Changes in Sagittal Lumbar Configuration With a New Method of Extension Traction: Nonrandomized Clinical Controlled Trial

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Objective: To determine if a new method of lumbar extension traction can increase lordosis in chronic low back pain (LBP) subjects with decreased lordosis.

Design: Nonrandomized controlled trial with follow-up at 3 months and 1 1/2 years.

Setting: Primary care spine clinic in Nevada.

Patients: Beginning in mid-1998, the first 48 consecutive patients, who met the inclusion criteria of chronic LBP with decreased lordosis and who completed the treatment program were matched for sex, age, height, weight, and pain scores to 30 control subjects with chronic LBP, who received no treatment.

Interventions: A new form of 3-point bending lumbar extension traction was provided in-office 3 to 4 times a week for 12±4 weeks. Per session, traction duration was started at 3 minutes and was increased to a maximum of 20 minutes. For short-term pain relief, torsion lumbar spinal manipulation was provided in the initial 3 weeks.

Main Outcome Measures: Pain as measured on a visual analog scale (VAS) and standing lateral lumbar radiographic measurements.

Results: Pain scales and radiographic measurements did not change in the control subjects. In the traction group, VAS ratings decreased from mean ± standard deviation of 4.4±1.9 pretreatment to 0.6±0.9 posttreatment (P<0.001), and radiographic angles (except at T12–L1) showed statistically significant changes. Mean changes were 5.7° at L4–5 (P<0.001), 11.3° between posterior tangents on L1 and L5 (P<0.001), 9.1° in Cobb angle at T12–S1 (P<0.001), 4.6° in pelvic tilt (P<0.001), and 4.7° in Ferguson’s sacral base angle (P<0.001). At long-term follow-up (17±1mo), 34 of the 48 (71%) subjects returned. Improvements in lordosis were maintained in all 34.

Conclusions: This new method of lumbar extension traction is the first nonsurgical rehabilitative procedure to show increases in lumbar lordosis in chronic LBP subjects with hypolordosis. The fact that there was no change in control subjects’ lumbar lordosis indicates the stability of the lumbar lordosis and the repeatability of x-ray procedures. Because, on average, chronic LBP patients have hypolordosis, additional randomized trials should be performed to evaluate the clinical significance of restoration of the lumbar lordosis in chronic LBP subjects.

Key Words: Lordosis; Low back pain; Posture; Radiography; Rehabilitation.

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RECENTLY, THERE HAS BEEN a surge of interest in the biomedical literature about the normal shape and magnitude of the lumbar lordosis. Multiple studies have investigated the normal magnitude and distribution of lumbar lordosis in asymptomatic subjects.1-4 These studies have found a species-specific shape that is minimally lordotic at T12–L3, with 65% of the total lumbar lordotic angle at L4–S1. Variables such as age (except advanced age), gender, geographic location, and ethnicity have little influence on this species-specific shape.5-8 This unique distribution for the lumbar lordosis has been closely modeled with an ellipse.9,10 Several cross-sectional studies7,9,11,12 have found clinically and statistically significant differences in the magnitude of lordosis between matched asymptomatic controls and various lower back pain patients, with the latter group having hypolordosis. In a recent longitudinal study, Adams et al13 identified loss of the lumbar lordotic curve as a risk factor for the first-time occurrence of serious low back pain (LBP). In postsurgical studies, a decrease in the distal lumbar curve has been correlated to the patient’s perception of LBP. In general, a decrease in the lumbar lordotic curve, especially the distal lumbar lordotic area, in postsurgical patients is indicative of a poor outcome.14,16 Additionally, a decreased lumbar lordosis and/or kyphosis have been found to be a significant risk factor for degenerative changes of the intervertebral disk and vertebral body.12,18

Few studies exist on conservative rehabilitative attempts to improve the magnitude of the lumbar lordosis; a review of the literature located only 4 articles.19-22 Of these 4, 2 used spinal manipulation21,22 and 2 used spinal exercises.19,20 None of the studies found increases in lumbar lordosis posttreatment.

