

A biomechanical assessment of hydraulic ankle-foot devices with and without microprocessor control during slope ambulation in trans-femoral amputees

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Summary

The biomechanical effects of a rigidly-attached foot, a passive hydraulic ankle and a microprocessor-controlled hydraulic ankle were measured during slope ascent and descent for trans-femoral amputees. The hydraulic ankles showed improved bio-mimicry in both walking conditions and better prosthetic knee stability during slope descent.

Method

Components: Esprit, Echelon, Elan

Measurements: 3D gait analysis on a 5° slope

Subjects: Five active unilateral, trans-femoral amputees, K3/4 (all male, 42±17years, 107±16kg, 1.83±0.02m) and 14 non-amputee subjects (5 male, 9 female, 26±2 years, 68±15kg)

Data collection protocol: Each of the amputees used a fixed ankle, a passive hydraulic ankle or a microprocessor-controlled hydraulic ankle with their habitual prosthetic knee. 3D gait analysis recorded kinematic and kinetic data as the subjects walked up and down a 5° slope. The control subjects also performed these tests. The amputees were also asked to complete a feedback questionnaire.

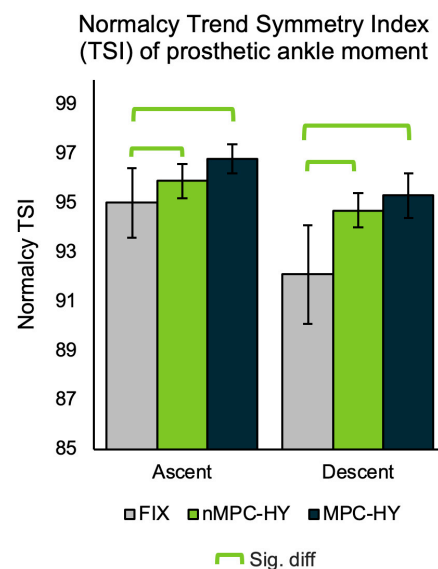
Analysis: Trend Symmetry Indices (TSI) were calculated for symmetry between prosthetic and sound limbs and for 'normalcy' (compared to control subjects). Shapiro-Wilk tests were used to assess data normality and repeated measures one-way ANOVA tests were performed for walking condition and for prosthetic foot. Post-hoc analyses were conducted with post-hoc Tukey tests.

Results

The mean walking speeds were not significantly different across prosthetic conditions. The hydraulic ankles presented an increased range of motion, compared to the rigidly-attached foot, as well as improved bio-mimicry of the prosthetic ankle moment, indicated by the normalcy TSI. In addition, the hydraulic ankles increased mid-stance external prosthetic knee extensor moment during downhill walking. Compared to the passive hydraulic ankle, the microprocessor hydraulic ankle further improved these parameters, significantly increasing mid-stance external prosthetic knee extensor moment during downhill walking ($p=0.027$). Subjects thought that the hydraulic ankle offered improvements over the fixed ankle, specifically highlighting the improved safety offered when descending slopes.

Conclusion

The authors conclude that the major benefits of hydraulic ankles, compared to rigidly-attached feet, are slope adaptation during gradient walking and increased safety during slope descent. The improved range of motion and normalcy TSI values indicate better adaptation to the slope. The increase in prosthetic knee extensor moment during mid-stance is interpreted as improved knee stability, allowing a safer descent. The microprocessor hydraulic ankle further improved knee stability in slope descent compared to the passive hydraulic ankle.



Products with Related Technology:

Linx, Elan, Echelon, EchelonVT, EchelonVAC, Avalon