INTRA- AND INTEREXAMINER RELIABILITY OF COMPRESSIVE LEG CHECKING AND CORRELATION WITH THE SIT-STAND TEST FOR ANATOMIC LEG LENGTH INEQUALITY

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ABSTRACT

Introduction: Most forms of leg checking are for functional short leg, believed related to a treatable clinical entity, such as pelvic subluxation. However, a short leg may be anatomic in nature, which could lead to different treatment procedures. A variant termed compressive leg checking is thought to identify an anatomic short leg. The primary objective of the present study was to study the intra- and interexaminer reliability of compressive leg checking. The secondary objective was to assess the inter-method agreement of compressive leg checking and the sit-stand test, another test for anatomic leg length inequality.

Methods: A convenience sample of asymptomatic chiropractic college students was recruited. Each wore modified surgical boots capable of measuring LLI to the nearest millimeter, prone. To assess interexaminer reliability, each subject was measured 3 times, at 2.5-minute intervals. A subset of subjects entered an interexaminer module, and another subset an intermethod module comparing the results of compressive leg checking and the sit-stand test.

Results: Intraexaminer reliability module: ICC=.71 (0.48, 0.85). Mean of the absolute values for 31 subjects, 3 measures per subject (93 paired examiner differences) was 2.8mm and the median of these absolute values was 2.0mm. The Median Absolute Deviation = 1.0 mm. Intraexaminer module: ICC=0.67 (0.25, 0.87). Mean of the absolute values of the 15 examiner differences was 3.1mm, and the median of the absolute values of these absolute values was 3.0mm. The Median Absolute Deviation=1.0mm. Inter-method module: Weighted kappa for n= 22 subjects agreement between compressive leg checking and the sit-stand test was 0.65 (0.38, 0.91).

Conclusion: Compressive leg checking demonstrated good intra- and interexaminer reliability, and correlates well with the sit-stand test. While compressive leg checking is reliable and valid for detecting artificially created LLI, its accuracy compared with a radiological reference standard has not been determined. (Chiropr J Australia 2017;45:184-195)

Key Indexing Terms: Chiropractic; Leg Length Insufficiency; Reliability

INTRODUCTION

Various forms of prone and supine leg checking exist in the manual therapy professions (1). Most of these are intended to identify a "functional short leg" as an indicator of subluxation (in chiropractic) or somatic dysfunction (in osteopathy) (2, 3). In the case of functional LLI (fLLI) the legs are structurally even in length and yet appear unequal during (usually visual) inspection. Although evidence exists for the existence of fLLI (4), manual therapists continue to discuss and debate its significance. Anatomic (or structural) leg length inequality (aLLI) is established as a risk factor for lower extremity and low back conditions (5, 6).

The presence of fLLI as compared with aLLI may lead to different clinical interventions and outcomes. There is evidence that an anatomic short leg results in pelvic torsion with an anteriorly rotated innominate bone on the short leg side and a posteriorly rotated innominate bone on the long leg side (7). At the same time, it is widely believed in the manual therapy professions that a functional short leg predicts ipsilateral posterior innominate rotation and contralateral anterior rotation (8-10). Thus, depending on whether an observed short leg is anatomic or functional in nature, a clinician may deploy opposite vectors of correction during sacroiliac manipulation (8). Apart from guiding the choice of the optimal vectors to be used, diagnosing aLLI may support treating the patient with heel lifts to reduce the risk of lower extremity, sacroiliac, and spinal complaints (11). Since about half of asymptomatic individuals and closer to 75% of symptomatic individuals possess aLLI of ≥5mm (5, 6), many individuals are at risk for conditions associated with aLLI (12).

Since the appropriate clinical intervention depends, in part, on whether the patient's short leg is anatomical or functional in nature, it would be appropriate to determine which type of LLI is present. Imaging, more specifically scanogram x-ray, is generally regarded to be the reference standard for identifying aLLI (13), even though the accuracy of the scanogram has been put in question (14). On the other hand, imaging procedures for detecting aLLI can be costly in terms of both economic costs and the potential hazards of exposing the patient to ionizing radiation. Thus, there is a strong clinical rationale for using a less expensive and less invasive method of detecting aLLI.

