INCIDENCE OF FOOT ROTATION, PELVIC CREST UNLEVELING, AND SUPINE LEG LENGTH ALIGNMENT ASYMMETRY AND THEIR RELATIONSHIP TO SELF-REPORTED BACK PAIN

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ABSTRACT

Objective: To determine the incidence of pelvic unleveling, foot rotation, and supine leg length alignment asymmetry in a nonclinical population and to examine the validity (sensitivity, specificity, positive and negative predictive values) of these visual tests and their relationship to self-reported back pain.

Design: Volunteers answered a questionnaire regarding back pain and were then examined by a chiropractor who was unaware of the status of their back pain.

Participants: Seventy-four unscreened volunteers answered the questionnaire.

Main Outcome Measures: The association of visual tests with back pain and their validity indices; Visual Analogue Scale ratings.

Results: Fifty-one percent (n = 74) of volunteers examined had supine leg length alignment asymmetry (LLA). Pain intensity on a Visual Analogue Scale was significantly higher (P < .001) for those demonstrating supine LLA than for those without LLA. Those with back pain and recurrent back pain were significantly (P < .001) more likely to have supine LLA. The validity indices of the supine leg check showed acceptable levels for sensitivity (87%), specificity (84%), and positive predictive value (73%) in recurrent back pain. Findings also indicated a high incidence of supine LLA in volunteers with chronic back pain (85%).

Conclusion: The results indicated that, in this group of volunteers, the supine leg length alignment check had clinical validity as a stand-alone test for recurring back pain. Further testing on a larger, statistically defined cross-section of the population is recommended. (J Manipulative Physiol Ther 2002; 25:e1)

Key Indexing Terms: Leg Length Inequality; Chiropractic; Back Pain; Incidence; Validity

INTRODUCTION

In evaluating patients with back pain, deviations of posture have long been suspect as an indicator of possible dysfunction.1-4 Postural deviation includes the findings of pelvic unleveling, foot rotation, and leg length inequality (LLI).5,6 LLI is believed to be divided into 2 groups: anatomic, or actual anatomic asymmetry as a result of injury, disease, or developmental error; and physiologic or functional LLI, which may be the result of hypertonicity in suprapelvic and pelvic muscles causing pelvic torsion in an unloaded condition.6-10 The physiologic/functional LLI is not actually a shortening of leg length, and is best described as leg length alignment asymmetry (LLA).

Data concerning the incidence of postural deviation in the general (nonclinical) population and any correlation to back pain is limited. Roncarati and McMullen11 surveyed the general population for correlates to low back pain (LBP) and found anatomic LLI of at least 1⁄2 inch (determined by tape measure with patients supine) to be significantly more frequent in the LBP group. However, the tape measurement method of determining LLI has been found to be unreliable and imprecise,12,13 making these results suspect.

In another study of the general population, Biering-Sorensen14 did not find a correlation of LLI (determined by standing iliac crest unleveling) with patients who had back pain. However, when the same group was recalled a year...
later, significantly more participants with the previously noted leg length discrepancy (pelvic unleveling) had experienced LBP.

Leg check or alignment tests performed by chiropractors have a long history\textsuperscript{15} and are widely used in clinical practice.\textsuperscript{6,16} Such checks have the advantage of being technologically simple and do not require a patient’s report of pain.

Testing of non weight-bearing leg checks has given mixed results.\textsuperscript{6,17} In a recent analysis, Hestboek and Leboeuf-Yde\textsuperscript{17} found it difficult to draw conclusions regarding the usefulness of leg length alignment tests because of the many different types of evaluations used. They did note some evidence for intraexaminer and interexaminer reliability in prone checks.

However, these 2 reviews examining leg length alignment tests used no data accumulated since 1995. Since that date, testing of the prone leg check found an interexaminer total agreement of 85% and a kappa value of 0.66.\textsuperscript{18} In a reliability study of the supine leg check as described by J.F. Grostic (unpublished data, 1946),\textsuperscript{19} Hinson and Brown\textsuperscript{20} used 9 experienced clinicians to estimate the supine leg length differential of 9 subjects, 3 of whom were assessed twice. The subjects wore similar bowling shoes and were draped so only the feet were visible, blinding both examiners and subjects. Examiners were to estimate leg length differential to the nearest \(\frac{1}{8}\) inch. Overall, intraclass agreement among examiners was high (>0.9); intraexaminer reliability was good (0.7).

