INFLUENCE OF AGING ON THE DYNAMICS OF LATERAL STABILIZATION IN WALKING, IN DIFFERENT EXPERIMENTAL CONDITIONS RELATED TO SHOE WEARING AND FLOOR HARDNESS[1]

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INTRODUCTION

Even if the aging process has been studied for many years, very little information dealing with the relationship between walking stabilization dynamics and aging process has been generated. This whole area of study challenges biomechanics researchers (Schultz, 1992).

Review of biomechanics literature on the influence of aging on the locomotor system indicates that safe load bearing as well as deformation sustaining capabilities of biological tissues decrease with age (Winter et al., 1990; Skinner et al, 1984). Postural studies of older populations have disclosed more body sway than in younger age groups and have often associated loss of balance with locomotion problems of old age people (Nobuou, 1986; Nigg et al., 1988). On the other hand, biomechanical studies of walking and running have already demonstrated that wearing shoes and shoe characteristics can play an important role in shock absorbtion (Light et al., 1980). However the influence of aging on the dynamics of lateral stabilization in walking in relationship with shoe wearing and floor hardness has received very little attention. Such a biomechanical approach to locomotion is becoming more important since more and more older people are involved in sport and fitness activities including some form of locomotion. These shortcomings are surprising when we consider the large amount of literature dealing individually either with locomotion or adaptation processes in humans.

The present study has been undertaken in order to investigate the influence of aging together with shoe wearing and floor hardness on some of the main components of lateral stabilization in walking, namely the lateral forces (Fx), the lateral impulse (Ix) and the lateral deviation of the center of pressure (CPx).

METHODOLOGY

In order to pursue its objectives, the present study was designed with subjects belonging to a sample of convenience of different age groups, from young adults to elderly. Three groups of physically active male subjects (17-22 years old:N = 15; 40-45 years old:N = 16; 65-70 years old:N = 13) were instructed to walk on a Kistler force platform at a predetermined pace (110 steps/minute) set by a metronome as reported previously by Winter et al. (1990). Experimental conditions included walking barefoot and with regular shoes, on a hard and a softer surface (3 cm mat). Kinetic data were recorded on the 5^{th}, 25^{th}, 50^{th}, 100^{th} and 500^{th} steps for each condition, the signals were digitized on-line at a frequency of 300 Hz by a LabMaster-16 analog to digital converter (12 bits). The digital values were processed with the use of the computerized Ariel Performance Analysis System. The measurements of the lateral forces and of the lateral displacement of the center of pressure used a global laboratory coordinate system (longitudinal axis of the platform). The lateral impulse was the summation of the scalar values of all the lateral impulse vectors.

Data were analyzed using an ANOVA for repeated measures (SAS v6.01; 3x2x2x5 design) and then submitted to Tukey's post hoc test in order to extract the statistically different main effects and interactions ($\alpha = 0,05$).

RESULTS AND DISCUSSION

Analysis of data showed significant differences between the three age groups in CPx. The middle age group exhibited larger CPx in all experimental conditions, while the older group had CPx larger than in young adults, also in all experimental conditions (Figures 1-3). Since

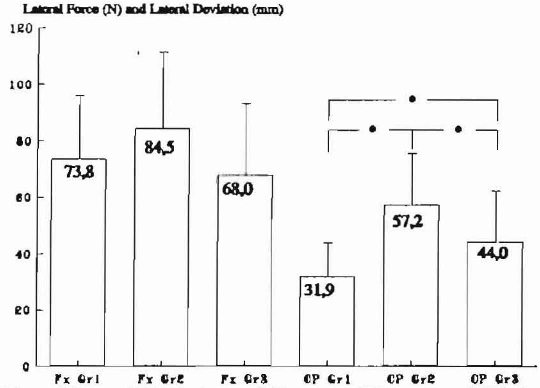

Figure 1. Lateral Forces (Fx) and Lateral Deviations of Centers of Pressures (CP) for the Three Age Groups. (*:p ≤ 0,05; mean + 1 S.D.)

body weight of younger and older subjects was comparable (Gr1: $\bar{x}$ = 66,4 kg; Gr3: $\bar{x}$ = 65,3 kg), while the middle age group was heavier (Gr2: $\bar{x}$ = 79,3 kg), the results of these two

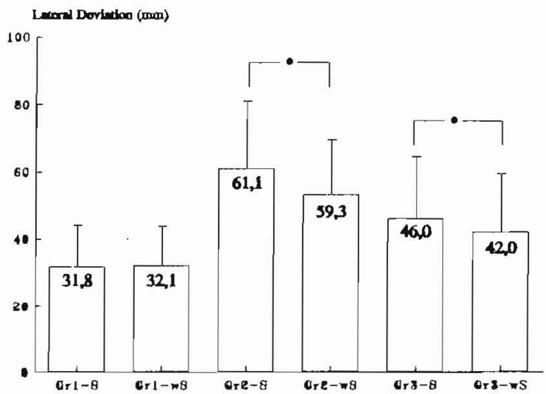

Figure 2. Lateral Deviations of Center of Pressure with (S) and without Shoes (wS) for the Three Age Groups. (*:p≤0,05; mean + 1 S.D.)

former groups can be compared without any possible influence of body weight. Their center of pressure findings, when compared with lateral force results, disclose a very interesting phenomenon; the older subjects developed much less lateral force even if they experienced more lateral deviation of the center of pressure. Since Nobuou (1986) associated smaller lateral forces with larger pronations of the foot, which are considered an instability factor, the findings of the present study could be an indication of the deterioration of motor response in the elderly sample. According to Schultz (1992), these changes could possibly be attributed mainly to inappropriate body segment motion sequencing, increased reaction time, reduced muscular strength and joint range of motion.

