

A THREE-DIMENSIONAL KINEMATIC AND KINETIC COMPARISON OF OVERGROUND AND TREADMILL WALKING IN HEALTHY ELDERLY SUBJECTS

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INTRODUCTION

Instrumented treadmills offer a number of advantages for the biomechanical analysis of elderly gait, yet it is unclear how closely treadmill gait approximates overground gait. Although studies have indicated that the kinematics and kinetics of overground and treadmill gait are very similar in young adults [1-3], very few studies have investigated treadmill walking in the elderly. In order to validate the use of instrumented treadmills with an elderly population, the differences between treadmill and overground gait in the elderly must be understood. The purpose of this study, therefore, was to compare the three-dimensional kinematics and kinetics of treadmill gait to overground gait in a group of healthy elderly subjects.

METHODS

Three-dimensional kinematic and kinetic data for eighteen healthy, nondisabled elderly subjects, age 65 to 81 years (mean, 70.3yrs), were collected for speed-matched overground and treadmill walking conditions. Ground reaction force signals from an AMTI compound instrumented treadmill (AMTI, Watertown, MA, USA) and stationary in-ground force plates were collected and synchronized with kinematic data from a ten camera VICON 624 motion analysis system (Figure 1).

Each subject first walked 15 m overground at his or her self-selected comfortable walking speed until at least three complete gait cycles were collected for each lower limb. The average walking speed of two randomly selected overground trials for each subject was determined to establish speed for subsequent treadmill walking trials. Subjects then walked on the side-by-side treadmill force plate units for a two minute acclimation period followed by a 30 second data collection period.

Motion capture and GRF data were processed using VICON Plug-in Gait to calculate joint kinematics, joint kinetics, and temporospatial parameters (VICON, Centennial, CO, USA). Data obtained from the instrumented treadmill were pre-processed using in-house algorithms implemented in LabView (National Instruments, Austin, TX, USA). Maximum and minimum kinematic and kinetic values at characteristic peaks were obtained from each subject's average curves. The differences between each subject's overground and treadmill maxima and minima were evaluated using paired-samples *t*-tests.

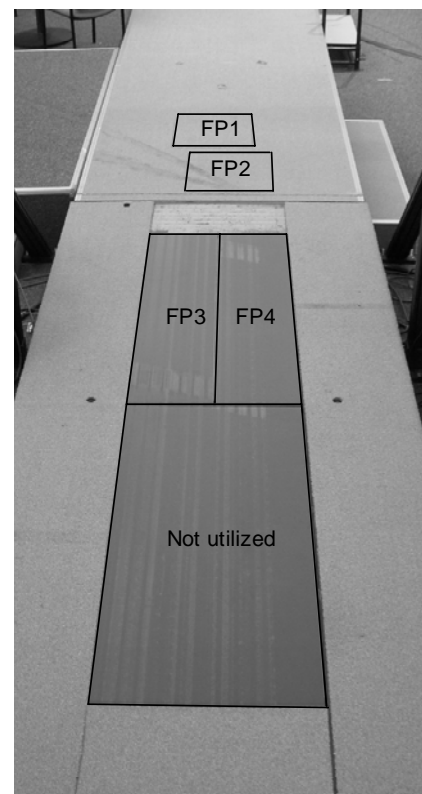


Figure 1. Location of individual force plates on the raised walkway. FP3 and FP4 are imbedded in the split belt treadmill. Overground trials used any of the four plates while treadmill trials used FP3 and FP4.

RESULTS AND DISCUSSION

This comparison of treadmill to overground gait in elderly subjects revealed the adoption of both a quicker cadence and shorter stride length during treadmill walking (Table 1). The majority of absolute kinematic maxima and minima were reduced for treadmill walking, implying a larger range of motion for overground gait. While the overall patterns of the three-dimensional joint moments at the hip, knee, and ankle were similar for treadmill and overground walking, significant reductions in sagittal and coronal plane hip and knee joint moments were observed during treadmill walking. Also, treadmill gait showed significant reductions in ankle and hip power generation and power absorption at the knee during push-off.

Compared to our previous study of young adults [1], temporospatial differences between treadmill and overground walking were much greater in the elderly than in the young adult population (Table 1). Similar reductions in joint angles and moments and also hip power generation and knee power absorption were observed in young adults during treadmill walking, but to a lesser extent than was seen in the elderly subjects. Although a two minute accommodation period was used and subjects

reported feeling comfortable prior to data collection, possible inexperience of the elderly subjects with treadmill use may have contributed to the gait related changes that were observed.

CONCLUSIONS

Most of the differences observed between treadmill and overground walking are likely due to changes in temporospatial parameters that may be linked to treadmill unfamiliarity. Because of this, we believe that instrumented treadmill use for research or training purposes in the elderly is appropriate, but that accommodation to treadmill ambulation may likely be more difficult than is observed in young adults.

REFERENCES

1. Riley, P. O., et al. *Gait Post.* **26**, 17-24. 2007.
2. Murray, M. P., et al. *J. Appl. Phys.* **59**, 87-91. 1985.
3. Matsas, A., et al. *Gait Post.* **11**, 46-53. 2000.

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Table 1. Mean (SD) temporospatial characteristics for both young and elderly subjects for treadmill and overground walking, with p -values reported for the elderly subjects. SD = standard deviation.

	Young (Mean 23.4 yrs, SD 4.3)		Elderly (Mean 70.3 yrs, SD 4.8)		
	Treadmill	Overground	Treadmill	Overground	p
Speed (m/s)	1.40 (0.16)	1.45 (0.17) [†]	1.25 (0.21)	1.27 (0.20)	0.069
Cadence (steps/min)	113.43 (7.83)	113.48 (7.78)	116.88 (10.63)	110.10 (7.60)	0.009*
Stride Time (s)	1.06 (0.07)	1.07 (0.07)	1.04 (0.09)	1.10 (0.08)	0.009*
Stride Length (m)	1.49 (0.13)	1.53 (0.13) [†]	1.30 (0.24)	1.39 (0.19)	<0.001*

[†] Significant difference in the young adult study ($p < 0.05$) [1].

* Significant difference in the elderly adult study ($p < 0.05$).