HIP AND KNEE FRONTAL PLANE MOMENTS IN PERSONS WITH UNILATERAL, TRANS-TIBIAL AMPUTATION

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INTRODUCTION

Persons with unilateral, trans-tibial amputation demonstrate significant asymmetrical gait patterns. Their gait pattern results from an inability of the affected limb to function normally, most likely the result of pain, weakness, and/or instability. Specifically, the prosthetic limb displays a smaller push-off force, longer swing time, longer step length, and shorter stance time than the intact limb (Mattes et al., 2000). As a result, the intact limb experiences excessive joint loading (Sanderson & Martin, 1997); predisposing it to greater risk of developing degenerative joint disease, e.g., osteoarthritis (OA).

Current literature lacks adequate information to provide a clear understanding of the relationship between gait mechanics and osteoarthritis in amputees; however, previous research on osteoarthritic gait has demonstrated an important link between abnormal joint loading and osteoarthritis of the knee (Sharma et al., 1998) and hip (Hurwitz et al., 1998b).

The purpose of this study was to determine whether a significant difference exists between joint loading of the intact limb versus the prosthetic limb in unilateral, trans-tibial amputees. We hypothesized that peak net internal abduction moments of the intact limb would be significantly greater than the peak net internal abduction moments of the prosthetic limb at both the knee and hip.

METHODS

Five males and one female (M_age = 39.9 ± 11.0 yrs; M_height = 173.7 ± 7.3 cm; M_mass = 87.3 ± 19.5 kg) with a unilateral, trans-tibial amputation served as subjects. All were recreationally active (able to comfortably walk for at least 30 minutes continuously without an assistive device, such as a cane or crutch), and utilized an energy storing prosthetic limb.

Freely chosen walking speed (M_speed = 1.2 ± 0.2 m/s) was calculated from consecutive interruptions of photocells linked to a digital electronic timer. Walking speed was controlled (± 5%) for all trials. To obtain data used in calculating gait mechanics, lightweight reflective markers were placed bilaterally on the legs and feet of the subject using the Cleveland Clinic marker set. Motion analysis cameras captured three-dimensional position data (60Hz) of these markers and a force platform captured ground reaction force data (480Hz) as the subject walked overground along a 20-meter walkway.

Peak net internal abduction moments for the knee (MK_abd) and hip (MH_abd) of both legs were determined using an inverse dynamics approach and normalized to body mass (Orthotrak software, Motion Analysis Corporation). Two dependent t-tests were used to test for significant differences in frontal plane joint moments between limbs (p < .05). Effect sizes (ES) were also calculated where differences existed.
RESULTS AND DISCUSSION

Between limb asymmetries existed for both the knee and hip (Figure 1). $MK_{abd}$ for the intact limb was 66.1% greater than the prosthetic limb ($p < .05; ES = 1.04$). $MH_{abd}$ for the intact limb was 65.9% greater than the prosthetic limb ($p < .05; ES = 1.35$).

![Figure 1](image_url)

**Figure 1.** Peak abduction moments for the intact limb were larger ($p < .05$) than the prosthetic limb for both the hip and knee.

The internal knee abduction moment has been shown to reflect the force distribution between the medial and lateral compartments of the knee joint, where larger knee abduction moments correspond to greater loads on the medial knee versus the lateral knee compartment (Schipplein & Andriacchi, 1991). Sharma and colleagues (1998) reported a significant relationship between the frontal plane knee moment and osteoarthritis disease severity. In our study, $MK_{abd}$ for the intact limb was 0.56 Nm/kg, which is 19.1% greater than normal (approximately 0.47 Nm/kg) reported by Hurwitz and colleagues (1998b). This suggests that the intact limb of unilateral, trans-tibial amputees is concomitantly made more susceptible to degenerative joint disease, specifically OA. Indeed, Melzer and colleagues (2001) reported 65% of unilateral, lower-extremity amputees had some degree of knee OA in the intact limb.

Hurwitz and colleagues (1998a) reported a significant positive correlation between hip joint loads and femoral neck bone mineral density, which may be associated with increased risk of OA. In our study, $MH_{abd}$ for the intact limb was 0.92 Nm/kg, which is 9.5% greater than normal (approximately 0.84 Nm/kg) reported by Hurwitz and colleagues (1998a).

SUMMARY

Individuals with unilateral, trans-tibial amputation have approximately 65% larger peak frontal plane moments for the knee and hip compared to the prosthetic limb. Moreover, moment values for the intact limb are greater than normal values reported in the literature, which is problematic because the non-affected limb may be predisposed to premature degenerative joint disease.

REFERENCES


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