3D Joint Kinematic and 2D Quality of Movement Comparison Between Lateral and Forward Step Downs

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Recommended Citation
Price, Samantha Kaye; Davis, Ryne William; Hinton, Andrew Jonathan; Rowland, Jimmy Lee; Werner, David; and Barrios, Joaquin Alberto, "3D Joint Kinematic and 2D Quality of Movement Comparison Between Lateral and Forward Step Downs" (2021). *Graduate Student Showcase*. 5.  
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3D Joint Kinematic and 2D Quality of Movement Comparison Between Lateral and Forward Step-Downs

Werner D1, Price S1, Davis R1, Hinton A1, Rowland J1, Barrios J1

1 – University of Dayton, Department of Physical Therapy

Background
- Step down analyses are frequently used in clinical settings with the lateral step-down (LSD) and forward step-down (FSD) two common variations.
- The LSD and FSD are both reliable and are commonly used for the assessment of lower extremity pathologies such as patellofemoral pain, anterior ligament reconstruction, and femoral acetabular impingement (1-7).
- Step down kinematics can be influenced by reduced dorsiflexion mobility (8).
- Previous studies have demonstrated altered movement quality in those with pathology during either the LSD or FSD (4,7).
- However, no studies have directly compared the lower extremity movement patterns of the FSD and LSD, using either 3-dimensional (3D) joint angle analysis or 2-dimensional (2D) assessment of faulty movement patterns.

Hypotheses
- 3D: The LSD will require greater lower limb flexion, potentially eliciting or increasing out-of-plane movements compared to the LSD.
- 2D: The LSD will elicit more faulty movement patterns compared to the LSD.

Participants
- Thirty individuals were recruited from a university setting using electronic advertisements.
- All participants provided written informed consent.
- Between 18-40 years of age and identified as healthy. Participants were excluded if they had undergone spinal or lower extremity surgery within the last 9 months or had a spinal or lower extremity injury within the last 6 months.

Methods
- Participants had markers placed on their dominant lower extremity, pelvis, and trunk using an established marker set.
- For the LSD, individuals positioned their toes to the central front edge of the box, while for the FSD, individuals positioned their toes to the central front edge of the box (Figure 2A).
- For the LSD, individuals positioned the medial aspect of their test limb foot along the non-test limb in front of the box (Figure 2A).
- In both tasks, participants lowered the non-test limb heel to the floor and returned to the start position for 6 consecutive repetitions at a self-selected pace.
- 3D marker data were collected using an 8-camera motion analysis system (Vicon, Centennial, CO, 100 Hz).
- For the LSD, the middle 4 repetitions of each task were cleaned and extracted from 3D data using custom LabVIEW code.
- 3D: The middle 4 repetitions of each task were collected concurrently with 3D data using two smartphone cameras (30 Hz, iPhone 7, Apple Inc., Cupertino, CA, USA).
- Videos were assessed by a board certified orthopedic physical therapist using known scoring criteria for the front view and novel criteria for the lateral view (Table 3).
- Using an alpha level of 0.05, paired t-tests and Cohen’s d effect sizes for paired samples were calculated for the 3D data. McNemar’s and Wilcoxon-signed ranks tests were used for the 2D data.

Results
- Descriptive data for all participants is presented in Table 1.
- 3D: The LSD averaged approximately 7° more knee flexion, 4° more ankle dorsiflexion, 1° more hip abduction and 1° more ankle eversion, but 2° less hip flexion than the LSD (Table 2).
- 2D: There were more faults elicited during the FSD than the LSD (Table 4). During the FSD, 24/30 participants demonstrated a fault in steady stance, versus 15/30 during the LSD (p=0.022). 9/30 individuals demonstrated heel rise during the FSD, while 1/30 demonstrated heel rise during the LSD (p=0.021).

Discussion/Conclusion
- The results suggest that the LSD demands greater knee flexion and ankle dorsiflexion at a level that exceeds known minimum detectable differences (9). The remaining significantly different variables were within the error of the measure.
- These findings may suggest that the LSD is a more demanding task than the LSD for patients with reduced tolerance to loaded knee flexion and/or limited ankle mobility.