This study reports on lordotic changes induced by a new method of lumbar traction that has a 3-point bending design. Prospectively selected chronic LBP patients without radiculopathy who were receiving this new method of extension traction, were compared with a control group of similar patients who did not receive the treatment. Outcome measures included pre- and poststudy subjective assessment of pain intensity and pain frequency, and objective quantification of pre- and posttreatment lateral lumbar radiographs.
METHODS

Forty-eight prospectively selected consecutive LBP subjects with decreased lumbar lordosis volunteered to receive the new method of lumbar traction that is based on the 3-point bending principle and to have pretreatment, posttreatment, and long-term follow-up lateral lumbar radiographs. Subjects with less curvature than the magnitude and distribution of lumbar lordotic curvature between L1 and L5 in an average normal shape (40°) and an ideal normal shape, were identified as having a decreased lumbar lordosis. This included decreased Cobb angle, decreased Ferguson’s sacral base angle, and decreased pelvic tilt. In the first 3 weeks of treatment (9 visits), a lumbar torsion type of manipulation was provided for short-term pain relief. The 30 chronic LBP subjects in the control group, who elected to have no treatment, were asked to have an initial lateral lumbar x-ray and a follow-up lateral lumbar radiograph.

Subjects in the treatment group were asked to have in-office traction sessions 3 to 4 times a week. Treatment was completed between mid-1998 and February 2000. Forty-eight patients met the inclusion criteria and completed the program. Thirty-four of the 48 (71%) returned for long-term follow-up evaluation at 14.6±6 months after the first follow-up examination (mean, 17.5 mo).

Subjects were patients at a spine clinic in Elko, NV. This study was approved by an institutional review board, and volunteers gave informed consent. There were 27 men and 21 women in the traction treatment group. By using mean ± standard deviation (SD), these subjects averaged 36.5±16.6 years of age, 171.3±11.4 cm in height, and 73.6±15.9 kg in weight. There were 18 men and 12 women in the control group. They averaged 39.4±13.7 years of age, 173.4±9.2 cm in height, and 82.5±16.3 kg in weight.

For both groups, inclusion criteria were chronic LBP without lower-extremity radicular pain, without previous surgery, and without neurologic deficit. For this study, chronic LBP was defined as either current pain of more than 6 weeks in duration or a history of recurrent disabling LBP (causing absence from work or significant modification in activities of daily living). All participants in both groups had a normal neurologic examination, with no nerve root tension signs on straight-leg raising and the Braggard test. All subjects completed a history that included a pain drawing to indicate the location of pain and a visual analog scale (VAS) from 0 to 10, on which subjects rated the intensity of their perceived pain (0, no pain; 1, minimal pain; 2, constant minimal pain to intermittent slight pain; . . . ; 9, constant moderate pain to intermittent severe pain; 10, constant severe pain [incapacitated]).

For the 3-point bending traction in the supine position, an anterior pull was applied between the upper torso and lower pelvis (fig 1). Tension was applied according to the individual patient’s tolerance. The angle of the anterior force relative to vertical varied, depending on the subject’s area of maximum deviation from the normal lumbar elliptical shape. If the patient’s sagittal balance (vertical line through posterior-inferior SI) measured posterior displacement of T12, then a firm foam block was placed under the patient’s ribcage and head. This caused anterior displacement of the ribcage while the traction force was applied (fig 2). The Velcro strap constrained the femurs to permit increased forward rotation of the pelvis.

The traction duration began at 3 minutes per session, increased 1 minute per session to 20 minutes, at which time traction was applied for 20 minutes per session. The magnitude of the traction force varied, depending on the patient’s pain tolerance. After they became familiar with the traction, subjects were encouraged to use the maximum tolerable force. The average number of traction sessions was 36 over the approximate 12-week study period.

Standard standing lateral lumbar radiographs, taken by the same clinician, were obtained with the subject’s right side against the grid cabinet at a tube distance of 101.6 cm (40 in). Subjects were asked to stand straight but relaxed, with the arms folded across the chest in accord with previous studies. In the treatment group, the follow-up lateral lumbar radiograph was taken a minimum of 24 hours after the last traction session. Radiographs were digitized with a GP9™ Sonic Digitizer. Digitized points were processed with a code that we developed with Trent Computer Systems. The 4 vertebral body corners of T12 through S1 and the superior acetabulum were the digitized points.

