A CLASSIFICATION SYSTEM FOR BELOW-KNEE AMPUTEE GAIT MECHANICS

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INTRODUCTION

Multiple prosthetic causes or physical limitations are implicated in the commonly observed gait deviations in below-knee amputees (Esquenazi, 1994). Prosthetic adjustments, gait retraining and/or strengthening programs may be prescribed to correct these specific deviations however each deviation has many potential contributors and an intervention cannot be determined until the primary contributor to the irregular asymmetry has been ascertained. The purpose of this study was to establish a classification system based on the kinematics of the knee joint in the sagittal plane to assist in determining the contributors to asymmetry. The joint moments developed at the knee and ankle joints provide evidence of the cause of asymmetry due to the action of the ground reaction force (GRF) against the toe and heel levers of the prosthetic foot.

METHODS

Four unilateral below-knee amputees whose amputations were due to traumatic causes participated in this study. Prosthetic fit was assessed prior to testing. One participant was tested in two different prostheses with similar componentry, but a change in alignment. All participants wore different types of sockets. Participants 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. Four age and height matched controls provided normative data.

RESULTS AND DISCUSSION

Figure 1 illustrates the two patterns identified in this study; crouch knee gait and mild flexed knee gait (MFK). The red line illustrates data from the same participant. The crouch group is characterized by excessive and persistent knee flexion from loading response through to toe-off. The MFK group is classified by the small increase in knee flexion at initial contact and during mid-stance. The assumption that the prosthetic side knee joint compensates for the lost foot-ankle function and the alteration in the ankle plantar flexion – knee extension couple is supported by this study (Andres, 1990). The knee and ankle joint moments in Figure 1 indicate the crouch group sustained a knee extensor moment pattern during single stance, whereas the knee and ankle joint moments are markedly varied in the MFK group. In the crouch group the participant with a Flex foot (green) produced a relatively normal dorsiflexor moment, suggesting the inability to extend the knee was a consequence of physical causes. The double bump ankle moment pattern generated by the second participant (red) suggests an increase in the length of the heel lever would control the progression of the horizontal GRF. A similar moment pattern was evident in one participant in the MFK group (green), which was associated with a knee flexor moment. A dorsiflexed foot reduces the length of the heel lever resulting in an early heel rise. The two additional participants in this group developed similar moment patterns to those described by Winter and Sienko (1988). The variation in the red ankle moment early stance is associated with a hard heel counter.

**Figure 1**: Individual prosthetic side knee joint angle, moment and ankle joint moment for the crouch group (A,C,E) and the mild flexed knee group (B,D,F). Legend: Computer data (solid line) = Normal Prosthetic Side

SUMMARY

A classification system has been proposed that demonstrates the primary adaptations made due to the inadequate prosthetic ankle/foot system are related to the knee joint. The dominant cause of adaptation was related to the length of the heel lever, with the kinetic patterns resolving the nature of the required adjustment. One participant demonstrated an example of the effect on joint kinematics and kinetics after a change in alignment. This classification system has the potential to identify cause of asymmetry in below-knee amputees and assist in determining intervention strategies.

REFERENCES