Biomechanics of ramp descent in unilateral trans-tibial amputees: Comparison of a microprocessor-controlled foot with conventional ankle–foot mechanisms

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Summary

A microprocessor-controlled ankle-foot device was compared to the more conventional mechanical device, in terms of its effect on gait parameters during ramp descent.

Method

Components: Elan, Epirus

Measurements: 3D gait analysis, temporal-spatial parameters

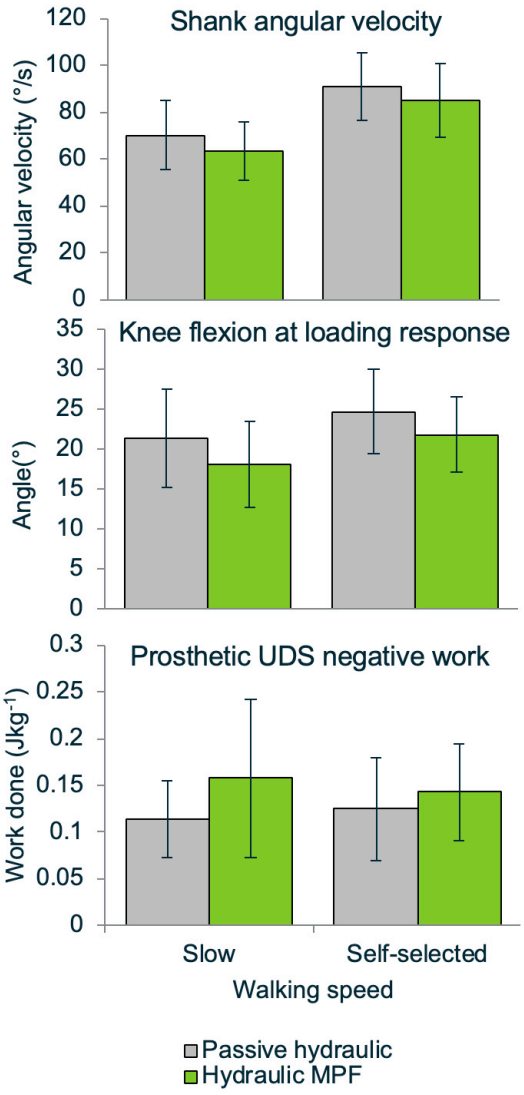
Subjects: Nine K3, unilateral, trans-tibial amputees (41.2±12.9 years; 74.14±15.7 kg)

Data collection protocol: Subjects repeatedly walked down a 5° ramp while gait analysis was performed for a slow walking speed and a self-selected speed. They would either have a rigid attachment ankle ('elastic'), a hydraulic ankle with settings optimised for level walking ('non-MPC') or a hydraulic ankle with intelligence to adapt to slope walking ('MPC').

Analysis: Residual limb kinematics, joints moments/powers and prosthetic foot power absorption/return were averaged across trials for each subject and normalised to body-weight. Kolmogorov-Smirnov tests indicated normal distributions and a repeated measures ANOVA was used to compare across ankle types and speed categories. To assess the effects of habitual use of prosthesis in some subjects, analyses were repeated using a mixed-design ANOVA with the patient's habitual foot as a 'between factor', Significant results were analysed using post-hoc Tukey HSD tests.

Results

Foot-flat occurred earliest with the rigid ankle foot and second earliest with the MPC ($p<0.001$); it occurred later at the slower speed across both foot types ($p<0.001$). Prosthetic shank single-support mean rotation velocity ($p=0.006$) and residual knee flexion ($p<0.001$) were reduced by walking speed and use of the MPC. Negative work done was decreased at the residual knee ($p=0.08$) and increased in the prosthetic side ankle-foot ($p<0.001$) when using the MPC, irrespective of speed. This suggests a reduction in sound side compensation.



Conclusion

The authors conclude that using MPC hydraulic feet will reduce the biomechanical compensations used to walk down slopes. Unilateral trans-tibial amputees often report difficulty with descending slopes more slowly – the increased negative prosthetic ankle work during stance phase illustrates the increased resistance to dorsiflexion, or 'braking effect' provided by the MPC. The reduced prosthetic shank rotation velocity in single support when using the active hydraulic ankle suggests that this technology helps to control descent speed, improving the safety of the user.

Products with Related Technology:

Linx, Elan