Using the posterior tangent method, which has high reliability, low standard errors of measurement, and small absolute differences of observers’ measurements, and segmental angles (RRAs) were calculated for T12—L1, L1—L2, L2—L3, L3—L4, L4—L5, and L5—S1 (fig 3). Using the sum of the segmental angles from L1—L2 to L4—L5, a global angle at L1—L5 (ARA) was determined. Cobb angles, at the inferior endplate of T12 and superior sacral base, were computed. Ferguson’s inclination of the sacral base to horizontal was calculated. An angle of pelvic tilt was determined as the angle between horizontal and
The reliability of our digitizing method has been confirmed.9 After averaging digitized posterior body (x,y) coordinates for each subject, an elliptical ratio (b/a) of the minor axis to major axis was determined for the posterior body corners of inferior T12 and superior S1. By using the least squares method reported by Harrison et al.,9 the geometric shapes of the lumbar curvature along the sagittal plane were modeled as ellipses. The geometric shapes of the lumbar curvature along the horizontal plane were modeled as ellipses. The horizontal displacement (Tz) of T12 above S1 was calculated. By using paired t tests for equality of the means derived from radiographic analysis for control subjects, there were no statistically significant differences in the 6 segmental angles from posterior tangents from T12–L1 to L5–S1. Also for the control group, there were no statistically significant differences in the ARA drawn with posterior tangents at L1–5, in the Cobb angles at T12–S1, in Ferguson’s sacral base angle, and in the angle of pelvic tilt (table 2). For the traction treatment group, all radiographic angle measurements showed statistically significant improvement in lordosis angles at T12–L1. The largest increases in lordosis were found at L4–5 (5.7°), in the ARA at L1–5 (11.3°), and in the Cobb angle at T12–S1 (9.1°). The inclination of the sacral base increased 4.7° and the pelvic tilt increased 4.6° (table 3). Figures 4A through 4C (kyphotic region in the lumbar curve) and figures 5A through 5C (hypolordosis) show 2 cases with increased lumbar lordosis after treatment.

At long-term follow-up of the traction treatment group, improvements in lumbar lordosis were maintained. Comparisons of measurements from the first post radiographs and from the long-term radiographs showed no statistically significant differences (table 3). Ellipses were passed through averaged (x,y) coordinate points by using the least squares method. By using a ratio of the minor axis (b) to the major axis (a), the mean elliptic ratio was not significantly different (P=.76) for the control group on the pretreatment (b/a=.23) versus posttreatment (b/a=.23) lateral lumbar radiographs. There was a statistically significant difference (P=.002) in the mean b/a ratio for the traction treatment group (b/a range,.16–.24).

RESULTS

Traction treatment duration was 11.8±4.4 weeks between initial and first follow-up evaluation. For the control group, follow-up radiographs were obtained at a mean of 9.1±7 months. By using 2-sample t tests, there were no statistically significant differences between the 2 groups for age, height, and pretreatment VAS scores, whereas there was a borderline significant difference (P=.02) for weight (table 1). The female-to-male ratio was similar for both groups: 40% female in the control group and 43.8% female in the treatment group. There was a statistically significant difference in the posttreatment VAS scores for the 2 groups. Although paired t tests indicated that the pretreatment VAS (4.2±2.0) and posttreatment VAS (3.7±2.1) scores for the control group were not statistically different, there was a statistically significant difference (P=.001) for VAS scores in the traction treatment group (4.4±1.9 vs 0.6±0.9) (table 1).

For the control group, all pretreatment and posttreatment radiographic angles changed less than 1° for the difference of the means (table 2). By using paired t tests for equality of the means derived from radiographic analysis for control subjects, there were no statistically significant differences in the 6 segmental angles from posterior tangents from T12–L1 to L5–S1. Also for the control group, there were no statistically significant differences in the ARA drawn with posterior tangents at L1–5, in the Cobb angles at T12–S1, in Ferguson’s sacral base angle, and in the angle of pelvic tilt (table 2).