Bourdillion described what may best be called the “sit-stand test” for anatomical LLI (15), in which the relative positions of the posterior superior iliac spines (PSISs) are compared in the seated and standing positions. Any discrepancy would be due to anatomical difference in leg length. As an alternative, clinicians may use any number of tape measure methods, although a review of the literature calls into question their accuracy, which appears to be no better than ±5mm (16). In an alternative measuring procedure for aLLI called the “block” or “indirect” method (17), the examiner determines what width of block to place under the leg on the side of an inferior iliac crest side to level the iliac crests. A review of the literature for the block method shows its accuracy to be comparable to that of the tape measure methods (17). The Allis method for identifying aLLI has been called into question, in a study that modeled the method and found it of poor construct validity (18). Given that clinically significant aLLI may be as little as 3 mm (12), the accuracy of these various methods for identifying and/or quantifying aLLI may not be adequate.

Cooperstein et al have hypothesized that the "compressive leg check" accurately detects aLLI (9). In this instrumented, prone leg checking procedure, the examiner applies moderate cephalad pressure to the feet. This hypothetically overwhelms whatever impact differences in suprapelvic muscle tone have on the relative Y axis position of the lower extremities (9), so that any observed LLI would represent an anatomic difference. Compressive leg checking has been shown to accurately detect artificially created aLLI in 2 studies; a longitudinal calibration study (19) obtained 26 measurements on each of 3 participants; and a follow-up cross-sectional calibration study (20) extended the procedure to a larger and more representative subject pool by obtaining 2 measurements on each of 29 subjects. In both studies, the mean difference between the compressive leg checking results and the known artificially created aLLI was approximately ±2mm, suggesting the method was quite accurate. Although these calibration studies showed compressive leg checking can effectively quantify artificially produced aLLI, the intraexaminer and interexaminer reliability of compressive leg checking have not been studied. In addition, its results have not been compared with those of any other visual test thought to credibly detect aLLI. To be clinically useful, examination methods must be both valid and reliable.

The primary objective of the present study was to study the intra- and interexaminer reliability of compressive leg checking. The secondary objective was to assess the inter-method agreement of compressive leg checking and the sit-stand test.

METHODS

A convenience sample of asymptomatic chiropractic college students was recruited as subjects for the study, and signed a consent form authorized by the college's Institutional Review Board, who approved the study. The only exclusion criteria were a recent history of foot or ankle trauma, or anticipated inability to tolerate mild to moderate cephalad pressure on the legs in the prone position. All subjects entered the study module assessing the intraexaminer reliability of compressive leg checking. A subset of these subjects entered a module to study the interexaminer reliability of compressive leg checking, and another subset entered a module to assess the inter-method reliability of the sit-stand test and compressive leg checking.

Each subject was placed in the prone position and fitted with a pair of surgical boots made snug to the feet using Velcro straps (Figure 1). The surgical boots were mounted on ½" thick wood “footprints” that featured screws pointed medially from the heels. A ruler mounted on a T-square was placed between the distal legs, extending a few inches distal to the surgical boots, such that the ruler could be read to the nearest millimeter. The examiner then performed a compressive leg check, applying moderate cephalad pressure against the plantar surface of the feet, while assessing where the medially-directed nails pointed in relation to the ruler. The difference between the measurements for the right and left legs quantified the amount of aLLI. After assessment, the subject dismounted from the table, and was free to walk about or sit prior to the next measurement. Each subject was measured 2 more times by the same examiner at approximately 2.5-minute intervals. After the third compressive leg check, a second examiner performed the compressive check just once, to provide data for the interexaminer module of the study; the second examiner’s leg check results were compared with the second measurement of the three leg checks performed by the first examiner. The first examiner performed the sit-stand test on a subset of 22 of the subjects to determine the inter-method agreement of this test and compressive leg checking. (Figure 2).

