JOINT LOADING AND BONE MINERAL DENSITY IN PERSONS WITH UNILATERAL, TRANS-TIBIAL AMPUTATION

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INTRODUCTION

Persons with unilateral, trans-tibial amputation have an asymmetrical gait pattern, most likely the result of pain, weakness, and/or instability on the prosthetic side. 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).

Previous research on osteoarthritic gait has demonstrated an important link between abnormal joint loading and bone mineral density (BMD). Patients with medial compartment knee OA have large knee abduction moments and elevated proximal tibia BMD (Wada et al., 2001); likewise, larger hip joint moments corresponded to greater proximal femoral BMD in subjects with end-stage hip OA (Hurwitz et al., 1998a). There is an associated link between increased BMD and osteoarthritis, however the causative relationship is not clear (Hurwitz et al., 2001). Osteoarthritis is a degradation of articular cartilage, nonetheless, Radin and Rose (1986) have suggested that OA is initiated by or prompted to progress by increased density of subchondral bone.

The purpose of this study was to examine gait mechanics and BMD in persons with unilateral, trans-tibial amputation. We hypothesized that peak net internal abduction moments and BMD of the intact knee and hip would be significantly greater than that of the prosthetic side.

METHODS

Six males and one female (Mage = 45.7 ± 7.9 yrs; Mheight = 169.2 ± 18.9 cm; Mmass = 98.4 ± 19.9 kg) with a unilateral, trans-tibial amputation served as subjects. All were recreationally active and utilized an energy storing prosthetic limb.

To obtain data used in calculating gait mechanics, lightweight reflective markers were placed bilaterally on the legs and feet of the subject using the Helen Hayes 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 at their freely chosen speed (Mspeed = 1.3 ± 0.2 m/s) overground along a 20-meter walkway. Peak net internal abduction moments for the knee (MKabd) and hip (MHabd) of both legs were determined using an inverse dynamics approach and normalized to body mass (Orthotrak software, Motion Analysis Corporation). BMD of the hip (femoral neck) and knee (medial compartment of the proximal tibia) was measured bilaterally via dual energy x-ray absorptiometry (Hologic Delphi W).

Dependent t-tests were used to test for significant differences in knee and hip frontal plane joint moments and bone mineral density between limbs (p<.05).
RESULTS AND DISCUSSION

$\text{MK}_{\text{abd}}$ for the intact limb was 71.8% greater than the prosthetic side (Figure 1). The between limb difference in mechanical loading is reflected in the intact proximal tibia BMD which was 54.1% larger than the prosthetic side (Figure 2). $\text{MK}_{\text{abd}}$ for the intact limb was 0.53 Nm/kg, which is 12.7% 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 et al (2001) reported 65% of unilateral, lower-extremity amputees had some degree of knee OA in the intact limb.

For the intact limb was 0.86 Nm/kg, which is 2.4% greater than normal (approx 0.84 Nm/kg) reported by Hurwitz et al (1998a).

![Graph showing peak internal abduction moment for intact and prosthetic sides.](image)

**Figure 1.** Peak internal abduction moments for the intact limb were larger (p<.05) than the prosthetic side.

$\text{MH}_{\text{abd}}$ for the intact limb was 37.5% greater than the prosthetic limb (Figure 1). The between limb difference in mechanical loading was also evident in the intact femoral neck BMD which was 10.9% greater than the prosthetic side (Figure 2). 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, $\text{MH}_{\text{abd}}$

![Graph showing bone mineral densities of knee and hip for intact and prosthetic sides.](image)

**Figure 2.** Bone mineral densities of the knee and hip were greater for the intact limb than for the prosthetic side (p<.05).

SUMMARY

Individuals with unilateral, trans-tibial amputation have greater mechanical loads on the intact knee and hip, which is reflected in the BMD at the knee and hip. Increased BMD may indicate risk of osteoarthritis.

REFERENCES


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