For the traction treatment group, all radiographic measurements showed statistically significant improvement (P<.01) to an increased lordosis, except for the segmental angle at T12–L1. The largest increases in lordosis were found at L4–5 (5.7°), in the ARA at L1–5 (11.3°), and in the Cobb angle at T12–S1 (9.1°). The inclination of the sacral base increased 4.7° and the pelvic tilt increased 4.6° (table 3). Figures 4A through 4C (kyphotic region in the lumbar curve) and figures 5A through 5C (hypolordosis) show 2 cases with increased lumbar lordosis after treatment.
When separating subgroups above and below the median age (39.5 y), there were no statistical significant differences in radiographic measurements in the subgroups of younger and older treatment subjects. Comparing the mean radiographic changes for men and women (table 4), there were only 3 borderline (.01<P<.05) 2-sample t tests (at T12–L1, L4–5, L5–S1), whereas all other means did not differ significantly (P<.05). In general, women had slightly less improvement in lordosis.

**DISCUSSION**

Forty-eight treatment subjects received a program of spinal manipulation and a new form of 3-point bending lumbar extension traction. Beginning and follow-up radiographic measurements and VAS scores were compared with a control group of 30 subjects who were not treated. For the initial and follow-up evaluations in the control group, no statistically significant differences were found in the radiographic angle measurements and VAS scores. The measured means changed less than 1.0° for all radiographic angles in the control group. In contrast, statistically significant differences were found in the treatment subjects in VAS scores and all radiographic measurements (except the segmental angle at T12–L1).

For the treatment group, clinically significant increases in lumbar lordosis and pelvic forward (+Rx) rotation were found at the L4–5 segmental angle (5.7°), ARA angle between posterior tangents at L1–5 (11.3°), Cobb angle at T12–S1 (9.1°), Ferguson’s sacral base inclination (4.7°), and pelvic tilt to horizontal measured at posterior-inferior S1 to superior acetabulum (4.6°).

The elliptic parameter ratio of the minor axis to major axis (b/a) has been shown to discriminate between pain groups.9 Chronic LBP groups were reported to have stretched ellipses with a b/a ratio of less than .27, whereas healthy subjects had b/a equal to .38.9 Our treatment group’s elliptical ratio improved from b/a equal to .16 and to .24. This indicates that the posttreatment lumbar ellipse is deeper in the minor axis direction.

It is interesting that our treatment group subjects obtained a significant reduction in pain even though their posttreatment elliptical ratio was still below the value reported for chronic LBP groups. We speculate that the reasons for the discrepancy are 3-fold. First, the improvements in lumbar lordosis and sacral base angle after treatment to within 1 SD of average values2 could be enough lordosis to prevent the occurrence of LBP. Second, the study9 that found a lordotic elliptic ratio of .27 in subjects with chronic LBP was based on average values. Included in this average were chronic LBP subjects who likely had hyperlumbar lordosis, whereas our treatment group included only subjects with loss of lumbar lordosis and chronic LBP. Third, the 1½-year follow-up of our treatment subjects may not be long enough to detect permanent resolution of chronic LBP. It is possible that our treatment group may still be predisposed to LBP because of a reduction in the b/a elliptical parameter.

The nearly identical initial and follow-up lumbopelvic measurements for our control group are strikingly similar to the findings of Jackson et al.24 who compared initial and follow-up lateral full-spine radiographs in 20 volunteers and 20 LBP patients taken 66 months and 2 weeks apart, respectively. They24 reported ranked correlation coefficients of .93 to .96 for lumbar lordotic measurements for initial and follow-up x-rays. These data indicate the reproducibility and stability of the lumbar lordosis in upright neutral stance. Thus, in the present study, the increases in lumbar lordosis in the treatment group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control Group (n=30) Mean ± SD</th>
<th>Treatment Group (n=48) Mean ± SD</th>
<th>P* (between groups)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>39.4±13.7</td>
<td>36.5±16.6</td>
<td>.41</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>173.4±9.2</td>
<td>171.3±11.4</td>
<td>.37</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>82.5±16.3</td>
<td>73.6±15.9</td>
<td>.02</td>
</tr>
<tr>
<td>VAS Pre</td>
<td>4.2±2.0</td>
<td>4.4±1.9</td>
<td>.66</td>
</tr>
<tr>
<td>VAS post no. 1</td>
<td>3.7±2.1</td>
<td>0.6±0.9</td>
<td>.0000</td>
</tr>
<tr>
<td>VAS difference</td>
<td>−0.5</td>
<td>−3.8</td>
<td></td>
</tr>
<tr>
<td>P* (within groups)</td>
<td>.17</td>
<td>.0000</td>
<td></td>
</tr>
<tr>
<td>VAS long-term follow-up (post no. 2)</td>
<td>0.6±0.9</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>VAS difference of follow-up (post no. 1)</td>
<td>0.1</td>
<td>.47</td>
<td></td>
</tr>
</tbody>
</table>

