CYCLING WITH A TRANS-TIBIAL AMPUTATION: MOTOR ADAPTATIONS TO POSTERIOR-ANTERIOR CLEAT POSITION

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INTRODUCTION

Cycling, as a form of recreation and exercise, is growing in popularity for individuals with a trans-tibial amputation (AMP-TTA). Alignment of the body relative to the bicycle, i.e. bicycle fit, can alter how a person is able to propel the bicycle and yet little is known on the relationship between bicycle fit, prosthetic alignment, and cycling performance. In particular, the anterior/posterior relationship of the socket relative to the cleat should alter how loads can be transmitted to the pedal. This relationship has shown to effect ankle moment and muscle activation in cyclists with two intact limbs (Ericson et al., 1985). Therefore, this should also affect how someone can control the prosthesis and ultimately cycling performance when pedaling with a uni-lateral transtibial amputation. In this study, we analysed the relationship between posterior translation of the cleat relative to the socket during cycling and the response in the amputated limb using joint moments and muscular activity changes. We hypothesize that by translating the cleat of AMP-TTA individuals posteriorly on the individual's shoe, we can influence the superior hip extensors, namely the gluteus maximus.

METHOD

Eight TTA (34.1 ± 8.7 yrs, 1.83 ± 0.08 m, 83.8 ± 14.9 kg) and a group of nine intact subjects (34.7 ± 8.8 yrs, 1.82 ± 0.05 m, 82.4 ± 11.7 kg) provided written informed consent to participate in for this IRB approved study. Subjects pedaled at a constant cadence and torque of 90 rpm and 15Nm respectively. A Helen Hayes marker set in combination with a six infrared camera system (Peak Motion Systems) recorded lower limb kinematics at 60 Hz. Dual piezoelectric element force pedals (Broker & Gregor 1990) recorded pedal reaction forces at 300 hz. Muscular activity was recorded at 1000 Hz using surface electromyography (Noraxon 1400). Control or anterior position of the cleat was in the center of the foot in the coronal plane and aligned with the subject's first metatarsal head on his or her sound limb in the sagittal plane, the posterior position was 40% the distance between the ankle joint and the anterior position. Data was recorded for thirty seconds after two minutes of cycling at each condition. Ten consecutive crank cycles were time normalized to 100 datapoints and averaged together per subject and condition. Moments at the joints were calculated using inverse dynamics based on pedaling kinetics and limb kinematics (Broker & Gregor, 1990). Amputated (AMP-TTA) side hip extension moment, gluteus maximus EMG activity, and work asymmetry variables in the anterior and posterior cleat positions were compared using a paired T-Test.

RESULTS

Results showed an increase in average hip joint extension moment from -37.4 (±9.9) to -47.3 (±12.1) (P=0.01) between the cleat in the forward and posterior positions. Gluteus maximus activity in the posterior position increased from 0.30 (±0.04) to 0.85 (±0.97)(P=0.15). Work asymmetry of the AMP-TTA group was dropped from 24.5 (±10.1) to 20.5 (±11.3)(P=0.56) when the posterior cleat position was used.

DISCUSSION

Hip extension moments for AMP-TTA were significantly increased during posterior cleat position trials when compared to the forward location. Work asymmetry during the pedaling cycle did decrease, although the results did not show a significant difference between the control or the posterior locations.

CONCLUSION

Our most significant finding was that we were able to significantly increase the extension moment at the hip of the AMP-TTA group by translating the pedal posteriorly relative to the socket. This suggests a hip based strategy was used by the subjects and incorporated larger muscle groups, such as the gluteus maximum. By understanding the biomechanical principals involved in adapting to posterior-anterior translation of the pedal interface of cyclists with a trans-tibial amputation, we can better assist these individuals in the areas of rehabilitation and recreation. In addition, by decreasing the amount of work asymmetries between the sound and amputated side, we can increase the performance of the intact limb by allowing operation at a lower output for a given load (Childers et al., 2011).

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