

# THE EFFECTS OF LATERAL LOADING ON INTRALIMB COORDINATION DURING WALKING ON YOUNG AND ELDERLY FEMALES

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## INTRODUCTION

Previous research has indicated that older adults adapt their gait towards that of a safer and more stable pattern (Judge et al., 1996); however, every year many elderly individuals find themselves victims of falls during walking. Proper coordination of the limb segments is necessary to generate a safe gait pattern. The majority of gait studies of healthy elderly focus on kinematic changes associated with aging, with less attention directed toward the study of coordination. The purpose of this study was to examine elements of coordination during the gait patterns of young and elderly women during free selected and perturbed walking. We challenged the coordination of our subjects by adding an ankle weight to one limb. In this way, the walking task becomes more difficult, as subjects have to adapt to a new walking strategy to compensate for the added weight. To examine walking strategies we used the Dynamical Systems Theory (DST). In DST, the interacting components are examined while manipulating a control parameter to elicit new patterns of coordination (Clark & Phillips, 1993). By using DST, we investigated the interacting segments in the same limb (intralimb coordination), while manipulating a control parameter (added weight).

## PROCEDURES

Twenty females (10 women age 20-30 yrs, 10 women age 67+ yrs) walked at a self-

selected pace with and without a weight (5% of their body weight) attached on their right ankle. Sagittal view kinematics were collected (60 Hz) from the leg carrying the weight using the Peak Performance system. To examine intralimb coordination, the phase portraits from segmental angular positions and velocities were used to calculate phase angles (Scholtz, 1990). Relative phase (RP) curves were calculated for two segmental relationships [foot-shank (F-S) and shank-thigh (S-T)] by subtracting the phase angle of the proximal segment from the distal segment. Mean ensemble RP curves were calculated for all conditions. From these curves two parameters were evaluated: a) mean relative phasing (MRP), and b) deviation phasing (DP). MRP and DP were calculated by averaging the absolute values and the standard deviations, respectively, of all points of the mean ensemble RP curve. MRP and DP were calculated for two intervals of the stance period: braking and propulsion. Two-way mixed ANOVAs (weight by age) with repeated measures on the weight factor were performed on MRP and DP for each segmental relationship and for each interval ( $p < 0.05$ ).

## RESULTS AND DISCUSSION

The group results are presented in Table 1. For the young group, the added weight resulted in significant increases for the S-T MRP in both periods. This indicated a more out-of-phase relationship or more independence in the actions of the two

segments. No differences were found for the F-S MRP. For the elderly group, the added weight had a significant effect only during the braking period and for both S-T and F-S. This effect was opposite for the two segmental relationships. The S-T MRP increased and became more out-of-phase, while the F-S decreased and became more in-phase. No differences were found during the propulsion period. Furthermore, no differences were found between the two age groups, except for S-T MRP during the braking period and without the weight. The DP results, revealed a significant increase for S-T in the elderly group and during the braking period. Even though no other DP comparisons were significant, the added weight always increased DP. Increases in DP reveal an unstable system, while decreases are associated with a fixed and rigid system. Finally, the results revealed no significant interactions.

## SUMMARY

In this study we simulated an imbalance between the lower limbs by adding an ankle weight. This resulted in behavioral changes

that were different between the two groups. While the young addressed the added weight with compensations throughout the stance only at the knee, the elderly also incorporated changes at the ankle. The changes in the elderly group occurred only during the braking period. Thus, it seems that this period is more crucial for the elderly than the young females. In conclusion, the differences identified between the two groups suggest that changes in intralimb coordination may take place with the aging process. The parameters identified in this study can be used in future research to determine if these coordinative changes have a direct effect on an individual's risk of falling.

## REFERENCES

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- Scholtz, J.P. (1990). *Phys Ther*, **70**, 827-843.

**Table 1:** Parameters evaluated for both groups (mean  $\pm$  SD). All values are in degrees.

	Young Females		Older Females	
	No weight	Weighted	No weight	Weighted
Braking S-T MRP	18.9 <sup>♦*</sup> $\pm$ 3.9	21.1 $\pm$ 3.2	15.1 <sup>♦</sup> $\pm$ 2.6	18.1 $\pm$ 3.6
Braking F-S MRP	22.7 $\pm$ 2.3	22.2 $\pm$ 2.2	25.4 <sup>♦</sup> $\pm$ 2.9	23.6 $\pm$ 2.6
Propulsion S-T MRP	59.0 <sup>♦</sup> $\pm$ 5.0	63.0 $\pm$ 4.0	57.6 $\pm$ 5.3	58.2 $\pm$ 6.1
Propulsion F-S MRP	11.5 $\pm$ 2.8	12.2 $\pm$ 2.3	13.8 $\pm$ 3.3	13.2 $\pm$ 3.3
Braking S-T DP	5.2 $\pm$ 1.5	5.8 $\pm$ 3.1	5.5 <sup>♦</sup> $\pm$ 1.5	6.6 $\pm$ 2.2
Braking F-S DP	4.1 $\pm$ 0.9	4.3 $\pm$ 1.2	3.7 $\pm$ 1.5	4.1 $\pm$ 0.8
Propulsion S-T DP	9.7 $\pm$ 5.5	10.3 $\pm$ 8.8	7.5 $\pm$ 1.6	9.9 $\pm$ 2.4
Propulsion F-S DP	2.7 $\pm$ 0.9	2.9 $\pm$ 0.9	3.0 $\pm$ 0.8	3.5 $\pm$ 0.8

♦ significant differences between weight conditions for the same group

♣ significant differences between age groups for the same weight condition