* Two-sided 2 sample t test.
† VAS: 0, no symptoms, no limitations to daily living; 10, severe pain and bed ridden.
‡ Two-sided paired t tests for VAS scores within groups.
were treatment induced and did not result from radiographic positioning differences between the initial and follow-up examinations.

Although extension exercises of the thoracic cage and pelvic flexion (forward tilt) exercise therapy are promoted in the literature as being effective for LBP, we did not find any studies that showed an improved lumbar lordosis after exercise therapy. Likewise, earlier studies using lumbar spinal manipulative therapy were unable to show clinically or statistically significant improvements in the lumbar lordosis and pelvic angles. In the present study, bilateral long-lever torsion lumbar manipulation was applied for pain relief and increased mobility during the first 3 weeks of the approximate 12-week program. Pain relief and increased mobility are documented side effects of manipulative therapy. However, most of the documented effects of spinal manipulation deal with acute LBP of less than 4 weeks in duration, whereas some guidelines recommend this as a beneficial treatment for chronic LBP.

Because of the nonrandomized nature of this study, it has several limitations. First, because there was no treatment group receiving spinal manipulative therapy only, we cannot rule out the possibility that lumbar spinal manipulation may have caused some of the changes in the pre-post treatment group’s lateral lumbar alignment. We doubt that this was the case because previous studies using lumbar manipulative therapy did not have this outcome. Second, also because there was no manipulation treatment group, there is no evidence that the

Table 3: Treatment Group (n=48) Average Lateral Lumbar X-Ray Measurement Comparisons

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre X-Ray (mean ± SD)</th>
<th>1st Post X-Ray (mean ± SD)</th>
<th>Change</th>
<th>P*</th>
<th>2nd Post X-Ray† (mean ± SD)</th>
<th>Change†</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>T12-S1</td>
<td>−17.1±3.1</td>
<td>−16.6±2.9</td>
<td>0.5</td>
<td>.84</td>
<td>−19.4±2.19</td>
<td>−1.0</td>
<td>.64</td>
</tr>
<tr>
<td>RRA T12-L1</td>
<td>−2.0±4.2</td>
<td>−0.9±3.3</td>
<td>1.1</td>
<td>.13</td>
<td>−1.6±4.0</td>
<td>−0.3</td>
<td>.67</td>
</tr>
<tr>
<td>RRA L1-2</td>
<td>−0.2±4.2</td>
<td>−2.9±3.6</td>
<td>2.7</td>
<td>.00</td>
<td>−2.9±3.6</td>
<td>0.1</td>
<td>.86</td>
</tr>
<tr>
<td>RRA L2-3</td>
<td>−4.3±3.6</td>
<td>−5.7±3.2</td>
<td>−1.3</td>
<td>.00</td>
<td>−5.5±3.2</td>
<td>0.0</td>
<td>.96</td>
</tr>
<tr>
<td>RRA L3-4</td>
<td>−7.3±4.1</td>
<td>−8.7±3.9</td>
<td>−1.5</td>
<td>.01</td>
<td>−8.9±3.9</td>
<td>−0.0</td>
<td>.98</td>
</tr>
<tr>
<td>RRA L4-5</td>
<td>−10.6±5.9</td>
<td>−16.3±4.3</td>
<td>−5.7</td>
<td>.00</td>
<td>−16.7±3.9</td>
<td>−0.3</td>
<td>.60</td>
</tr>
<tr>
<td>RRA L5-S1</td>
<td>−32.9±8.3</td>
<td>−30.2±8.7</td>
<td>2.8</td>
<td>.01</td>
<td>−30.2±9.3</td>
<td>−0.1</td>
<td>.93</td>
</tr>
<tr>
<td>ARA L1-5</td>
<td>−22.4±9.2</td>
<td>−33.7±7.4</td>
<td>−11.3</td>
<td>.00</td>
<td>−34.5±6.6</td>
<td>−0.1</td>
<td>.88</td>
</tr>
<tr>
<td>Cobb T12–S1</td>
<td>−47.6±11.5</td>
<td>−56.7±9.2</td>
<td>−9.1</td>
<td>.00</td>
<td>−57.8±8.3</td>
<td>−0.1</td>
<td>.94</td>
</tr>
<tr>
<td>Ferguson</td>
<td>30.5±7.1</td>
<td>35.2±6.2</td>
<td>4.7</td>
<td>.00</td>
<td>35.9±5.2</td>
<td>0.7</td>
<td>.33</td>
</tr>
<tr>
<td>Pelvic tilt</td>
<td>36.1±11.9</td>
<td>42.7±11.9</td>
<td>6.6</td>
<td>.00</td>
<td>42.1±11.4</td>
<td>1.2</td>
<td>.22</td>
</tr>
</tbody>
</table>

