Immediate Effects of a New Microprocessor-Controlled Prosthetic Knee Joint: A Comparative Biomechanical Evaluation

Summary of Findings

Reference

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This was an intervention, cross-over study with repeated measures investigating the immediate biomechanical effects after transitioning from a C-Leg to a Genium prosthetic knee joint. The study enrolled 11 subjects (mean age: 36.7 ± 10.2 yrs SD). All study subjects were transfemoral amputees, experienced C-Leg users, and had functional classification levels of K3-K4. Subjects were initially tested with their C-Leg on day 1 and then switched to the Genium. Only the prosthetic knee was changed. Subjects then trained for a half-day with the Genium and were allowed an additional half-day of accommodation after which identical testing was conducted on day 2 using the Genium. Immediate biomechanical improvements were experienced with the Genium as compared to the C-Leg.

Results

Level Ground Walking

Improved Step-Length Symmetry: Active above-knee amputees typically take longer steps with the affected side when walking on level ground. This often results in compensatory movements on the sound side. The Genium knee provides 4° of pre-flexion at initial contact, resulting in increased step-length symmetry. Compared with C-Leg, the Genium reduced the mean asymmetry of the step length in all walking velocity tests, and was statistically significant (p<0.05) at both slow and mid walking speeds.

Swing Phase Control (Knee Flexion Symmetry): Insufficient flexion (bent knee) during the swing phase can result in inability to clear the foot, which may result in a stumble or fall. Physiologically, independent of velocity, the knee should be flexed between 60° and 65° during swing phase. During testing, the mean knee flexion for the C-Leg increased by 14.6° as velocity increased by 1m/s, while Genium stayed constant at 63.8°, indicative of a more natural gait pattern.

Taking Small Steps: Transfemoral amputees often find themselves in unsafe situations when transitioning from stance into swing phase while taking small steps. With the C-Leg, switching was not initiated in 24.7% of all tests, and with the Genium, it was not initiated in only 4.9%. Thus, Genium enabled safer small step walking as compared to C-Leg.

Inclines and Declines

Standing on a 10° Decline: The Genium accepted a higher load than the C-Leg (p<0.05), thus giving relief to the same side hip joint and reduction of postural sway (P<0.01)

Improved Walking on Ramps: Genium mean knee flexion angles were significantly increased (p<0.01), compared to C-Leg, both when ascending and descending ramps.

Descending Stairs: Genium mean knee flexion moment was significantly increased (p<0.05) compared to C-Leg when descending stairs, with resulting decrease in sound-side ground reaction forces.

Ascending Stairs: The conventional method for ascending stairs with a prosthetic knee is to take 2 steps at a time with the sound-side limb and lift the prosthetic side to the level of the same step. With the Genium, the subjects ascended stairs step-over-step. When step-over-step (Genium) was compared to the conventional method (C-Leg), gait parameters that more closely approximate those seen in unaffected users (including more physiologic movement of both the sound side and affected side, reduced loading on the sound side knee joint, and more physiologic usage of the residual limb) were significant in favor of Genium (p<0.01).