Both of these recent studies would score above the 80% level for quality as outlined by Hestboek and Leboeuf-Yde\textsuperscript{17} and would enhance the evidence for the reliability of visual leg length alignment tests. Regardless, the evidence for the reliability of visual leg length alignment tests has not reached consensus. In addition, the validity and clinical significance of these checks need to be examined.

A validity study comparing supine leg check findings against the standard of standing radiograph of femoral head height as a putative determinant of anatomic leg length inequality found a poor correlation.\textsuperscript{21} If, as hypothesized, the supine leg check is a method to determine abnormal activation of pelvic and suprapelvic muscles (a physiologic leg length asymmetry), these results, compared with putative anatomic LLI, are not surprising. Another validity standard, not related to anatomic LLI, would be more appropriate. One such standard, described as a bronze standard, is to use self-reported back pain.\textsuperscript{22}

This study was undertaken to examine the incidence of pelvic unleveling, foot rotation, and supine leg length alignment asymmetry in a nonclinical population and their relationship to self-reported back pain, as well as the validity (sensitivity, specificity, and positive and negative predictive value) of these visual tests.

\textbf{Materials and Methods}

This study involved subjects from the general (nonclinical) population. Typically, an announcement would be made at the beginning of a gathering explaining that the examiner was present for the purposes of a research project. The attendees were informed that participation in the study was purely voluntary and totally anonymous (no record of name, address, or phone number). Volunteers were told that they would fill out a questionnaire and then undergo a short postural examination. Informed consent was obtained. The gatherings attended included meetings, parties, a reunion, and a class.

A small pilot study was done involving 8 subjects to check that the questionnaire was understandable. The questionnaire was altered in response to the pilot study, and the examination procedure moved smoothly. These results were not included in the present study.

The questions asked were directed at the frequency and longevity of back pain. The Visual Analogue Scale (VAS), an outcome tool shown to be reliable\textsuperscript{23,24} and valid,\textsuperscript{25} was included to rate the severity of the reported back pain.

The questionnaire divided the frequency of back pain into 2 groups: nonrecurring (“none” and “rare”) and recurring (“occasional,” “frequent,” and “constant”). The rationale for this division was an attempt to filter out back pain resulting from rapidly healing simple strain. Eighty percent to 90% of back pain resolves in less than 8 weeks without functional loss,\textsuperscript{26-28} which is consistent with an etiology of acute strain. Recurring back pain implies factors other than simple overload or overwork. By using this dividing line, we examined the visual tests against back pain and recurring back pain (more than 2 episodes per year).

Volunteers were given the questionnaire and instructed to fill out forms (the SF-12 Health Survey for persons aged 20 and older and a back pain questionnaire) to the best of their ability without asking the examiner any questions (Fig 1). Once completed, the questionnaire was coded with a number.

The examiner, a clinician with 20 years’ experience, was blinded to the questionnaire findings and performed the visual tests and observations. First, the volunteers stood facing away from the examiner and spread their feet 6 to 8 inches. A pelvic level device with a weighted gravity line superimposed on a scale in \(1^\circ\) increments was clamped in place on the palpated superior aspects of the iliac crests. High-side deviation, right or left, was noted and recorded, as was any inability to adequately locate the iliac crests.

Second, foot rotation was observed. For this test and the supine leg check, a standard (not portable) table was used. This table was trapezoidal (18 inches at the foot tapering to 8 inches at the headpiece), stood 18 inches off the floor, and was covered with slick naugahyde. The examiner demonstrated to the volunteers the proper method of lying down supine on the examination table. The volunteers stood at the end of the table, sat down, and then used their arms to pull themselves evenly toward the head of the table and lie down with their head on the headpiece. The volunteers were then told to take a breath and relax.

After relaxation, the examiner visually observed the volunteers’ feet, making note of any asymmetric rotations.
Third, the leg check was performed with the subject resting in the supine position. In this leg check, the examiner squatted and lightly grasped and cupped the heels of the subject’s shoes. The feet were then derotated and squared to remove any foot rotation asymmetry. The examiner compared the positioning of the subject’s heel/sole interface from side to side (J.F. Grostic, unpublished data, 1946). LLA was then estimated, with \( \frac{1}{8} \) inch or less considered even, in accordance with the protocol in the Hinson and Brown reliability test.20 Test sensitivity, specificity, and positive and negative predictive value were calculated from a \( 2 \times 2 \) table (LBP or no LBP vs LLA or no LLA), and the statistical significance was estimated by using the \( \chi^2 \) test. To minimize the possibility of a Type-I error as a result of the multiple \((n = 3)\) statistical tests used, the significance level was adjusted from \( P = .05 \) to \( P = .0167 \) according to Bonferroni’s correction \((0.05/3)\).29 Nonparametric comparison of the pain scale for subjects with and without LLA was done with a 2-tailed Mann-Whitney test.

