INTRODUCTION

People with an amputation are more likely to experience joint degeneration related to asymmetry in joint kinetics between the sound and amputated limbs (Baker & Hewison, 1990). It is common within clinical practice to “optimize” the movements of persons with amputation by adjusting the prosthesis i.e. adjusting task mechanics, so they gravitate toward symmetrical joint kinematics and presumably more symmetrical joint kinetics (Kapp, 2004) during the stance phase of gait. This clinical practice assumes a relationship between symmetrical joint kinematics and joint kinetics. Prior research has shown a poor correlational relationship between kinematic symmetry and performance measures (Baker & Hewison, 1990) and little research exists establishing a more direct relationship.

The relationship between kinematic and kinetic asymmetries has been explored during gait yet these studies require visual feedback thus introducing the confounding effect related to motor control from supraspinal centers (Dingwell et al., 1996). Cycling is a rhythmic motor task similar to walking yet provides a method to maintain the limbs within a closed kinematic chain with potentially less supraspinal involvement. In addition, kinematic asymmetries may be minimized for example, by shortening the crank arm on the amputated side (Childers et al., 2009).

The purpose of this research was to shorten the crank arm on the amputated limb to reduce asymmetries in joint kinematics and measure the effect on limb output during a cycling task.

METHOD

Subjects: A group of eight TTA (34.1 ± 8.7 yrs, 1.83 ± 0.08 m, 83.8 ± 14.9 kg) volunteered for the IRB approved study. Subjects used cycling for recreation.

Procedures: The subjects pedaled at a constant torque of 15Nm and a constant cadence of 90 rpm (~150 watts). Subjects pedaled with 173mm length crank arm on sides (Control) and with the crank arm length shortened to 165mm on the amputated side (CRANK). Pedaling kinetics and limb kinematics were recorded following protocols in prior research (Broker & Gregor 1994).

Analysis: Mean joint angle and range of motion (ROM) were calculated for both limbs. Work asymmetry was calculated to demonstrate differences in pedaling kinetics. Mean hip and knee flexor and extensor moments were calculated.

Joint/pedal kinetics and joint kinematics were compared using paired t-tests.

RESULTS

The CRANK condition significantly reduced hip and knee ROM in the amputated limb compared to the control condition. In addition, there were no significant differences in joint kinematics between the sound and amputated limbs during the CRANK condition.

Pedaling asymmetry did not demonstrate significant differences and was 23.0 ± 9.8% and 23.2 ± 12% for the control and CRANK conditions respectively.

DISCUSSION

Our results demonstrate a shortened crank arm on the amputated limb will minimize kinematic asymmetries. Despite the minimization of kinematic asymmetries these subjects still pedaled with significant kinetic asymmetries. These data suggest more detailed studies require discussion of both kinematic and kinetic measures.

CONCLUSION

Kinetic symmetry may not be the goal of the motor system, even in the presence of kinematic symmetry. Instead, a person with an amputation will make motor adjustments within the remaining limbs in order to utilize the mechanical properties of the prosthesis and contend with the interface between the residuum and the prosthesis. Taken together, a more important goal during rehabilitation would be to enable the person to perform a functional task, e.g. locomotion, with the understanding there will be motor adjustments rather than simply setting the rehabilitation goal toward symmetrical kinematic output.

Clinicians have historically used visual gait analysis to “optimize” prosthetic alignment while assuming a cause/effect relationship between limb kinematics and limb kinetics. However, this research demonstrates a poor relationship between these variables and encourages the clinician to include measuring limb kinetics to aid in prosthetic alignment.

REFERENCES