THE INFLUENCE OF WEDGED INSOLES ON KNEE AND ANKLE MOMENTS AND ANGULAR IMPULSES DURING WALKING

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INTRODUCTION

High frontal plane knee joint angular impulse has been associated with patellofemoral pain syndrome (PFPS) and knee osteoarthritis (OA) [1,2]. Interventions that reduce frontal plane knee joint loading may provide clinical benefits. Wedged insoles have widely been proposed as one form of such an intervention. It has been shown that a laterally wedged insole can effectively decrease the peak frontal plane knee moments and reduce knee OA progression [3]. Medially wedged insoles have been associated with a reduced ankle inversion moment during stance [4]. Nevertheless, it is still unknown whether wedged insoles can reduce the knee joint frontal plane moments without increasing the loading in the ankle joint. Therefore, the purpose of this study was to investigate the effects of lateral and medial wedged insoles on knee and ankle joint moments and angular impulses during walking.

METHODS

Ten healthy males (height: 178.6 ± 7.8 cm, mass: 78.1 ± 7.6 kg, age: 25.7 ± 3.1 years) participated in this study. Informed written consent in accordance with the University of Calgary’s Ethics Committee was obtained from all subjects prior to testing.

Each subject performed five walking trials in each of the following conditions: a neutral condition, a 6º lateral wedge (LW6), a 9º lateral wedge (LW9), a 6º medial wedge (MW6), and a 9º medial wedge (MW9). The neutral condition was performed with a neutral running shoe (adidas adiZero Aegis 2.0). Each wedge was made out of ethylene vinyl acetate (EVA) and was inserted into the neutral shoe condition.

Retro-reflective markers were attached to the right shank and shoe and the position of each marker was recorded with an eight camera high-speed motion analysis system at 240 Hz (Motion Analysis Corp., Santa Rosa, CA), while the subjects walked on a 10m walkway at 1.4 m/s. Ground reaction forces were collected at 2400Hz using a force platform (Kistler AG, Winterthur, Switzerland). A walking trial was considered valid if the subject planted their right foot near the middle of the force platform and their walking speed was within 5% of the target speed.

Internal knee and ankle moments were calculated using an inverse dynamics approach with Kintrak 7.0 (Motion Analysis Corp.). The angular impulses were calculated by integrating the joint moments over stance time. A repeated measure ANOVA (α=0.05) was performed in SPSS (SPSS inc., USA) to determine whether there was a wedge effect on the frontal plane knee and ankle joint moments and angular impulses.

RESULTS AND DISCUSSION

The laterally wedged condition decreased knee abduction moment and knee abduction impulse whereas the opposite was found for the medially wedged condition. Statistical differences (p < 0.05) were found between lateral and medial conditions (Table 1). Larger differences were noticed when higher amounts of lateral (LW9) and medial (MW9) wedge were compared. Figure 1 highlights a descending knee abduction moment pattern from the higher medial wedge (MW9) to the opposite higher lateral wedge (LW9), particularly in the first peak. Smaller knee frontal plane loadings have been associated with prevention of the progression of knee OA [3]. Previous prospective studies showed an association between higher knee angular impulse in the frontal plane and PFPS and the severity of knee OA [1,2]. Therefore, the reduced knee frontal plane loadings obtained with the lateral wedge
would possibly prevent PFPS and slow the progression of knee OA. Nonetheless, further studies investigating these particular populations need to be conducted to provide additional insights.

**Figure 1:** Mean time-series knee abduction joint moment across shoe conditions.

On the other hand, the ankle inversion moment and the ankle inversion impulse showed a tendency to increase with the lateral wedges while the medial wedges showed opposite effects (Fig 2). Table 1 details the mean and standard deviation of the ankle joint moments which were statistically different \( (p < 0.05) \) between conditions. Similarly to the knee, the effects of the wedges were more evident when higher amounts of lateral (LW9) and medial (MW9) wedge were compared.

**Figure 2:** Mean time-series ankle inversion joint moment across shoe conditions.

**CONCLUSIONS**

These findings suggest that the decrease of the knee joint moment was associated with an increase at the ankle joint. The lateral wedge was effective in reducing knee frontal plane loadings during walking. In particular, the magnitude of the knee abduction moment was inversely proportional to the wedge amount. Therefore, a lateral wedge could be a method to avoid progressive degeneration of the knee joint that leads to knee OA.

**REFERENCES**


**Table 1:** Means and standard deviations in each shoe condition.

<table>
<thead>
<tr>
<th></th>
<th>MW9</th>
<th>MW6</th>
<th>NEUTRAL</th>
<th>LW6</th>
<th>LW9</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak Knee Abduction Moment [Nm]</strong></td>
<td>42.5 (13.9)\textsubscript{a,b}</td>
<td>39.3 (12.8)\textsubscript{a}</td>
<td>37.3 (12.4)</td>
<td>33.7 (12.4)\textsubscript{c}</td>
<td>30.3 (10.8)\textsubscript{d,e}</td>
</tr>
<tr>
<td><strong>Knee Abduction Impulse [Nm]</strong></td>
<td>15.5 (5.9)\textsubscript{a,b}</td>
<td>14.1 (4.9)\textsubscript{a}</td>
<td>13.7 (5.6)</td>
<td>12.3 (5.2)\textsubscript{c}</td>
<td>11.1 (4.3)\textsubscript{d,e}</td>
</tr>
<tr>
<td><strong>Peak Ankle Inversion Moment [Nm]</strong></td>
<td>17.8 (3.4)</td>
<td>16.1 (2.9)\textsubscript{a}</td>
<td>16.9 (2.8)</td>
<td>18.6 (4.8)</td>
<td>21.9 (4.5)\textsubscript{d}</td>
</tr>
<tr>
<td><strong>Ankle Inversion Impulse [Nm]</strong></td>
<td>5.7 (1.3)\textsubscript{a}</td>
<td>5.9 (1.3)\textsubscript{a}</td>
<td>6.5 (1.4)\textsubscript{a}</td>
<td>7.8 (1.6)</td>
<td>9.9 (2.1)\textsubscript{c,d,e}</td>
</tr>
</tbody>
</table>

Subscript letters indicates sample group for which there are significant mean differences \( (p < 0.05) \): \textsubscript{a} = LW9, \textsubscript{b} = LW6, \textsubscript{c} = Neutral, \textsubscript{d} = MW6, \textsubscript{e} = MW9.