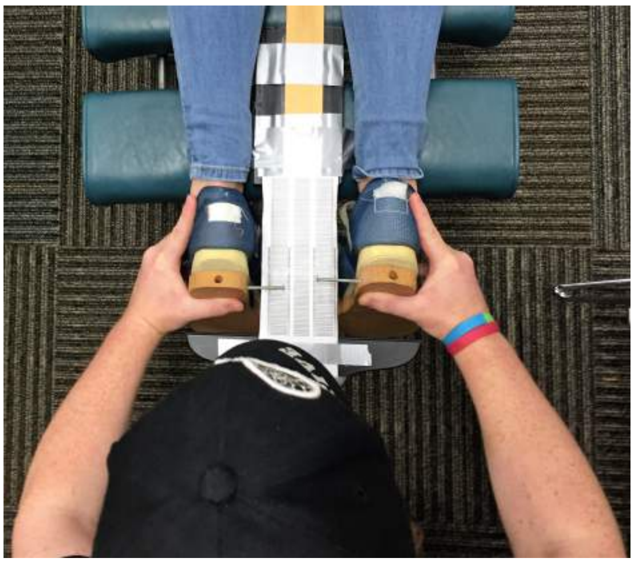

Figure 1. Compressive leg checking

In the sit-stand test, the examiner made contact with the inferior aspect of the PSISs of the seated subject, visually estimating any discrepancy in height (Figure 2). The examiner maintained contact with the PSISs while the subject rose to the standing position, once again noting any vertical discrepancy in PSIS positions. A difference between the PSIS discrepancies noted in the seated compared to the standing position suggested the presence of aLLI. The examiner classified the subjects as having a right short leg, left short leg, or even legs. To compare the results of compressive leg checking, which acquires continuous data, with the sit-stand test, which acquires discrete data, the investigators used a 3 mm cut point to place the continuous leg checking data into discrete baskets. Legs that were ≤3mm different in length were classified as even, while legs that differed by >3mm were judged left or right short as the case may be. A weighted kappa statistic was computed to determine the inter-method agreement of the sit-stand test and compressive leg checking.

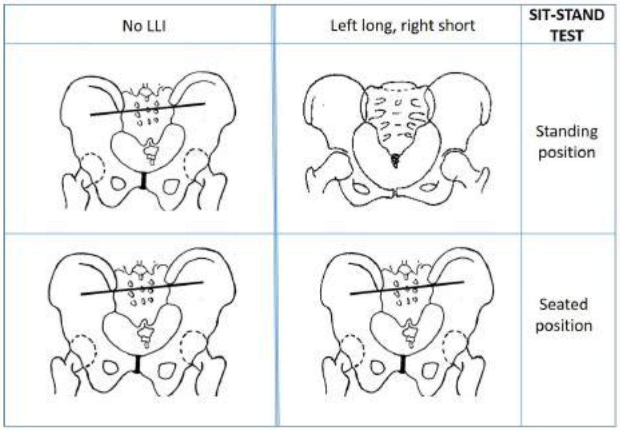

Figure 2. Sit-Stand text

RESULTS

Thirty-one asymptomatic chiropractic college students were recruited as subjects for the study. All satisfied the inclusion criteria. Half were female, mean age 26 years. All 31 subjects entered the intraexaminer module assessing the reliability of compressive leg checking, 15 entered the interexaminer module, and 22 entered into the inter-method reliability module comparing the results of the sit-stand test and compressive leg checking,

Intraexaminer Module

In analyzing the compressive leg check data, we subtracted the right leg measurement from the left leg measurement, so a negative result indicated a right short leg. In 23/31 cases (74.2%) the subjects exhibited a right short leg as the mean of 3 measurements; in 7/31 (22.6%) cases the subjects exhibited a left short leg; and in 1 case (3.2%) a subject had even legs. Fourteen of 31 subjects (45.1%) exhibited LLI ≥5mm. In 22 of 31 (71.0%) of cases, all 3 measurements were consistent in identifying the side of the short leg, whereas in 9 of 31 (29.0%) of cases there was a sign reversal. Among these sign reversal cases, the mean LLI was ≤3.0mm.

Shapiro-Wilk testing determined that the test-retest measurements of LLI for the entire dataset of 93 measurements (31 subjects, 3 measurements per subject) were not normally distributed, precluding calculating intraclass correlation (ICC). Among the 3 subsets of pair-wise measurements (first and second, first and third, and second and third), Shapiro-Wilk testing showed the differences between the first and third measurements to be normally distributed, supporting the calculation of intraclass correlation for that subset: ICC=.71 (0.48, 0.85). This corresponds to “fair to good” in the Portney scale (21). In the Portney scale, ICC above 0.75 = good reliability, 0.40 to 0.75

= fair to good reliability, and below 0.40 = poor reliability (21).
The mean of the absolute values of the 93 paired examiner differences was 2.8mm and the median of these absolute values was 2.0mm. The Median Absolute Deviation (MAD, explained below) was 1.0 mm.

