Patient Perception of Socket Fit may not be Associated with Gait and Loading Characteristics in Individuals with Transfemoral Amputations

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INTRODUCTION: As of 2017, 57.7 million people were living with a traumatic limb amputation worldwide[1]. Secondary musculoskeletal conditions, including contralateral hip and knee osteoarthritis and ipsilateral hip osteoporosis, commonly occur after lower limb amputation due to compensatory changes in gait mechanics which have been linked, in part, to poor prosthetic fit[2]. Current methods for evaluating prosthetic fit are dependent upon clinician expertise and qualitative patient feedback[3]. Complex quantitative tools such as socket pressure monitors[1] and inertial measurement units[4] have been developed to improve these processes and provide clinicians with new information that could inform their practice[3,5,6]. However, it can be difficult to determine the extent to which these technologies improve upon current practice due to the paucity of literature investigating the relationship between patient feedback and gait or loading characteristics. The aim of this interim analysis of an ongoing study is to determine if a patient's perception of socket fit is associated with their gait kinematics and kinetics. We hypothesized that individuals with transfemoral amputation would demonstrate greater lateral trunk lean, greater asymmetry in lower extremity kinematics, and greater contralateral limb loading with poorly rated sockets compared to highly rated sockets.

METHODS: Individuals with unilateral transfemoral amputations who had been ambulating with their prosthesis for more than a year provided written informed consent to participate in this IRB approved study[7]. Participants were casted and fitted by a licensed prosthetist with 3 to 7 custom check sockets which varied in stiffness, brim height, cross-sectional area, and shape. During lab visits, participants wore a set of 53 reflective markers placed on their trunk and lower extremities. They then walked across a 10m lab walkway at a self-selected pace 4 times per socket. Trunk and sagittal plane lower extremity kinematics were collected using a 12-camera Vicon motion capture system (100 Hz). Ground reaction forces were collected when participants stepped onto a Bertec dual-belt instrumented treadmill centered in the lab walkway (1000 Hz). Participants rated each socket's comfort and function on a scale of -7 to +7 using the Global Rate of Change (GROC) scale[8], with 0 being their definitive socket. Kinematics, bilateral hip forces, and contralateral knee forces and moments were calculated in Visual3D for 4 to 8 steps per socket, interpolated to percent stance, and averaged per participant and socket type. The highest, lowest, and mid rated sockets based on summed GROC scores were identified. Differences in trunk and lower extremity kinematics, joint moments and forces, and side-to-side differences (SSD) in lower extremity kinematics among the three socket ratings were evaluated using statistical parametric mapping one-way repeated measures ANOVA ($p<0.05$) with post-hoc Bonferroni corrections ($p<0.017$).

RESULTS: Six individuals with traumatic unilateral amputations (1F, age: 56±17 years, height: 179.5±7.7 cm, weight with prosthesis: 80.8±18.2 kg) were included in this interim analysis. The average combined GROC scores used to classify the high, mid, and low rated sockets were -0.5±3.1, -3.7±1.4, and -9.2±2.6, respectively. Between socket differences in trunk and lower extremity kinematics were up to 36.9° with the largest difference occurring in sound knee flexion. The greatest differences in joint moments and forces between sockets occurred in the bilateral hips and were up to 0.4 Nm/kg and 1.0 BW, respectively. No differences were found among sockets in terms of SSD in lower extremity kinematics, trunk kinematics, or lower extremity kinematics during stance phase of gait (Figure 1, $p>0.05$). Additionally, no differences were found in joint forces or moments among the high, mid, and low rated sockets (Figure 2, $p>0.05$).

DISCUSSION: Although the peak between socket differences were relatively large, no differences were found among the high, mid, and low rated sockets in terms of gait or loading characteristics in this preliminary analysis. However, this could be due the small sample size. Additional participants are being tested to verify these findings.

SIGNIFICANCE: Patient-reported socket comfort and function may not correspond to differences in kinematics and kinetics during gait.

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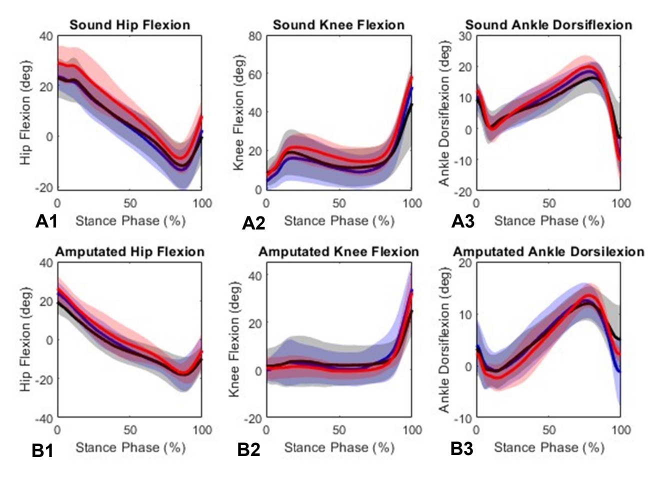

Figure 1: Sagittal plane kinematics in high (blue), mid (black), and low (red) rated sockets for all participants. No differences were found in sound limb (A1-A3), amputated limb (B1-B3), or SSD in lower extremity kinematics (p>0.05).

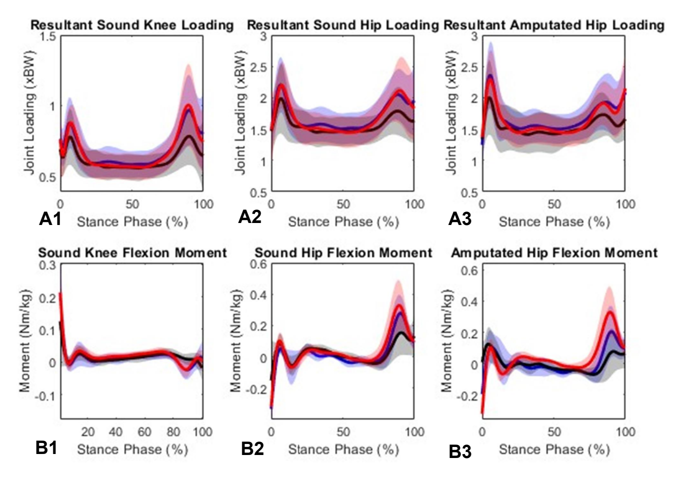

Figure 2: Resultant joint forces and internal flexion moments in high (blue), mid (black), and low (red) rated sockets for all participants. No differences were found in sound knee (A1,B1), sound hip (A2,B2), or amputated hip (A3,B3) forces or moments (p>0.05).