Note: First follow-up post x-rays obtained at an average of 11.8 weeks. Long-term follow-up post x-rays (2nd post) are based on 34 subjects (34/48, 71%) at an average of 14.6±6 months. Negative sign in RRA, ARA, and Cobb means extension. Values in degrees unless otherwise noted.

* Two-sided paired t test.
† Based on 34 subjects at long-term follow-up and their first post x-ray.
pre to post differences in the treatment group’s VAS scores were related to lumbar traction treatment.

Clinically, we have found that, in patients with largely decreased or kyphotic lumbar curves, restoration of the normal lordosis is the factor that improves their pain and quality of life. Several recent lumbar postsurgical outcomes14-17 have shown that patients who attained adequate improvements in lumbar lordosis and pelvic inclination are clinically and statistically improved compared with the noncorrected lordotic group.

Using the difference in the pre-post treatment means tends to conceal the variation in the magnitude of a given patient’s increase in lordotic angles (table 3). We speculate that this was the result of several factors, including the magnitude of force that the patient can tolerate during traction, the stiffness of a patient’s spine, the extent of degenerative changes in the lumbar spine, and the gender of the patient. Although we did not find statistically significant differences in 8 of 11 measures (table 4) for men and women, men might have clinically significant increases in lordotic values compared with women. This may be because of the greater elastic recovery in female tissues. Deformation in spinal tissues is related to the magnitude of the applied load as well as to the duration. Because the force of the applied traction load varied with patient tolerance, only the duration of load application during 3-point bending traction was standardized in our study.

In spinal ligaments, most of the stress relaxation process is completed in 500 seconds (8.33 min); however, the intervertebral disk continues to deform for 20 to 60 minutes. In extension loading, most of the lumbar creep will be completed during a 20-minute period of sustained loading. For this reason, we increased the duration of traction gradually until 20 minutes was reached, after which each session continued for 20 minutes.

There is significance in the fact that the largest changes in the traction group occurred in the distal lumbopelvic spine. The majority of the nonsurgical, cross-sectional studies7,9,11,12 as well as postsurgical outcome studies have identified the distal lumbopelvic curve as the area of decreased lordotic curve in chronic LBP patients.14-17 This study may provide a tool that has been missing for the rehabilitation of the decreased lumbopelvic curve. This study indicates that randomized clinical trials using this type of lumbar traction with long-term follow-ups are warranted.

CONCLUSION

By using a new type of 3-point bending lumbar extension traction, combined with lumbar manipulation, statistically significant and clinically significant reductions in pain and increases in lumbar lordosis and sacral inclination were found in chronic LBP subjects. At 1/2-year follow-up of 34 of 48 subjects (71%), extension traction-induced improvements in lumbar curvature remained stable. There were no statistically and clinically significant differences for beginning and follow-up radiographic measurements in control subjects, which indicates the repeatability of x-ray positioning, of radiographic line-drawing analysis, and the longitudinal stability of the lumbar lordosis and pelvic positions. On average, chronic LBP subjects have hypolordosis. Therefore, investigations with randomized trials should be performed to evaluate the clinical significance of restoration of the lumbar lordosis in chronic LBP subjects.