Interexaminer Module

In the n=15 subset used to calculate interexaminer reliability, Shapiro-Wilk testing confirmed that the paired examiner differences did come from a normal distribution, supporting the use of intraclass correlation to determine interexaminer reliability: ICC=0.67 (0.25, 0.87). This corresponds to “fair to good” in the Portney scale (21). The mean of the absolute values of the 15 examiner differences was 3.1mm, and the median of the absolute values of these absolute values was 3.0mm. The MAD was 1.0mm.

Inter-method reliability module

To compare the results of compressive leg checking with the sit-stand test, the continuous leg compressive leg checking data were transformed to discrete data as follows: legs that were ≤3mm discrepant were classified as even, while legs that differed by >3mm were judged left short or right short as the case may be. The data were entered into Table 1. The weighted kappa statistic for inter-method agreement was 0.65 (0.38, 0.91). This corresponds to “substantial” in the scale developed by Landis (22). The methods agreed either on the side of the short leg or that the legs were even in 18/22 (81.8%) cases.

Table 1. Compressive leg checking vs. sit-stand test

	Sit/stand test				
		left	Even	right	totals
Comp. leg check	left	1	1	0	2
	Even	0	7	0	6
	Right	0	3	10	14
	Totals	1	11	10	22

DISCUSSION

Leg length assessment often call for the application of some cephalad pressure on the legs. For example, one author suggests the examiner may "apply a gentle constant headword pressure with the thumbs pushing through the long axis of the legs” (23); although another author advises not to "cram the legs into the acetabular joints or shake the legs" (24). The compressive leg checking procedure that was used in our experiment differs from typical prone leg checking, such as the 6-point landing system described by Fuhr et al (23), in that more cephalad force is deployed. It has been measured with a soft tissue algometer to apply about 3 kg/leg, somewhat more force than reported by Hartley and Charley (25), who also used a form of loaded leg checking. During conventional unloaded leg checking, the finding of a short leg suggests the presence of increased ipsilateral suprapelvic muscle tone, which in the prone position laterally flexes the pelvis, pulling one leg relatively cephalad, creating a functional short leg (or contralateral functional long leg). This has been explained in Travel's analysis of the quadratus lumborum muscle (26), Schneiders "muscular short leg" model (27), Knutson's discussion of fLLI (3), and Cooperstein's modeling of pelvic torsion (9). Hypothetically, compressive leg checking reverses that relationship: applying cephalad force to the feet trues the pelvis by overwhelming any difference in left-right iliac crest positions related to modest differences in left-right suprapelvic muscle tone, so that differences in foot positions would reflect aLLI.

The great majority of leg check studies asked the examiner(s) to simply determine which leg was shorter, some studies allowing for the finding of even legs. The reliability of dichotomous, discrete data such as these is typically measured with the kappa statistic (28). Quantifying the degree of LLI, as in our study, generates continuous data that not only identifies the side of a short leg, but also the magnitude of LLI. If the paired differences between assessments are normally distributed, the Intraclass Correlation Coefficient (ICC) statistic can be used to calculate interexaminer or inter-method reliability. Since this was not the case in the n=93 intraexaminer module, we reported intraexaminer reliability as both the mean of the absolute differences between measurements, and the median of these absolute values: 2.2mm and 1.0mm, respectively. These differences are in the range for which compressive leg checking has previously been shown to accurate in detecting artificial aLLI (29). Since the differences between the first and third measurements were in fact normally distributed, ICC could be calculated, ICC=.0.65 (0.38, 0.91), which corresponds to “fair to good” (21).

The dispersion (i.e., variability) of the data in both the intra- and interexaminer modules was reported as the Median Absolute Deviation (MAD,) which was 1.0mm in both. Calculating MAD (30) involves (a) calculating the median of the absolute values of paired examiner differences, (b) subtracting this median value from each paired difference to derive another set of absolute values; and (c) calculating the median of this derived set of absolute values. This series of steps is represented by the following equation: for each value x_i, MAD = median($|x_i$ - median$(x_i)|$). MAD is a measure of statistical dispersion, analogous to the standard deviation that is calculated for parametric data. It is considered a robust statistic, in the sense that it is more resilient to outliers in a data set than is standard deviation. In computing MAD, outliers at the extremes of a data set do not have undue impact on the computation, because its calculation depends on median values.