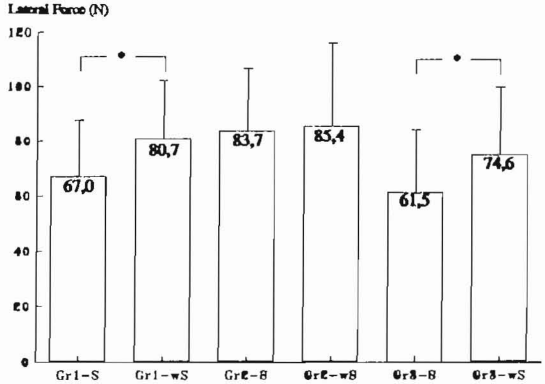

Figure 3. Lateral Forces with (S) and without Shoes (wS) for the Three Age Groups. (*:p≤0,05; mean + 1 S.D.)

Inter-group comparisons for the different experimental conditions also showed that walking with or without shoes did not influence CPx trajectories in young adults (Figure 2), probably due to their higher adaptability (Winter, 1991; Czerniecki, 1988); however they had to use more lateral forces (Figure 3) when walking barefoot than when wearing shoes. Middle aged and older subjects exhibited larger CPx when wearing shoes, but the older ones developed significantly less lateral force to do so. This phenomenon could indicate that the shoe periphery is producing an unstabilizing lever and since older people need more time and amplitude to detect passive joint motion (Skinner et al., 1984), their deviation of CPx is adversely affected when wearing shoes.

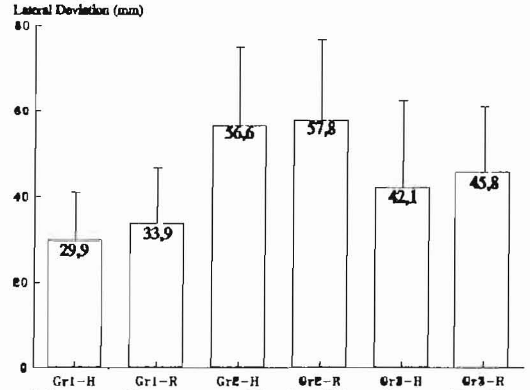

Figure 4. Lateral Deviations of Center of Pressure on Harder (H) and more Resilient (R) Surfaces for the Three Age Groups. (mean + 1 S.D.)

Floor hardness did not have a significant influence on the CPx trajectories of any group but harder surface required more lateral force (Figures 4 and 5). This phenomenon, even if present, was less important in the elderly.

Lateral impulse results did not reveal any significant difference between groups or conditions even though younger subjects results are approximatively half of the two other groups. Discrepancies in the number of results between the groups for this variable did not permit a statistically significant difference. However the impulse reported in this study are well within the absolute values reported by Nigg et al. (1988).

CONCLUSIONS

Analysis of results of the present study, in light of available knowledge, seems to indicate that, even though older people try to have a safer (less force) locomotion pattern (Winter et al., 1990; Nigg et al, 1988). The higher CPx produce less stable gait patterns as compared to young adults. Since their stabilization adjustments are slower and less important (Schultz, 1992), the elderly could be considered as offering more risks of loss of balance in locomotion activities requiring some form of adaptation either to the surface (a harder surface showing a

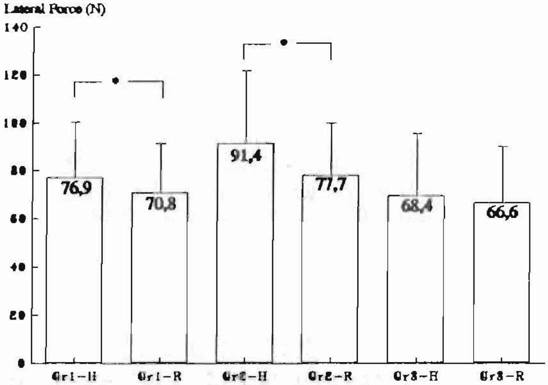

Figure 5. Lateral Forces on Harder (H) and more Resilient (R) Surface for the Three Age Groups. (*:$p \leq 0{,}05$; mean + 1 S.D.)

decreased CPx) or to the shoes (the barefoot condition showing a decrease in CPx and an increase in the Fx). Physical educators and coaches working with older people should be aware of such a situation in order to adapt the environmental conditions to the capacities of the participants.

REFERENCES

Czerniecki, J.M. (1988). Foot and ankle biomechanics in walking and running. *American Journal of Physical Medicine and Rehabilitation*, **88**, 246-252.

Light, L.H., McLellan, G.E., & Klenerman, L. (1980). Skeletal transients on heel strike in normal walking with different footwear. *Journal of Biomechanics*, **13**, 477-480.

Nigg, B.M. & Skleryk, B.N. (1988). Gait characteristics of the elderly. *Clinical Biomechanics*, **3**, 79-87.

Nobuou, M. (1986). Control of the medial-lateral balance in walking. *Acta Orthopedica Scandinavia*, **57**, 555-559.

Schultz, A.B. (1992). Mobility impairment in the elderly: challenges for biomechanics research. *Journal of Biomechanics*, **25**, 519-528.

Skinner, H.B., Barrack, R.L., & Cook, S.D. (1984). Age related decline in proprioception. *Clinical Orthopaedics Related Research*, **184**, 208-211.

Winter, D.A. (1991). *The biomechanics and motor control of human gait: normal, elderly and pathological* (2nd Ed.). Waterloo, ON: University of Waterloo Press.

Winter, D.A., Patla, A.E., Frank, J.S., & Walt, S.E. (1990). Biomechanical walking pattern changes in the fit and healthy elderly. *Physical Therapy*, **70**, 340-347.