Acknowledgments: We thank Dr. Sanghak O. Harrison for her artwork, Dr. Shirlene Ching and Dr. Mark Szostczuk for data collection, and Stephanie Springob for modeling.

References

9. Harrison DD, Cailliet R, Janik TJ, Troyanovich SJ, Harrison DE, Holland B. Elliptical modeling of the sagittal lumbar lordosis and

Table 4: Comparisons for Gender and Age (median age, 39.5y) Mean X-Ray Changes (1st postinitial) in the Treatment Group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Women (n=21)</th>
<th>Men (n=27)</th>
<th>P*</th>
<th>≤39y (n=24)</th>
<th>&gt;39y (n=24)</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tz12-5 (mm)</td>
<td>11.8±11.3</td>
<td>17.0±10.4</td>
<td>.10</td>
<td>13.8±12.0</td>
<td>15.7±10.2</td>
<td>.56</td>
</tr>
<tr>
<td>RRA T12-L1</td>
<td>−0.7±4.8</td>
<td>2.5±4.4</td>
<td>.03</td>
<td>0.2±5.3</td>
<td>2.0±4.3</td>
<td>.22</td>
</tr>
<tr>
<td>RRA L1-2</td>
<td>−3.7±2.7</td>
<td>−2.3±2.3</td>
<td>.22</td>
<td>−3.2±2.6</td>
<td>−2.3±2.4</td>
<td>.26</td>
</tr>
<tr>
<td>RRA L2-3</td>
<td>−1.4±3.1</td>
<td>−1.3±2.2</td>
<td>.84</td>
<td>−1.8±3.1</td>
<td>−0.9±2.0</td>
<td>.20</td>
</tr>
<tr>
<td>RRA L3-4</td>
<td>−1.1±3.2</td>
<td>−1.9±3.9</td>
<td>.47</td>
<td>−1.5±3.2</td>
<td>−1.5±4.0</td>
<td>.99</td>
</tr>
<tr>
<td>RRA L4-5</td>
<td>−3.9±3.2</td>
<td>−7.1±5.3</td>
<td>.02</td>
<td>−4.9±4.7</td>
<td>−6.5±4.8</td>
<td>.25</td>
</tr>
<tr>
<td>RRA L5-S1</td>
<td>3.9±6.2</td>
<td>1.9±6.8</td>
<td>.03</td>
<td>2.5±6.0</td>
<td>3.0±7.1</td>
<td>.78</td>
</tr>
<tr>
<td>ARA L1-5</td>
<td>−9.8±4.8</td>
<td>−12.5±8.2</td>
<td>.16</td>
<td>−11.4±7.2</td>
<td>−11.2±6.9</td>
<td>.91</td>
</tr>
<tr>
<td>Cobb T12-S1</td>
<td>−7.8±7.5</td>
<td>−10.1±10.6</td>
<td>.40</td>
<td>−8.9±9.2</td>
<td>−9.3±9.7</td>
<td>.90</td>
</tr>
<tr>
<td>Ferguson</td>
<td>4.4±4.9</td>
<td>4.9±5.7</td>
<td>.75</td>
<td>4.4±4.9</td>
<td>5.0±5.7</td>
<td>.72</td>
</tr>
<tr>
<td>Pelvic tilt</td>
<td>3.8±5.5</td>
<td>5.3±8.7</td>
<td>.46</td>
<td>4.3±6.9</td>
<td>4.9±8.1</td>
<td>.78</td>
</tr>
</tbody>
</table>

* Two sample t test.

NOTE. Values in degrees unless otherwise noted.

**Suppliers**

a. Littlefield Distribution, 704 Winthrop Dr, Alhambra, CA 91803-1142.
b. GTCO CalComp Inc, 7125 Riverwood Dr, Columbia, MD 21046.
c. Trent Systems, 15446 Shelby St, Harvest, AL 35749.