Frontal and Sagittal Plane Lower Extremity Mechanics during Single-Limb Squatting in Chronic Ankle Instability

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**Background**

Chronic ankle instability (CAI) is a common sequelae to the lateral ankle sprain (1). Individuals with CAI have a higher risk of developing osteoarthritis and reporting lower quality of life scores (2,3). Biomechanical variations have been observed in individuals with CAI during ambulation and landing (4,5). The single-limb squat (SLS) is a commonly used clinical assessment. However, to the authors’ knowledge there are no studies investigating the biomechanical profile of the SLS in individuals with CAI.

**Purpose**

The purpose of this study was to perform a bilateral comparison of sagittal and frontal plane joint angles and moments during a SLS in individuals with unilateral CAI.

**Hypothesis**

We hypothesized that inter-limb biomechanical differences would be observed in individuals with unilateral CAI.

**Participants**

All participants were recruited from a university setting and provided written informed consent. Individuals were included if they reported a history of at least 1 ankle sprain > 3 months prior to participation and scored > 10/37 (6) on the Identification of Functional Ankle Instability (IdFAI) scale (Figure 1). Participants were excluded if they had a recent ankle sprain (within the last 3 months), had a history of lower extremity surgery, or had any current lower extremity or spinal injury.

**Methods (continued)**

Participants performed the SLS with their stance limb on the force plate, arms crossed, and their non-stance limb knee flexed to 90 degrees with their thigh vertical (Figure 3). A trial was defined as 3 continuous repetitions at a free speed to maximum depth. Five SLS trials were collected bilaterally.

For the middle squat from each trial, marker trajectories were identified and gap-filled in Vicon Nexus software. Data were then exported as .C3D files for analysis in Visual 3D software (Figure 4) (C-motion, Germantown, MD).

Variables of interest included peak hip, knee, and ankle sagittal and frontal plane joint angles and internal moments, as well as peak vertical ground reaction force. Paired t-tests were performed between limbs using α=0.05.

**Results**

Descriptive data are presented in Table 1, and dependent variables in Table 2.

There was approximately 3 degrees less WB DF ROM (p=0.050) and peak DF angle on the involved limb (p=0.010). The peak plantarflexion moment was approximately 13% less (p=0.008). Post-hoc correlation of WB DF and peak ankle DF showed a moderate relationship (r=0.66).

**Discussion/Conclusions**

Individuals with CAI demonstrated reduced ankle DF during both clinical ROM assessment and during the SLS task. The reduced internal ankle plantarflexion moment supports previous results seen in single-leg landing in those with CAI (5). Frontal plane angles and moments did not differ between limbs.

**Clinical Relevance**

The clinical assessment of WB DF coincided with reduced DF mechanics during the SLS. The data suggest that interventions to increase DF ROM may facilitate improvement in SLS symmetry. The unexplained variance between WB DF and SLS ankle mechanics suggests that factors such as strength, neuromuscular control and kinesiophobia may also affect SLS performance.

**References**

6. Simon et al. (2012). *Foot Ankle Int. 33(9); 755-763.*

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**Table 1: Descriptive data expressed as mean (standard deviation) or frequencies**

<table>
<thead>
<tr>
<th>Sex (F:M)</th>
<th>Age (yrs)</th>
<th>BMI (kg/m²)</th>
<th>IdFAI</th>
<th>Leg Dominance (R:L)</th>
<th>Side of CAI (Dom:NonDom)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.6</td>
<td>23.6</td>
<td>24.34</td>
<td>17.07</td>
<td>14.1</td>
<td>10.5</td>
</tr>
</tbody>
</table>

**Table 2: Bilateral joint angles (degrees), internal moments (Nm/(kg*m)), and ground reaction forces (body weights expressed using mean (standard deviation))**

**Figure 1: IdFAI tool**

**Figure 2: Weight-bearing DF ROM using smartphone inclinometer**

**Figure 3: Example of SLS starting and peak descent positions. Participants maintained arms across chest and contralateral knee flexion.**

**Figure 4: Example of SLS rendering in Visual 3D**

**Figure 5: Sagittal plane ankle angles and moments demonstrated peak differences during the SLS task**