

Toe clearance when walking in people with unilateral trans-tibial amputation: Effects of passive hydraulic ankle

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Summary

The minimum toe clearance (MTC) mechanism in the swing phase of trans-tibial amputee gait was studied. The comparative effects of 2 different foot mechanisms, fixed ankle versus hydraulic ankle were examined.

Method

Components: Trans-tibial prostheses fitted with a range of dynamic response feet with fixed ankles as the habitual foot (habF). The feet exchanged with a hydraulic ankle (hyA-F, Echelon).

Measurements: Kinematics, 3D motion capture gait lab (Vicon).

Subjects: 21 active unilateral trans-tibial amputees (18 male, 3 female; 48.2±12.8 years; 87.4±13.2 kg).

Data collection protocol: Prosthetic intervention and exchange of the habF with hyA-F after period of acclimatisation, collected in 2 separate blocks, 10 walking trials at a speed perceived to be comfortable for each foot.

Analysis: 3D kinematic modelling, minimum toe clearance (MTC), repeated measures ANOVA, with post hoc analysis.

Results

Mean MTC was significantly affected by foot type ($p=0.03$) and by limb ($p=0.04$). MTC increased for both limbs when using a hyA-F compared with habF (2.17 vs 1.90cm) and was also greater on the sound side compared to the prosthetic limb (2.20 vs 1.91 cm). The mean foot angle at MTC was significantly affected by foot type ($p=0.01$). Mean MTC on the prosthetic was greatest with the hyA-F compared to habF (2.07 vs 1.76cm). The foot angle was reduced (indicating a slightly less toes down angle) on the prosthetic side compared to sound side (-17.7° vs -20.8°). The reduction in foot angle was only significant on the prosthetic side (4.8°). Mean walking speed was significantly greater using the hyA-F compared with when using the habF ($p<0.001$). Irrespective of foot type there was no significant correlation between walking speed and MTC.

Conclusion

The authors conclude that MTC is increased with use of a hydraulic ankle, and that this may reduce the risk factor for falling. Moreover while increased MTC variability on the prosthetic side was observed it did not contribute to any added increased risk of tripping. The increased MTC is partly driven by the dorsiflexed position of the ankle in swing phase.

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