Clinical Relevance
- Patients with lower extremity conditions may find the FSD to be more challenging than the LSD due to greater flexion requirements, particularly at the knee and ankle.

References
1. Piva et al. (2006) BMC Musculoskeletal Disorders. 7(1).

Table 1: Descriptive data as frequency counts or means (standard deviations)

<table>
<thead>
<tr>
<th>Sex Frequency (M:F)</th>
<th>Dominant Leg (R:L)</th>
<th>Age (years)</th>
<th>BMI (kg/m²)</th>
<th>Dorsiflexion Range of Motion (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:18</td>
<td>25:55</td>
<td>23.5 (1.7)</td>
<td>23.9 (3.3)</td>
<td>42.1 (7.0)</td>
</tr>
</tbody>
</table>

Table 2: Comparison of 3D lower extremity joint angles (degrees) between the LSD and FSD

<table>
<thead>
<tr>
<th>Variable</th>
<th>LSD</th>
<th>FSD</th>
<th>p-value</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Hip Flexion Angle</td>
<td>38.1 (8.5)</td>
<td>36.3 (8.1)</td>
<td>0.001</td>
<td>0.22</td>
</tr>
<tr>
<td>Peak Hip Adduction Angle</td>
<td>17.1 (4.2)</td>
<td>18.3 (4.0)</td>
<td>0.006</td>
<td>0.34</td>
</tr>
<tr>
<td>Peak Knee Adduction Angle</td>
<td>1.0 (6.6)</td>
<td>1.2 (6.9)</td>
<td>&lt;0.001</td>
<td>1.37</td>
</tr>
<tr>
<td>Peak Knee Flexion Angle</td>
<td>2.0 (3.3)</td>
<td>2.3 (3.7)</td>
<td>0.851</td>
<td>0.01</td>
</tr>
<tr>
<td>Peak Knee Adduction Angle</td>
<td>-6.0 (5.2)</td>
<td>-6.1 (5.1)</td>
<td>0.549</td>
<td>0.03</td>
</tr>
<tr>
<td>Peak Knee Internal Rotation Angle</td>
<td>8.8 (6.6)</td>
<td>9.1 (6.8)</td>
<td>0.376</td>
<td>0.04</td>
</tr>
<tr>
<td>Peak Ankle Dorsiflexion Angle</td>
<td>28.3 (4.0)</td>
<td>32.4 (3.9)</td>
<td>&lt;0.001</td>
<td>1.03</td>
</tr>
<tr>
<td>Peak Ankle Eversion Angle</td>
<td>11.5 (2.5)</td>
<td>12.6 (2.6)</td>
<td>&lt;0.001</td>
<td>0.42</td>
</tr>
<tr>
<td>Peak Ankle Abduction Angle</td>
<td>15.1 (4.5)</td>
<td>15.4 (4.7)</td>
<td>0.527</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Table 3: 2D video analysis scoring criteria using Modified Piva criteria

<table>
<thead>
<tr>
<th>Arm Strategy</th>
<th>Pelvic plane</th>
<th>Knee position</th>
<th>Steady Stance</th>
<th>Trunk Alignment</th>
<th>Lateral View</th>
<th>Heel Rise</th>
<th>Forward Lean</th>
<th>Total Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removal of hand from waist</td>
<td>Loss of horizontal plane</td>
<td>Tibial tuberosity medial to 2nd toe</td>
<td>Stepping down on non-tested limb or wattering of the tested foot from side to side</td>
<td>Leaning in any direction</td>
<td>heel rises off box</td>
<td>Ear fully anterior to foot</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: 2D Video Analysis Scoring

<table>
<thead>
<tr>
<th>Lateral View</th>
<th>Front View</th>
<th>Median</th>
<th>Mode</th>
<th>Range</th>
<th>FSD Score</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontal View</td>
<td>2 2 4 2.5 2 3</td>
<td>0.019</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral View</td>
<td>0 0 0 0 2</td>
<td>0.012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined Views</td>
<td>2 3 4 3 2 5</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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