

Effects of self-paced incline treadmill walking on lower limb muscles activation level

Chenmiao Lu¹, Mohammad Al-Amri^{1,2}

¹School of Healthcare Science, Cardiff University, Cardiff, UK

² Arthritis Research UK Biomechanics and Bioengineering Centre, Cardiff, UK

Corresponding author email: Al-AmriM@cardiff.ac.uk

Summary

The aim of this study was to investigate the effects of incline walking on muscle activation level of biceps femoris (BF), soleus (SOL), and tibialis posterior (TP). Subjects included 28 able-bodied volunteers walked at level and inclined self-paced instrumented treadmill. Uphill walking increased the muscle activation level of BF and SOL, while downhill walking increased muscle activation level of TP. Our findings suggest that inclined walking affects lower limb muscle activation level to maintain a comfortable and safe gait in able-bodied individuals.

Introduction

Gait requires active neuromuscular control to maintain stability [1]. This is done primarily by recruiting appropriate leg muscles in response to changes in environment, which are most active during ground-level walking. Those changes, for example, are accompanied by differences in joint kinematics and kinetics in the hip, knee, and ankle during incline walking [4]. Biceps femoris (BF), soleus (SOL), and tibialis posterior (TP) are crucial in maintaining ankle and knee stability during walking [1]. Limited literature demonstrates that inclined walking requires additional muscles activity to maintain gait stability than level-ground walking [2]. This has been subject to a small number of gait cycles on inclined surfaces in a laboratory or to a fixed speed treadmill. A reliable self-paced treadmill mode in combination with a speed-matched virtual reality has been introduced to overcome these limitations. The aim of this study was therefore to explore the effect of incline self-paced walking on muscle activity level of BF, SOL and TP.

Methods

Twenty-eight healthy subjects (age: 25.02±2.06 years) walked on an instrumented dual-belt treadmill at the inclination angles -8°, 0°, and 8° for 3 minutes after providing written informed consent. The treadmill is integrated with the GRAIL system (Gait Real-time Analysis Interactive Lab, Motek Medical B.V.) that also consists of a synchronized virtual reality system projected in a 180° screen and a 10-camera Vicon tracking system (Oxford Metrics, UK). Reflective markers

were placed using the Motek Human Body Model2 (HBM2) lower limb marker set. Estimated muscle activation levels (F/Fmax) were obtained from the HBM2. The peak muscle forces activation levels of BF, SOL and TP were further analysed in Matlab R2017 (The Mathworks Inc., USA). Repeated measures ANOVA and Freidman test were used to explore the effect of inclines in lower limb muscle activity and gait stability. The level of statistical significance was set at $p < 0.05$.

Results

Descriptive statistics of activation level of muscles are presented in Table 1. The muscle activations of BF and SOL were significantly ($P < 0.001$) increased and decreased during uphill walking and downhill walking, respectively. Whilst SOL activity level was significantly reduced during uphill compared to level and downhill walking. Downhill walking significantly increased muscle activation level of TP while it was significantly decreased during uphill walking.

Discussion and Conclusion

The results show that BF and SOL are most active during uphill, which indicate that uphill walking would be challenging for individuals with weak BF and SOL. TP activation level was increased by approximately 60% during downhill walking compared to other two gait conditions. This can be explained by the reason that more ankle plantarflexion is needed during downhill. The effects of incline self-paced walking on muscle activity level of BF, SOL and TP provide basic knowledge for clinical training. Taken together, this suggests that it is important to consider incline walking exercise as part of such neuromuscular training programme in order to increase lower limb muscles activity. However, further work should explore the effects of incline walking on muscles activation level in individuals with an injury.

References

- [1] Jonkers, I. et al. 2003. *Gait & Posture*, **17**: 264-272
- [2] Lay, A. N. et al. 2006. *J Biomech*, **39**: 1621-1628.
- [3] Lay, A. N. et al. 2007. *J Biomech*, **40**: 1276-1285
- [4] Pickle, N. T. et al. 2016. *J Biomech*, **49**: 3244-3251

Table 1: Descriptive statistics (means and standard deviations (SD)) of muscle activations during three walking conditions **BF:** Biceps Femoris; **SOL:** Soleus; **TP:** Tibialis Posterior **P₁:** P value of Free walking and Downhill walking; **P₂:** P value of Free walking and Uphill walking; **P₃:** P value of Downhill and Uphill walking

	Free walking Mean(±SD)	Downhill walking Mean(±SD)	Uphill walking Mean(±SD)	P value		
				P ₁	P ₂	P ₃
BF	0.19(0.06)	0.13(0.06)	0.65(0.49)	<0.001	<0.001	<0.001
SOL	0.42(0.11)	0.28(0.14)	0.40(0.10)	<0.001	0.235	0.002
TP	0.26(0.13)	0.86(0.31)	0.13(0.05)	<0.001	<0.001	<0.001