INFLUENCE OF PARTIAL FOOT AMPUTATION ON SAGITTAL GAIT MECHANICS AND LOCOMOTOR FUNCTION

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INTRODUCTION

Prosthetic management of the partial foot residuum aims to replace anatomical motion and flexibility of the foot. Substituting the shoe filler with the rigid forefoot lever of the prosthesis improves the ability to generate vertical and propulsive forces during terminal stance. The centre of pressure however remains over the support of the ankle joint (Pinzur, 1997). During the second half of stance high pressures on the distal plantar aspect of the residuum limit development of torque at the time in normal gait when the posterior calf muscles are generating power. The purpose of this study was to examine the relative contribution of the plantar flexors in support and propulsion during partial foot amputee gait and the subsequent influence in the interaction between the hip, knee and ankle joints in inter-segmental coordination.

METHODS

Two unilateral Syme level amputee, one bilateral partial foot amputee and two unilateral partial foot amputees participated in this study. Participants were evaluated in their custom made prosthesis and were instructed to walk at a self-selected pace. Kinematic data was collected with a six camera ExpertVision system (Motion Analysis Corporation, CA) at a sampling rate of 60Hz. Three AMTI force plates (Newton, Massachusetts) collected data simultaneously at 500Hz for the calculation of joint kinetics. All data was processed using Eva and OrthoTrak software (Motion Analysis Corporation, CA) to obtain joint rotations and moments. Angle-angle plots were used to determine the coupling of movements between the ankle and hip joints. Four age and height matched controls provided normative data.

RESULTS AND DISCUSSION

Strategies similar to those identified by Simon et al (1987) were utilised by the participants to ensure support and progression of the trunk was maintained. Figure 1 illustrates the prosthetic side ankle angle and moment for the Syme amputee (A-C) and a typical partial foot amputee (D-F). Sutherland et al (1980) suggested an increase in maximum knee extension and ankle dorsiflexion in terminal stance indicates insufficient muscle force to counter the extrinsic torque of gravity and inertia. This is consistent with the kinetic results which indicate minimal torque and power developed at the ankle in the partial foot amputee group. The Syme level amputees developed a normal shaped plantar flexor moment during stance yet generated limited power during pre-swing. The angle-angle plots identified that the groups altered their control strategy in a very similar manner, utilising rapid hip extension with continued dorsiflexion during terminal stance. Half way through pre-swing, at the point of maximum excursion, there was a simultaneous switch to hip flexion and ankle extension. The generation of hip power was increased and power absorption at the knee was decreased during this phase of the gait cycle.

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<tr>
<th>Symes Level</th>
<th>Partial Foot Level</th>
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<td>A</td>
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Figure 1: Prosthetic side joint angle, moment and power for the Syme amputee (A-C) and a typical partial foot amputee (D-F). Legend: —— 1S.D. Normal — Prosthetic Side

SUMMARY

Regardless of the preservation of the ankle joint and the plantar flexors, the partial foot amputee’s were unable to roll over the prosthesis during late single stance, regardless of the rigid foot lever. Only the Syme amputees utilised sufficient muscle force to decelerate dorsiflexion, restrain knee extension and then move the centre of mass beyond the supporting foot. The inability of the prosthetic foot to plantar flex however minimised the production of ankle power. The level of amputation appears to influence torque development at the ankle, but the essential development of power during pre-swing is absent. The compensatory changes seem to be similar between the Syme and partial foot amputation, with the hip joint synchronising its switch to flexion with maximum ankle dorsiflexion. This position increases the stretch of the hip flexors before they actively flex to initiate toe-off on the prosthetic side.

REFERENCES