BACKWARD UPSLOPE WALKING: IMPLICATIONS FOR THE KNEE JOINT

[1]Andrea N. Lay, [2]Chris J. Hass, and [3]Robert J. Gregor
[1]School of Mechanical Engineering, Bioengineering Program, Georgia Institute of Technology
[2] Dept of Biobehavioral Sciences, Teachers College, Columbia University
[3]Center for Human Movement Studies, School of Applied Physiology, Georgia Institute of Technology
E-mail: gtg449j@mail.gatech.edu (A. Lay)

INTRODUCTION

It has been shown that backwards walking is metabolically more demanding than forward walking at the same speed, in part due to the change in quadriceps activity [1]. During forward walking the quadriceps contract eccentrically in early stance, while during backward walking the eccentric activity is replaced by concentric activity, which has a higher energy cost. This increased demand may contribute to improvements in cardiovascular fitness when backward walking is included in a training program [2]. Reduced joint stresses, in addition to the increased demand also make backward walking beneficial as a rehabilitation strategy for those suffering from knee injuries. Changing the grade of the walking surface may further increase the demands on the muscles and therefore increase the benefits of backward walking for rehabilitation [3]. The purpose of this study was to investigate the knee joint kinetics of backward upslope walking, compared to forward upslope walking, as a means of assessing its functionality as a rehabilitation exercise. [4].

METHODS

Nine healthy adult volunteers (5M, 4F, mean age = 24 yrs) each read and signed an informed consent statement approved by the IRB at Georgia Tech. Participants were then fitted with fifteen retroreflective markers (Helen Hayes system) and performed sixteen walking trials (8 forward, 8 backward) at each of three different grades (0%, +15%, +39%) on a custom ramped walkway [5]. Starting positions were adjusted so each subject struck the force plate with their self-selected limb (8R, 1L). Each participant started at 0% and walked at a self-selected pace; for all subsequent forward trials the stance time was constrained to ±5% of his/her 0% average stance time.

Ground reaction forces (GRF) were sampled at 1200 Hz from a Bertec force platform concealed flush with the walkway surface. Kinematic data were captured at 60 Hz using a six camera Peak 3D Optical Capture system. GRF and kinematic data were exported to in-house software for inverse dynamics calculations. Joint moment and power data were normalized to 300 points over the stride (200 stance, 100 swing) and then ensemble averaged across all subjects for each grade.

RESULTS AND DISCUSSION

The joint moments and powers at the knee joint during backward and forward upslope walking are presented in Figure 1. The knee joint moment during the second half of stance in backward walking is dominated by a large extension moment that is not present in forward walking. The joint power data indicates that the knee extensors act concentrically during the entire stance phase of backward walking. During forward upslope walking the eccentric knee extensor activity also decreases from that at level forward walking, but the demands are much lower than during backward upslope walking. In both activities, the decrease in (or lack of) eccentric quadriceps activity may reduce the patellofemoral joint stresses that are often associated with anterior knee pain [3]. In addition, the large increases in the activity of the knee extensors during backward upslope walking may be useful for strengthening these muscles, a frequent goal in knee rehabilitation. Backward upslope walking also utilizes a greater range of knee joint motion (another common rehab goal) compared to forward upslope walking. In conclusion, backward upslope walking may be a more effective exercise than forward upslope walking for knee rehabilitation, although it is a more difficult task and may not be appropriate for all patient populations.

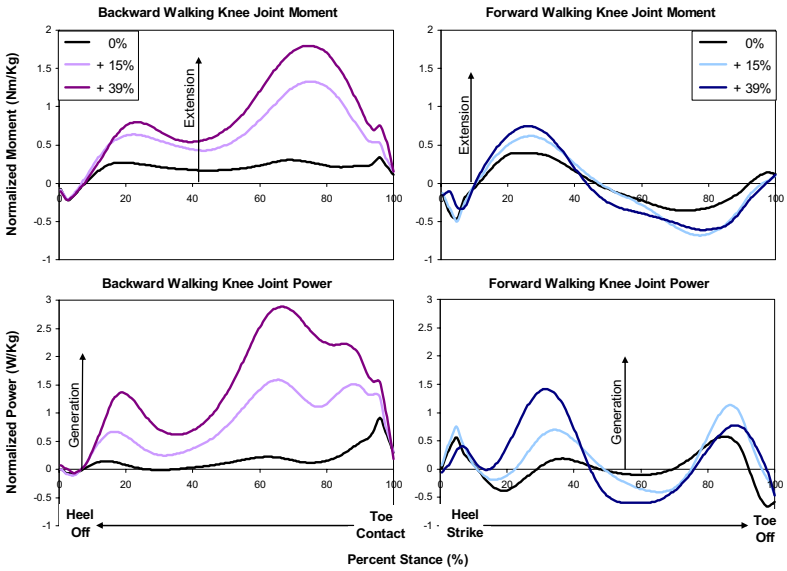

Figure 1: Backward (time-reversed such that the tasks are kinematically similar in time) and forward upslope walking joint moments and powers, ensemble averaged across subjects.

REFERENCES

1. Flynn TW, et al. *Med Sci Sports Exerc* **26**, 89-94, 1994.
2. Terblanche E, et al. *Int J Sports Medicine* **25**, 1-6, 2004.
3. Cipriani DJ, et al. *J Orth Sprt Phys Ther* **22**, 95-102, 1995.
4. Lange GW, et al. *J Orth Sprt Phys Ther* **23**, 294-301, 1996.
5. Lay AN, et al. *J Appl Biomech*, In Press.

ACKNOWLEDGEMENTS

This work is supported by a NSF GRF.