INTRODUCTION

Walking with a transfemoral prosthesis is a non-trivial task due to the mechanically-passive nature of most prosthetic knee units. Unlike the active, muscular control of an anatomical knee joint, persons with transfemoral amputation must learn to coordinate flexion and extension of an unactuated degree of freedom by implementing a control strategy that exploits the inter-segmental coupling of their residuum and prosthetic knee extension. Prosthetists may easily adjust to alignment perturbations during level walking tasks. Persons with transfemoral amputation may therefore require less adaptation to prosthetic knee units. Unlike the active, muscular control of an anatomical knee joint, persons with transfemoral amputation must learn to coordinate flexion and extension of an unactuated degree of freedom by implementing a control strategy that exploits the inter-segmental coupling of their residuum and prosthetic knee extension. Prosthetists may easily adjust to alignment perturbations during level walking tasks. Persons with transfemoral amputation may therefore require less adaptation to prosthetic knee units.

METHOD

Subjects: Five male subjects with traumatic, unilateral, transfemoral amputation (age 52±12 years; mass 88±3 kg; height 176±3 cm). All subjects were classified as ≥K3 ambulators by a certified prosthetist.

Apparatus: Gait data were acquired using a modified Helen Hayes marker set (Kadaba, 1990), an 8 camera, Eagle Digital RealTime motion capture system (MAC, Santa Rosa, CA), an iPecs™ load cell (College Park Industries, Fraser, MI), a single-belt treadmill (Cosmed, Rome, Italy), and EMG electrodes placed on the major muscles of the residuum and lumbar spine (Noraxon USA, Inc., Scottsdale, AZ).

Procedures: Subjects wore a standardized prosthesis comprising of their existing socket, an Otto Bock 3RS5 knee, a rigid pylon, and an Otto Bock 1D35 foot. In total, 3 alignment conditions were investigated: B-manufacturer’s recommended bench alignment; A2-anterior knee translation (2 cm); P2-posterior knee translation (2 cm). A certified prosthetist performed all alignment adjustments. Gait data were collected for each condition while subjects walked on a treadmill (harnessed and hands-free) at a constant, freely-selected walking speed. Alignment conditions were randomized; subjects were blinded to the condition.

RESULTS

Peak knee flexion torques significantly decreased for the A2 condition (p=0.02) and increased for the P2 condition (p=0.002) compared with baseline. In contrast, peak hip flexion (p=0.4) and extension (p=0.3) torques were less affected by the same alignment changes. For the subject shown in Figure 1, mean activity of most muscles increased for A2 and decreased for P2, particularly during the first 40% of stance phase.

DISCUSSION & CONCLUSIONS

Preliminary results from this study indicate that muscle strategies at the hip joint scale with variations in prosthetic knee joint alignment, while net hip torque strategies remain relatively invariant during level walking tasks. Persons with transfemoral amputation may therefore require less adaptation to prosthetic knee units. Unlike the active, muscular control of an anatomical knee joint, persons with transfemoral amputation must learn to coordinate flexion and extension of an unactuated degree of freedom by implementing a control strategy that exploits the inter-segmental coupling of their residuum and prosthetic knee extension. Prosthetists may easily adjust to alignment perturbations during level walking. Therefore, the effect of prosthetic alignment perturbations may be better assessed during gait tasks that are more mechanically demanding. Future work will focus on the effect of prosthetic alignment during sloped walking in which knee joint stability and controllability are considerably challenged.

REFERENCES


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