KINEMATICS OF THE YOUNG-ADULT AND OLD-ADULT LOWER LIMB DURING STAIR ASCENT AND STAIR DESCENT

Lori A. Livingston
Wilfrid Laurier University

Numerous studies have addressed changes in the overground gait patterns of the elderly compared with those of the younger adult. Common observations include decreases in walking speed with age, due to a shorter step length rather than reduced cadence, and increased stance times (Winter et al., 1990). Such strategies are used by the elderly population to aid in the maintenance of balance. Williams and Bird (1992) noted similar declines in movement velocities with increasing age during stair ascent, yet knowledge of the compensatory gait tactics utilized by the elderly to enhance stability when stairclimbing is limited. The purpose of this investigation, therefore, was to replicate an earlier study (Livingston et al., 1991) of young-adults with an older-adult population to allow for a systematic examination and comparison of selected gait characteristics during stair ascent and stair descent.

METHODS AND PROCEDURES

Five healthy, physically-active older-adult women with a mean age of 67.4 ($\pm$6.5) years participated in this study. Screening ensured that the subjects were pain free and did not suffer from any pathological conditions to the locomotor system. Data for five young-adult women (mean age 22.8$\pm$3.1 years) from the previous study were chosen for comparison. Similarity in height (ie, older-adults $X=155.7\pm5.6$ cm; young-adults $X=157.4\pm3.7$) was seen as an essential characteristic for the comparison groups since free-speed stairclimbing gait measures (eg, cycle, stance duration, cadence and walking velocity) have been shown to be systematically related to stature (Livingston et al., 1991).

Each subject completed two trials of free-speed overground walking and ten trials each of free-speed stair ascent and free-speed stair descent over three testing staircases (Table 1). Each staircase consisted of six steps. Sagittal (X,Y) plane images of the right lower limb were captured on high-speed film at a rate of 50 Hz. While stairclimbing, foot contact with steps 2, 3, and 4, as indicated by switchmats, triggered the on and off record of three digital clocks. As such, cine and switchmat data were collected simultaneously. Dependent variables of interest included cycle time, stance phase duration, cadence and movement velocity. A mixed between-within repeated measures multivariate analysis of variance procedure was used to analyze the data.

Table 1 Dimensions of the Testing Staircases

Staircase	Step Height (cm)	Tread Depth (cm)	Slope (°)
Steep	20.32	20.32	45
Moderate	20.32	30.48	33
Shallow	12.70	41.91	16

RESULTS AND DISCUSSION

Analysis of the free-speed walking data (Table 2) yielded a significant difference in stride length ($F(1,8)=7.78$, $p \leq .03$) but not stance time between the two groups. This difference in stride length was negated when stairclimbing, however, by the limiting dimensions of the testing staircases.

Analysis of the stair ascent and stair descent data uncovered several significant differences (Figures 1 and 2). During stair ascent, older-adults displayed longer cycle times ($F(1,8)=6.90$, $p \leq .03$) and somewhat slower cadences than their younger counterparts. Movement velocities slowed ($F(2,7)=191.6$, $p \leq .01$) for both groups, however, as the slope of the staircase, and hence the energy demands of the task, increased. During stair descent, the most significant group difference was observed for stance phase duration ($F(1,8)=15.08$, $p \leq .01$). Older-adults displayed consistently large stance phase durations (50% to 57%) while those of the young-adults varied (20% to 53%) with the staircase climbed. This appeared to be the chief compensatory mechanism for maintaining stability during stair descent.

Table 2 Mean Gait Components for Free-Speed Level Walking[a]

	Young-Adult (n=5)	Old-Adult (n=5)	P
Cycle Duration (s)	1.11 (0.07)	1.15 (0.11)	
Stance Phase (%)	63.7 (3.1)	64.7 (1.9)	
Swing Phase (%)	36.3 (3.1)	35.3 (1.9)	
Cadence (steps/min)	109.0 (6.9)	105.6 (5.1)	
Stride Length (m)	1.48 (0.03)	1.26 (0.17)	.03
Velocity (m/s)	1.34 (0.1)	1.12 (0.3)	