**Data**

Data were collected on 74 volunteers, ranging in age from 11 to 65 years (average age 36 years). The group consisted of 50 women and 24 men. There was no significant difference between the ages of those with supine LLA and those without \( (P = .91) \).

Eighty-two percent of volunteers answered “yes” to the question, “Have you ever had back pain.” The results were as follows: 43.2% of respondents described their back pain as “none” \((n = 11)\) or “rare” \((n = 21)\), which was defined as back pain once or twice a year at most; 56.8% described...
their back pain as “occasional” (every few months \[n = 31\]), “frequent” (every few weeks \[n = 7\]), or “constant” (once a week or more \[n = 4\]); 78.7% described their pain as acute (lasting less than 2 months), and 21.3% described their pain as chronic (lasting more than 2 months). The relationship among the frequency of back pain (rare, occasional, frequent and constant), the longevity of the pain (acute or chronic), pain intensity, and supine LLA is shown in Figure 2.

On the VAS pain scale of 0 (no pain) to 10 (worst pain imaginable), the average back pain rating was 3.5 (range 0-9, SD 2.1, mode 3). Those with no supine LLA had an average pain rating of 1.1 (SD 1.7); those with supine LLA had an average pain rating of 3.4 (SD 2.5). In the acute group, the pain intensity increased as the back pain became more frequent. The pain intensity in the chronic group (5.2, SD 0.38) was greater than in the acute group (3.2, SD 1.3), although this difference did not quite reach statistical significance \((P = .06)\).

In those volunteers with acute back pain, 54% had supine LLA. Eighty-five percent of those who indicated chronic back pain were found to have supine LLA.

For those who answered \((n = 61)\), the pain was located as follows: the lumbopelvic area (59%), the upper thoracic spine (18%), the cervical spine (13%), and the lumbodorsal spine (10%). Of those who were seeking treatment for back pain (13.5%), 5 were being treated by a chiropractor, 4 by a medical physician, and 1 by “other.” The vast majority of volunteers (95%) were unaware of any LLI.

Data on the postural deviations of pelvic leveling, foot rotation, and supine leg length alignment are shown in Table 1. Pelvic unleveling was defined as “mild” (to 3°), “moderate” (to 6°), or “severe” (above 6°). Foot rotations include a wide range of possible motions (dorsi- and plantar flexion, internal/external rotation, inversion/eversion), and categorizations of severity were based on clinical experience. Supine LLA was considered “none” from 0 to 3 mm (to \(\frac{1}{8}\) in), “mild” at 4 to 12 mm (over \(\frac{1}{8}\) to \(\frac{1}{2}\) in), “moderate” at 13 to 20 mm (\(\frac{1}{2}\) to \(\frac{3}{4}\) in), and “severe” above 20 mm.

**RESULTS**

Among this population of volunteers, 39% were found to have some degree of pelvic unleveling, 30% had asymmetric foot rotations, and 51% had supine LLA.

The validity indices of sensitivity (people with back pain should test positive), specificity (people without back pain should test negative), positive predictive value (a good indication of back pain), and negative predictive value (a good indication of the absence of back pain) for each of the postural distortions are shown in Table 2. A standard of 70% was set for each of these tests as the criteria for clinical usefulness.

In the comparison of back pain to postural deviation, only the results from the supine leg alignment check were statistically significant \((P < .001)\). The supine leg alignment test had a satisfactory specificity (71%) and positive predictive value (88%), but sensitivity (65%) and negative predictive value (38%) fell short of the standard.

In the comparison of recurrent back pain to postural deviation, supine LLA had satisfactory sensitivity (74%), specificity (78%), and positive predictive value (82%), and just under the clinically useful limit for negative predictive value (69%). The comparison of recurrent back pain to LLA was statistically significant \((P < .001)\).

