Evaluation of lumbar lordosis with and without high-heeled shoes

1, 2 Brent Russell, 1 Kimberly Muhlenkamp, and 1 Kathryn Hoiriis
1 Life University, College of Chiropractic, 2 Georgia State University
email: brussell@life.edu, web: http://www.life.edu

INTRODUCTION
Some women complain of low back pain (LBP) from wearing high-heeled shoes. Many doctors and therapists believe that these shoes cause increased lumbar lordosis as the source of the pain. For example, the American Physical Therapy Association has cautioned that, “Walking in high heels forces the back to arch and the chest to thrust forward. Basically, high heels cause the neck and back to hyperextend.” [1] In contrast, six of the seven published studies on this topic found either decreased lordosis or no effect from heels; but, some mixed results, small subject groups, and questionable methods have left the issue unclear. Considering both LBP and the wearing of high-heeled shoes are common, clinicians may be wasting time and effort with incorrect assumptions. The purpose of this project was to evaluate the effect of high-heeled shoes on lumbar lordosis using a more reliable method and larger sample size.

METHODS
We recruited 61 university students, faculty, and staff who reported no significant structural or neurological abnormalities. We included men as well as women, as had some previous studies. For measurement we used a Spinal Mouse (idiag AG, Fehraltorf, Switzerland; see below), previously shown to be reliable for assessment of lumbar lordosis and sacral angle [2]. After barefoot evaluation, each person wore high-heeled shoes for a ten-minute adaptation (four cycles of walking, sitting & standing up, carrying a box of office supplies, standing), after which a second lordosis measurement was done with shoes still on. All shoes had heel heights between 7.5–10 cm. Participants provided information for age, height and weight, frequency per week and number of years wearing high-heeled shoes, and whether the shoes caused them LBP. Our project was approved by the Life University IRB.

Figure 1: SM angles for one subject. The lumbar angle (absolute value) is decreased with heels, indicating decreased lordosis.

The Spinal Mouse (SM) is a hand-held device designed to roll down either side of the spine to detect angular change of position during scans from C7 to the third sacral segment. Rotation around its medial-lateral axis generates positive values in areas of kyphosis (“thorac” and sacral regions, Figure 1), and negative values in areas of lordosis (lumbar region and intersegmental angles). The bold lines in the figure are means of four individual paraspinous scans (thin lines), which vary with surface contour asymmetry and measurement inconsistency. The lumbar angle, representing the region from T12 to S1, was our main outcome measure, but we also monitored scan length for consistency between conditions; the sacral angle, representing pelvic tilt (part of the clinical perception of lordosis), was a secondary measure; and we did not analyze thoracic or spinal inclination angles (“inclin”, Figure 1) in this study. We used an Excel document for dependent t-tests of group means; however we excluded from analysis one subject with a lumbar kyphosis, two for scan length inconsistency (>5% barefoot-to-heels differences), and lost data for three from equipment malfunction.
RESULTS AND DISCUSSION
Lumbar lordosis and sacral angles for static standing in high-heeled shoes were slightly decreased from barefoot standing, but statistically insignificant, for our participant group (Table 1: degrees are absolute values). Only 31 subjects (all female) reported wearing heels previously, and only seven of them admitted to LBP from their shoes.

Some individuals did have an increase in lordosis. To examine them for shared characteristics, we separated subjects into two subgroups (Table 2) according to increased or decreased lordosis, and we considered “clinically significant change” to be magnitudes equal to or greater than the mean change plus one standard deviation (≥5 degrees). It is unlikely that changes smaller than this would be clinically detectable by visual or manual examination. Only four subjects with increased lordosis met this criterion; we believe it possible that clinicians are seeing these few and assuming the same effect for everyone. In our study they were somewhat younger and had a shorter history of wear, but did not otherwise appear much different, from the six subjects with a significantly decreased lordosis.

Some limitations: validity of Spinal Mouse sagittal plane measurement has not been established; in the main study of reliability, Mannion [2] felt there was no “suitable gold standard” for validity but found its measurements comparable to other surface contour devices. We relied upon Mannion’s [2] findings of reliability and did not use a control group of repeated measurements of barefoot subjects; but our mean barefoot lordosis and sacral angles were much smaller than Mannion’s 32 and 21 degrees, respectively [2]. A further limitation was that many participants were chiropractic students and faculty already familiar with the popular heels-cause-increased-lordosis belief. We let them know of the conflicting opinions and were careful not to suggest a desired outcome; we had no indications of anyone attempting to influence their results. Finally, one could question whether our adaptation time was adequate. Previous studies with results similar to ours used adaptation periods ranging from one minute to three hours [3]; there is no evidence that longer adaptation makes a difference.

CONCLUSIONS
It appears that high-heeled shoes do not have any significant effect on lumbar lordosis for most people. Low back pain attributed to heels likely is caused by some factor other than increased lordosis.

REFERENCES

ACKNOWLEDGEMENTS
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Table 1. Lumbar lordosis and sacral angles in wearing high-heeled shoes and standing barefoot (n=55)

<table>
<thead>
<tr>
<th>lordosis mean (SD)</th>
<th>sacral angle mean (SD)</th>
<th>scan length mean (SD)</th>
<th>gender age: mean (SD), range</th>
</tr>
</thead>
<tbody>
<tr>
<td>bare 22.9° (7.8) heeled 22.3° (7.4), P=.873</td>
<td>bare 10.4° (6.3) heeled 9.9° (6.2), P=.830</td>
<td>bare 472 mm (34) heeled 475 mm (35), P=.977</td>
<td>35 F / 20 M 33.3 y (10.8), 21 – 62y</td>
</tr>
</tbody>
</table>

Table 2. Subjects sorted by increased (†) or decreased (‡) lordosis (* 3 subjects had no change)
† “clinically significant change” defined as ≥ subgroup mean change + 1 SD
‡ only includes data for subjects who normally wear high-heeled shoes

<table>
<thead>
<tr>
<th>* subgroups ↓ or ↑ mean change (SD)</th>
<th>† clinically significa mean change (SD)</th>
<th>gender, age: mean (SD)</th>
<th>‡ wear /wk, ‡ yrs wear mean (SD), range</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=20</td>
<td>n=4</td>
<td>3 F / 1 M 24.5 y (2.52)</td>
<td>n=3, 1.3/wk (0.6), 1-2/wk 9.3 y (1.2), 8 – 10 y</td>
</tr>
<tr>
<td>↑ 3.1° (2.0)</td>
<td>↑ 6.5° (0.6)</td>
<td></td>
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<tr>
<td>n=32</td>
<td>n=6</td>
<td>5 F / 1 M 36.0 y (12.4)</td>
<td>n=5, 3.0/wk (1.8), 0.25 – 5/wk 16.2 y (12.0), 8 – 37 y</td>
</tr>
<tr>
<td>↓ 3.1° (2.0)</td>
<td>↓ 6.5° (1.6)</td>
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