration of both phases (ΔTB, ΔTP); interval time to reach the peaks (ΔT VGRF, ΔT A-PGRF); braking horizontal impulse (BHI), Propulsive horizontal impulse (PHI), braking vertical impulse (BVI) and propulsive vertical impulse. In order to compare variables between groups, BHI, PHI and A-PGRF peak were expressed relative to each subject's body mass (BM) while BVI, PVI and VGRF peak were expressed relative to each subject's body weight (BW).

Mean values, standard deviations and coefficient of variation were calculated for all variables. After using Kolmogorov-Smirnov normality test, the independent T-test was applied to compare these variables between groups. In the lack of normal distribution, the Mann-Whitney test was used. For all statistical analysis, using SPSS 13.0 software, the significance level of $p < 0.05$ was considered.

**Table 1 Mean values ± standard deviation for statistic significant variables 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 variables are: duration of Braking Phase (ΔTB), Vertical Ground Reaction Force Peak during phases (VGRF-B; VGRF-P), Interval Time to Vertical Ground Reaction Force Peak of the Braking phase (ΔT VGRF-B), duration of Propulsion Phase (ΔTP), Braking Horizontal Impulse (BHI), Propulsive Horizontal Impulse (PHI), Braking Vertical Impulse (BVI) and Propulsive Vertical impulse. Differences between groups significant at p < 0.05, and ns (not significant).**

| | Unobstructed Walk | | | Stepping-on | | | Stepping-off | | |
|---|---|---|---|---|---|---|---|---|---|
| | Elderly | Young | p | Elderly | Young | p | Elderly | Young | P |
| **Lead Foot** | | | | | | | | | |
| T B | **0.35±0.04** | **0.41±0.03** | **0.00** | 0.36±0.04 | 0.39±0.07 | ns | **0.24±0.02** | **0.28±0.03** | **0.01** |
| VGRF-B | 1.11±0.08 | 1.07±0.06 | ns | 1.04±0.06 | 1.12±0.05 | ns. | 1.81±0.17 | 1.71±0.17 | ns |
| T VGRF-B | **0.15±0.02** | **0.17±0.01** | **0.01** | **0.20±0.04** | **0.18±0.03** | **0.01** | 0.10±0.02 | 0.12±0.02 | ns |
| T P | 0.30±0.03 | 0.32±0.03 | ns | 0.42±0.03 | 0.43±0.04 | ns | 0.36±0.03 | 0.38±0.03 | ns |
| VGRF-P | 1.20±0.26 | 1.10±0.04 | ns | 1.14±0.07 | 1.16±0.06 | ns | 1.09±0.12 | 1.16±0.08 | ns |
| 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 | 1.18±0.16 | ns |
| BVI | 1.00±0.17 | 0.95±0.17 | ns | 0.89±0.03 | **0.86±0.03** | **0.03** | **0.87±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** | | | | | | | | | |
| T B | | | | 0.41±0.03 | 0.41±0.04 | ns | 0.46±0.05 | 0.46±0.06 | ns |
| VGRF-B | | | | **1.26±0.12** | **1.19±0.10** | **0.00** | 1.16±0.09 | 1.13±0.08 | ns |
| T VGRF-B | | | | **0.14±0.01** | **0.16±0.03** | **0.01** | 0.15±0.02 | 0.16±0.02 | ns |
| T P | | | | **0.25±0.05** | **0.31±0.04** | **0.01** | 0.35±0.04 | 0.36±0.03 | ns |
| VGRF-P | | | | 1.37±0.10 | 1.32±0.09 | ns | 0.95±0.07 | 1.09±0.03 | ns |
| 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 |
| PVI | | | | 0.77±0.04 | 0.78±0.03 | ns | **0.72±0.06** | **0.78±0.04** | **0.01** |

**RESULTS AND DISCUSSION:** Table 1 summarizes the main results of the analyzed parameters in the three task conditions from a kinetic point of view.
Although the difficulty of knowing whether the changes observed in the gait pattern of older adults are due to the aging process alone or some underlying disease process, clear differences are reported in literature when healthy older adults are compared with younger adults. The most significant changes are observed in the variable gait speed. Even healthy older adults with no history of falling had demonstrated to walk on average 20% slower than younger counterparts (Elble *et al.* 1991). Surprisingly, the elderly women of this study showed a similar gait speed when compared with the youngsters. When analyzed the anterior-posterior component of the ground reaction force, which is responsible for the forward progression of the body as a whole, all the parameters were similar between the two groups in all the study tasks.
During **unobstructed walking**, all force impulse values were similar between the groups. Nevertheless, in the braking phase, the temporal variables ΔT VGRF ($p = 0.01$) and ΔT total ($p = 0.00$) were significantly lower for elderly group. These results could be associated with a marginally superior gait velocity in the elderly group, reinforcing the idea that our elder group has high functional levels, leading us to think that physical activity may be a protective factor in what concerns the gait changes in elderly.
When **stepping-on** the lead-foot braking vertical impulse (BVI) was higher in the elder group ($p=0.03$) in accordance with the results found by Begg and Sparrow (2000). These results are probably connected with the increase of ΔT VGRF -B.
During **stepping-off**, BVI were higher for the lead-foot ($p = 0.00$), and lower PVI for the trail-foot ($p = 0.01$) in the elderly. 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 braking 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 braking demands.
The literature reports that the characteristics of the locomotor changes during an avoidance strategy appear to be far more conservative in the elderly, representing a safer strategy for going over obstacles (Patla, 1995). Our elder group did not highly manifest this behavior.

**CONCLUSION:** This group of healthy elderly with a high score of functionality (assessed by the SFT) produced ground reaction force patterns similar to youngsters during unobstructed walking. The present group of elderly women was 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 reported in literature (Begg & Sparrow, 2000; Chen *et al*, 1991, Prince *et al*, 1997). However, age significantly affects some force impulses during obstacle negotiation, highlighting the hypothesis that senior step exercise programs might improve gait stability in elderly. However, this positive effect is lessened in the case of more demanding walking tasks and, in the future, this should be taken into account in the development of senior step exercise programs.
The results obtained by our exercise group of elder women, reinforce our conviction that Step Exercise Program may accomplish adaptations leading to health promotion and well-being throughout the lifespan, thus ensuring the attainment of the best quality of life for a long as possible.

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