[a]() denotes standard deviation

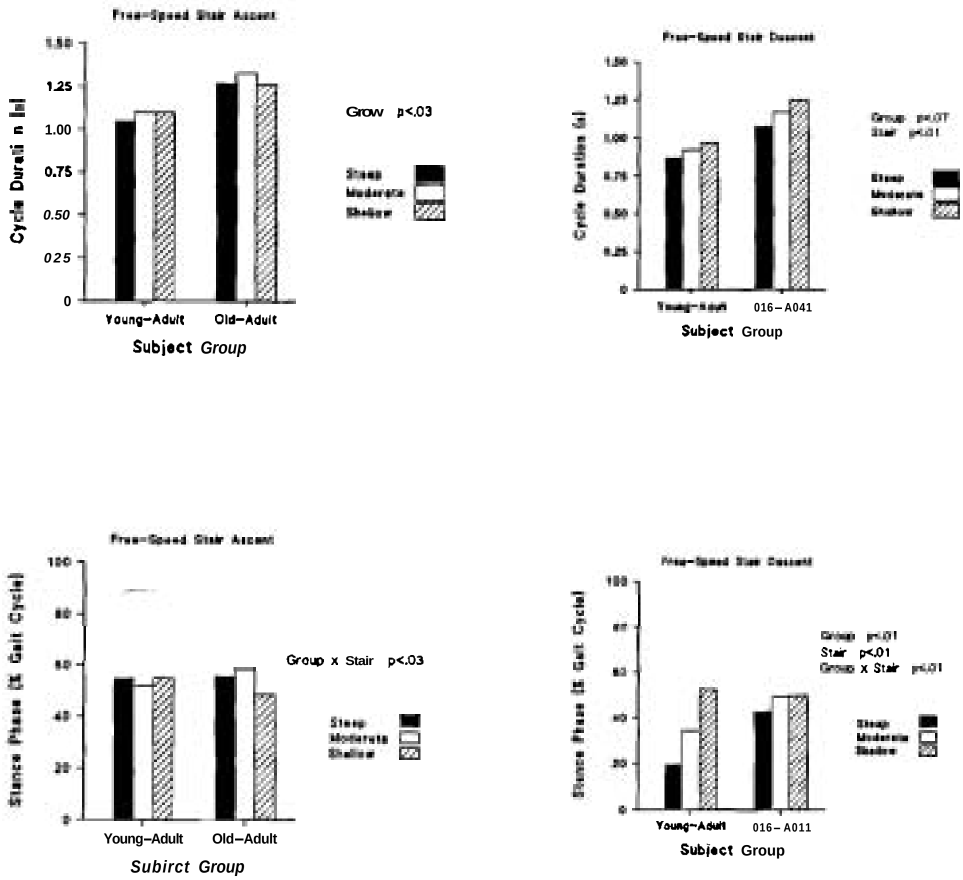

Figure 1 **Observed differences in mean teniporal gait quantities between groups and over stairs of differing dimensions.**

CONCLUSIONS

While some changes in stairclimbing gait with increasing age (eg, slowing) were observed, the dimensions of the staircase climbed appeared to play a larger role in altering gait. It is acknowledged, however, that age differences may have been more pronounced had a sedentary population been examined. Studies of stairclimbing must account for the effects of internal (ie, age, height) and external (ie, stair dimensions) constraints on the stairclimbers' behaviour. How older adults were able to lengthen the stance phase during stair descent requires further investigation. In conclusion, provided that the older-adult does not suffer from locomotor or balance impairments, stairclimbing as a form of exercise remains a viable option.

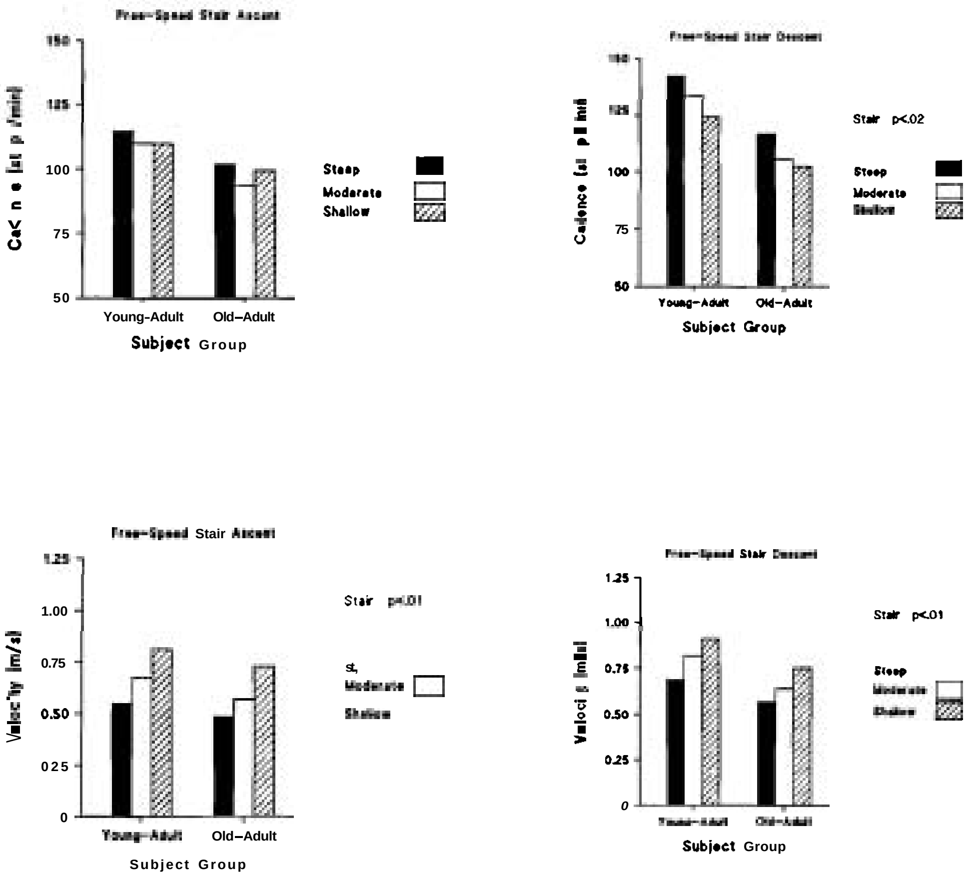

Figure 2 **Observed differences in mean linear gait quantities between groups and over stairs of differing dimensions.**

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