STANDING IN ANKLE PLANTARFLEXION REDUCES LOW BACK PAIN REPORTS DURING PROLONGED STANDING

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INTRODUCTION
A sloped surface that allows people to work while standing in dorsi- or plantarflexion reduces reports of low back pain (LBP) development in people who report LBP during level ground standing[1]. In the study[1], people were allowed to alternate between the incline and decline surfaces. These findings raised the question of why LBP decreased: the alternating posture that would result in small cyclic flexion and extension of the lumbar spine[1,2] or because the majority of time was spent in dorsiflexion, resulting in mild flexion of the lumbar spine [1,2]. As a result, the purpose of this study was to determine if standing solely on a declining surface during an occupational simulation would decrease LBP reports. A secondary purpose was to determine changes in kinematics caused by standing on the declining surface during both acute and prolonged bouts of standing.

METHODS
Seventeen participants (nine male, eight female) aged 18-35 with no history of LBP that required medical intervention or time off work longer than three days, previous lumbar/hip surgery, employment in a job requiring prolonged standing within the last 12 months, and the inability to stand for at least two hours were recruited for this study.

A motion capture system (NDI Inc., Waterloo, ON, 32 Hz) was used to track kinematics during data collection. Rigid bodies were placed on the spine at T9, L1/L2, and sacral levels. Bilateral rigid bodies were also placed on the thighs and feet. Anatomical landmarks for each segment were tracked within the respective rigid body. A 100 mm visual analog scale anchored with “No Pain at All” and “Worst Pain Imaginable” was presented (e-VAS, University of Waterloo) to the participant on a touch screen tablet (iPad 2) to assess LBP development when they entered the lab, at the start of prolonged standing, and every 7.5 minutes during the protocol.

Standing on level ground and a declining surface (16°) were tested on two separate days. The order the participants saw the conditions were randomized. Participants were instructed to “stand as you normally would if you were required to work at a computer workstation. You can lift up each foot, change your foot position, and shift your weight back and forth. You cannot support your body weight on the table or cross your feet”. During the prolonged standing task, participants worked at a computer performing a standardized typing task.

Figure 1. Level ground (left) and decline (right) standing

Once the participant was instrumented, they performed a static standing calibration trial and a maximum lumbar extension trial to determine relative angles. On the day of the sloped protocol, participants performed two 60-second foot constrained trials prior to prolonged standing to assess the acute kinematic differences between the standing positions. Participants then completed a 75-minute unconstrained standing trial while working at the computer workstation.

Participants were categorized as pain developers (PD) based on visual analogue scale scores provided during the level ground standing position if they surpassed a 10 mm increase in their score with respect to baseline[1]. Marker locations were imported into Visual3D (v4, C-Motion, Inc., Germantown, MD, USA) to calculate trunk, lumbar spine, hip angle, and trunk-to-thigh angle were
calculated and expressed with respect to the corresponding angle from maximum extension. The anterior-posterior distance between the location of the trunk center of gravity and joint center of the right angle was also calculated.

For the foot constrained standing trials, outcome measures were entered into a three-way general linear model with between factors of gender, pain group (PD/non-PD) and a within factor of standing condition (level/sloped). For prolonged standing, an additional within factor of time was added to the model. Significance was set at alpha = 0.05.

RESULTS AND DISCUSSION
53% of participants (9/17) were categorized as PD (four males, five females). While standing on the sloped surface, there was a 58% decrease in LBP VAS scores compared to each PD’s maximum VAS on level ground (Figure 1).

![Figure 2: Maximum visual analogue scale scores.](image)

During the foot constrained standing trials, there were no main effects including pain group for the kinematics. The sloped surface induced hip flexion (p=0.035), trunk-to-thigh flexion (p=0.01), and moved the location of the trunk center of gravity posterior compared to level ground (p<0.0001) (Table 1).

During prolonged standing, there was an interaction between pain group and standing condition (p=0.022). During level ground standing, the trunk center of gravity of PDs was on average 1.7 cm more anterior to the ankle than in non-PDs. During the sloped standing condition, the location of the center of gravity moved posterior and was aligned with the ankle joint (non-PD= 0.75 +/- 1.3 cm; PD= 0.83 +/- 1.3 cm).

We hypothesized that when standing on the declining surface the main kinematic change would occur at the lumbar spine[1,2] but this was not the case. Internal measurements while standing on a declining surface corroborate this finding[3]. The sloped surface appears to prompt participants to perform a hip dominant correction, allowing for a postural change without altering the moment induced by the trunk center of gravity at the L5/S1 joint. Also, a more anterior center of gravity with respect to the ankle would result in a greater moment arm with respect to the ankle for the force of the trunk due to gravity in PDs.

CONCLUSIONS
Standing on a sloped surface altered hip and trunk kinematics and may be a reason that self-reports of LBP development are lower in prolonged standing induced PDs when they stand on this surface. These results demonstrate that altering posture that results in mild flexion of the hips and alters the trunk center of gravity location, and not necessarily cyclic movement or isolated postural changes in the lumbar spine, may be responsible for the decreased pain development.

REFERENCES

Table 1. Kinematic changes during foot constrained standing. Note: mean(SD). Asterisks denote significant differences between the standing conditions. Angle: +=flexion. Trunk COG location: +=anterior to ankle.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Trunk Angle</th>
<th>Lumbar Angle</th>
<th>Left Hip Angle*</th>
<th>Right Hip Angle*</th>
<th>Left Trunk-Thigh Angle*</th>
<th>Right Trunk-Thigh Angle*</th>
<th>Trunk COG location (cm)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>22.6(10.6)</td>
<td>15.5(10.2)</td>
<td>9.2(10.5)</td>
<td>9.6(10.1)</td>
<td>31.1(14.3)</td>
<td>31.5(14.0)</td>
<td>4.43(1.94)</td>
</tr>
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<td>Sloped</td>
<td>22.8(10.6)</td>
<td>15.4(10.1)</td>
<td>11.0(11.2)</td>
<td>11.3(10.9)</td>
<td>33.0(14.9)</td>
<td>33.3(14.4)</td>
<td>2.55(1.72)</td>
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