**Table 1. Postural deviation via visual checks**

<table>
<thead>
<tr>
<th></th>
<th>None</th>
<th>Left</th>
<th>Right</th>
<th>Unable</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvic level</td>
<td>35 (47)*</td>
<td>19 (26)</td>
<td>10 (14)</td>
<td>10 (14)</td>
<td>21 (72)</td>
<td>7 (24)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Foot rotation</td>
<td>52 (70)</td>
<td>15 (20)</td>
<td>7 (9)</td>
<td>—</td>
<td>19 (86)</td>
<td>3 (14)</td>
<td>0</td>
</tr>
<tr>
<td>Supine LLA</td>
<td>36 (49)</td>
<td>19 (26)</td>
<td>19 (26)</td>
<td>—</td>
<td>32 (84)</td>
<td>6 (8)</td>
<td>0</td>
</tr>
</tbody>
</table>

*Numbers in parentheses are percentages.
The Mann-Whitney test found a statistically significant difference (P < .001, 95% CI) between the pain scale levels of those who did (n = 38) and did not (n = 36) demonstrate supine LLA.

**DISCUSSION**

In this study of postural deviation in the general population, supine LLA was found to occur in 51% of volunteers. The supine leg length alignment test was found to have a statistically significant relationship to back pain and recurrent back pain. The supine leg check validity indices were acceptable for sensitivity, specificity, and positive predictive value in volunteers with recurrent back pain. On average, those found to have supine LLA had higher VAS pain levels than those with no LLA.

Although the subjects examined were from the nonclinical population, this should not be considered a statistically defined cross-section of the general population. This potentially skewed sample leads to some problems. There were far more women volunteers (68%) than men (32%), yet a higher percentage of men (74%) than women (43%) had supine LLA. This finding makes it likely that the incidence of supine LLA in the general population may be higher than the indicated 51%. However, people with back pain may have been more likely to volunteer for the study, thereby artificially raising the population of those found with supine LLA.

Conversely, the question, “Have you ever had back pain?” resulted in a “yes” answer by 83% of the volunteers, which is concordant with other research studies of the general population.\(^{26,27,30}\) The percentage of subjects who claimed never to have had back pain (17%) is similar to the percentage cited in other research.\(^{31}\) Chronic back pain (lasting over 2 months \(n = 1\) and over 6 months \(n = 12\)) was reported by 21% of subjects, which is also similar to the figures reported by others.\(^{26,28}\) This concordance with other studies of the general population regarding the experience of back pain and its longevity suggests that this population sample may be adequately representative.

There may have been a visual bias toward finding postural deviation in older volunteers because age is associated with back pain.\(^{26}\) The study was limited to those age 65 and under, and there were fewer volunteers in their 50s \((n = 8)\) and 60s \((n = 7)\) than in any other age group. Additionally, there was a lower percentage of supine LLA among those in their 50s and 60s than among those in their 30s and 40s. Statistical analysis showed only a weak correlation between the percentage incidence of supine LLA and age \((P = .31)\). Perhaps with a fuller cohort of 50- to 65-year-old participants, the percentage of those with supine LLA would have increased. However, in the population sample examined, a bias toward suspecting back pain based on a visual guess of age would have been wrong.

Further concerns of visual bias include the possibility of a volunteer with acute antalgia prompting a guess of recurrent back pain and postural deviation. It should be recalled that the postural checking was done at nonmandatory organized events, making it unlikely that a person with acute, demonstrable (antalgic) back pain would attend. None was noticed in the course of this study.

The question, “How often do you have back pain?” was divided into 5 categories: “none,” “rare,” “occasional,” “frequent,” and “constant.” Figure 2 gives the number of volunteers in each category of occurrence. The small number of people in many of these groups should caution against making definitive pronouncements. That noted, supine LLA seems to be related to increasing occurrence of back pain, movement from “acute” to “chronic” pain, and increases in the subjective intensity of the pain.

The pelvic unleveling test was difficult to administer because of the inability to palpate pelvic crests in a significant percentage (13.5%) of volunteers. The pelvic level instrument was checked on a level surface before this study. However, there was a bias toward finding a left high iliac crest (65.5%), which may be a statistical fluke or indicative of examiner error. Devices to measure standing pelvic unleveling have not been shown to be reliable compared with radiographs in prior studies,\(^{32}\) and the results here may relate to that unreliability.

There was a significant association \((P < .001)\) between supine LLA and pelvic unleveling. However, the side of pelvic unleveling coincided with the side of supine LLA in 12 volunteers, and the side of pelvic unleveling was opposite the side of supine LLA in 14 volunteers. These data indicate that although standing pelvic unleveling is associated with supine LLA, it cannot be used to predict the side of the LLA.