Since the data in the interexaminer module were indeed parametric, we were able to calculate ICC=0.67 (0.25, 0.87). This corresponds to “fair to good” (21). This suggests the compressive leg checking may be clinically useful, although this would be clearer if its validity were demonstrated by comparison with an imaging reference standard. As is typically the case, in this study interexaminer differences (mean=3.1mm, median=3.0 mm) exceeded intraexaminer differences (mean=2.8mm, median=2.0mm).

The weighted kappa value of 0.71 for the agreement of compressive leg checking and the sit-stand test reflects “substantial” agreement according to the Landis and Koch (31) classification scheme. The preponderance of right short legs (74.1%) in both of the aLLI measuring methods used in this study is consistent with what has been reported in previous studies, as are the magnitudes of putative aLLI (45.1%≥ 5mm) (3).

Since in 29% of cases in the intraexaminer module the examiner did not identify the same leg as being short in all 3 measurements, it would seem that a clinical protocol estimating LLI by means of 1 single measurement is somewhat suspect. With purely dichotomous decision making with respect to LLI, a single-point measurement bears an unacceptable risk of pointing toward a sub-optimal clinical intervention, such as placing a heel lift under the wrong leg. Since in all the cases in which there was a difference in the leg judged to be short leg LLI≤3.0 mm, it would be prudent to regard very small differences as “even”. Sign reversals are to be expected when the subject’s legs are practically the same length. Using the mean of 3 repeated measures represents an acceptable compromise between the twin dictates of increasing accuracy and being time-efficient in examining a patient (32).

aLLI may be a risk factor for pelvic torsion, such that posterior innominate rotation occurs on the side of the long leg and anterior rotation on the side of the short leg (7). Therefore, having a low tech means of identifying aLLI can help a clinician choose vectors for mechanical interventions most likely to ameliorate intrapelvic misalignment. Moreover, there is evidence that aLLI, by whatever mechanism, is associated with chronic low back pain and other pain syndromes (5, 6); and correction of LLI with an appropriate heel lift often improves low back pain (11, 33). Thus, a non-invasive, accurate, clinical assessment of aLLI may lead to improved outcomes in low back pain patients.

This study had some limitations that should be acknowledged. The subjects were rather homogeneous, being asymptomatic and young, and not representative of most patients who might be assessed in this manner. Since this convenience sample of 31 was relatively small, one should be cautious in extrapolating its results to larger patient populations. The different sample sizes in the subject subgroups (15 in the interexaminer module, 22 in the inter-method reliability module) were owing to logistical considerations on the days data were acquired. While compressive leg checking is reliable and valid for detecting artificially created LLI, its accuracy compared with a radiological reference standard has not been determined. Although during the conduct of the interexaminer module the examiner stated he was unable to recall prior measurements during subsequent measurements, this cannot be verified. Granted there was good agreement between the compressive leg check and the sit-stand test, their accuracy in measuring aLLI remains unknown. When LLI assessment methods agree, they might both be accurate or inaccurate. Ultimately, it remains to be seen to what extent the knowledge supplied by compressive leg checking leads to significantly enhanced clinical outcomes.

CONCLUSION

Compressive leg checking has demonstrated good interexaminer and intraexaminer reliability. Its results correlate well with the sit-stand test, also thought to identify aLLI. If a visual check is to be performed to identify aLLI, it might be best to perform at least 2 tests rather than depend on the results of any one test. According to Miller et al "Two physical maneuvers that detect the same pathology are more likely to identify the pathology if performed together than if the tests are performed individually" (34). Compressive leg checking, by itself or preferably in conjunction with the sit-stand test for independent confirmation, may provide a useful alternative to other low tech methods of assessing for aLLI, including tape measure methods, block methods, and the Allis test. Granted that a useful clinical test must be both valid and reliable, either parameter could be satisfied first. The present investigators established concurrent validity first, by calibrating the accuracy of compressive leg check prior to establishing its reliability in this current series of experiments. By comparison, since the reliability of traditional unloaded leg length assessment has already been established (35), future investigators might consider calibrating or otherwise established the accuracy of these unloaded assessment procedures to establish their clinical utility.

Statement re conflict of interest

None of the investigators have any commercial or other conflict of interest associated with this project.

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