**Table 2. Validity indices for the supine leg alignment check with back pain and recurrent back pain**

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive predictive value</th>
<th>Negative predictive value</th>
<th>(\chi^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvic level</td>
<td>51%</td>
<td>77%</td>
<td>90%</td>
<td>29%</td>
<td>NS</td>
</tr>
<tr>
<td>Foot rotation</td>
<td>29%</td>
<td>69%</td>
<td>55%</td>
<td>42%</td>
<td>NS</td>
</tr>
<tr>
<td>Postural LLI</td>
<td>65%</td>
<td>71%*</td>
<td>88%*</td>
<td>38%</td>
<td>(P &lt; .001)</td>
</tr>
<tr>
<td>Pelvic level</td>
<td>48%</td>
<td>70%</td>
<td>90%</td>
<td>20%</td>
<td>NS</td>
</tr>
<tr>
<td>Foot rotation</td>
<td>38%</td>
<td>71%</td>
<td>55%</td>
<td>56%</td>
<td>NS</td>
</tr>
<tr>
<td>Postural LLI</td>
<td>74%*</td>
<td>78%*</td>
<td>82%*</td>
<td>69%</td>
<td>(P &lt; .001)</td>
</tr>
</tbody>
</table>

NS, Not significant.

*Meets validity criteria.
Foot rotation as a sign of postural deviation was relatively rare (<30% [Table 1]) and was not significantly associated with back pain or recurrent back pain (Table 2).

Of the 3 postural tests, supine LLA was the only one significantly correlated with back pain and recurrent back pain at the chosen significance level of \( P < .0167 \) (Table 2). Unlike pelvic unleveling, there was an even split in right (\( n = 19 \)) and left (\( n = 19 \)) LLA (Table 1).

In relation to recurrent back pain, the supine leg length asymmetry test came up just short of the 70% marker for clinical significance in negative predictive value (69%). Recall that negative predictive value is a good indication of the absence of recurrent back pain (i.e., the volunteer had no supine LLA but did have recurrent back pain). Because the data were sorted only in an attempt to eliminate acute back strain, this finding is not surprising. The supine leg check is not used in a vacuum. As with any other clinical test or sign, the presence of supine LLA must be evaluated in the context of other evidence, such as history, pain on palpation, and radiology. A disk injury, for example, could produce recurrent back pain but not be related to a supine LLA. The use of a pretest screening procedure to eliminate other causes of recurring back pain would likely raise the negative predictive value above the 70% clinical significance level.

Anatomic LLI results in a variety of anatomic compensations, the most prominent of which are unleveling of the femoral heads and iliac crest and curvature of the lumbar spine. However, unless the deformity is large (above \( \frac{1}{4} \) in), anatomic LLI has not been found to be correlated with back pain. Compensation for an anatomic leg length deficiency that did not seem to be demonstrable on supine leg check was reported in a recent case study. Supine LLA does not correlate with (putative) anatomic LLI and anatomic LLI (within limits) seems to be adequately compensated for and not related to back pain. Considering these findings and the results noted in this study, the supine leg alignment check may be a better indicator of unloaded pelvic torsion and this type of muscular activation/postural deviation correlated with, and perhaps causative of, back pain. Although this study demonstrated an association between supine leg length alignment and recurrent back pain, it would be an error to infer a causal relationship. Further research into unloaded pelvic torsion (the putative physiologic LLI as opposed to anatomic LLI) to establish cause and effect is recommended.

**Conclusion**

The population examined in this study demonstrated a statistically significant \( (P < .001) \) relationship between the supine leg length alignment check and back pain or recurrent back pain. The pain intensity of those who demonstrated supine LLA was significantly higher \( (P < .001) \) than those without such asymmetry. The supine leg length alignment check for recurrent back pain demonstrates acceptable validity indices for sensitivity (87%), specificity (84%), and positive predictive value (73%). Findings also indicated a high incidence of supine LLA in volunteers with chronic back pain (85%). Although few in number, the studies available regarding the supine leg alignment check indicate that it may be a reliable and valid test. A larger, statistically balanced sample of the general population is warranted to examine the relationship of supine leg length alignment to back pain and recurrent back pain.

**Acknowledgments**

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**References**

18. Nguyen HT, Resnick DN, Caldwell SG, Elston EW, Bishop...

19. Reference deleted by author.


