Comparison of Supine and Prone Methods of Leg Length Inequality Assessment

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Abstract

Objective: The primary objective of the current study was to determine the reliability between methods of supine and prone leg length inequality (LLI) assessment. The secondary objective was to determine if the degree of examiner confidence affected the degree of intermethod agreement.

Methods: Two experienced doctors of chiropractic assessed 43 participants for LLI, one using a prone and the other a supine method. They stated whether they were confident or not confident in their findings.

Results: Kappa values for intermethod agreement were 0.16 for the full data set; 0.00 for the n = 20 subgroup with both examiners confident; 0.24 for the n = 18 subgroup with 1 examiner confident; and 0.55 for the n = 5 subgroup with neither examiner confident. Supine and prone measures exhibited slight agreement for the full data set, but no agreement when both examiners were confident. The moderate agreement with both examiners not confident may be an artifact of small sample size.

Conclusions: This study found that supine and prone assessments for leg length inequality were not in agreement. Positioning the patient in the prone position may increase, decrease, reverse, or offset the observed LLI that is seen in the supine position. (J Chiropr Med 2017;16:103-110)

Key Indexing Terms: *Chiropractic; Diagnostic Techniques and Procedures; Leg Length Inequality*

Introduction

Leg length inequality (LLI) assessment is performed by doctors of chiropractic, physical therapists, and doctors of osteopathy for a number of reasons.[1] The test involves determining the baseline relative position of the feet in the prone or supine position, which amounts to a *y*-axis positional asymmetry of the distal lower extremities. There are also leg checking protocols in which LLI is assessed as an evoked response, as when the head is turned or the knees flexed to 90°[2] or when the examiner or patient makes contact with a part of the patient's body.[3] A review of the literature on the reliability and validity of measures used in manual therapy to localize the site of spinal manipulation[4] found varying levels of reliability for supine and prone LLI assessment procedures.[5-18] There was also some support for the validity of measures of supine and prone LLI.[19-25]

The clinical interpretation of LLI crucially depends on the distinction between *anatomic* LLI (LLIa),[26-28] wherein the legs are measurably of different length, and *functional* LLI (LLIf), in which the legs are de facto equal in length and yet 1 has been drawn cephalad in some manner (Table 1).[29,30] A review article on pelvic torsion includes discussion of various models for the functional short leg.[31]

Descriptions of leg length assessment procedures do not uniformly take into account that *observed* LLI (LLIo) may reflect primarily LLIa or LLIf, let alone what diagnostic difference this may make. It has been suggested that a functional short leg may be associated with posterior innominate rotation, whereas an anatomical short leg has been found to predict anterior innominate rotation.[29] Considerations such as these suggest that discrimination of functional from anatomic short legs may have an impact on clinical outcomes.[32]

Practitioners who focus on the upper cervical spine are also entrenched in functional leg checking.[33,34] The assumption for this group is that it may be a surrogate measure of the state of atlas alignment, given that upper cervical radiographs cannot be obtained during every office visit. An upper cervical monograph states: "Not only does the short-leg indicate the presence of nervous imbalance in the CNS [central nervous system], but the amount of shortness can indicate the degree of neurological imbalance."[34] Although upper cervical chiropractors typically assess LLI in the supine position,[35] other chiropractic techniques employ LLI assessments the prone position.[33]

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Table 1. *Clinical Parameters Related to Functional and Anatomic Short Legs*

Type of Leg Check	Clinical Consideration[1]
Functional short leg[26]	May identify the site of and direction of misalignment of specific subluxations (chiropractic) or segmental dysfunctions (physical therapy, osteopathy)
	An outcome measure for provocative testing of sites of potential spine and sacroiliac care, as well as vectors for therapeutic interventions
	An indicator of whether a single adjustment or multifaceted clinical intervention to a specific somatic structure has been successful
	A general indicator of the patient's overall health status or changes in that status
Anatomical short leg[27]	Risk factor for somatic pain conditions involving the lower extremity, sacroiliac joints, spine, and possibly craniofacial structures
	Results in spinopelvic compensating mechanisms, including pelvic torsion[29]
	≥5 mm seen in 44% of asymptomatic and 75% of symptomatic low-back patients[30]

Although supine and prone leg checks are used in practice, there are few published studies as to whether their results agree. There are also few studies evaluating if the information supplied by leg checking influences clinical outcomes. A previous study reported that supine and prone leg length assessments manifested different associations with pelvic obliquity, but no direct comparison was drawn between the leg checking methods.[36] A different study comparing the results of leg checking with radiographs included a module assessing the agreement of supine and prone leg checks; however, only part of the data was reported.[22]

We feel that it would be worth knowing if prone and supine leg checks may be regarded as equivalent procedures, or if they should be regarded as dissimilar procedures that provide different information. Therefore, the primary objective of the current study was to determine the intermethod reliability of supine and prone LLI assessment. The secondary objective was to determine if the degree of examiner confidence had an impact on the degree of intermethod agreement.

Methods

The number of participants to be included in this study was based on the following: for κ agreement coefficients, the required number of participants depends on (1) the relative error r, where it has been suggested that any estimated interrater reliability coefficient should differ from its "true" value by no more than 20%; and (2) the difference $p_a - p_e$ between the overall agreement probability p_a and the chance-agreement probability p_e.[37] Under the best-case scenario that chance agreement in this study was zero, it would take 39 participants to detect 80% intermethod agreement for $r \leq 20\%$. The investigators chose $n = 39$ as the minimum number of participants to be recruited.

The inclusion criterion was a willingness to participate in the study. The exclusion criterion was a prior adverse response to any form of chiropractic leg checking procedure. Each participant provided written informed consent, and the institutional review board of Palmer College of Chiropractic approved the project. The 2 examiners in the project (Dr. Terri Payton, Dr. John Lockenour) were both experienced clinicians, one with 30 years' experience in the supine assessment procedures preferred by upper cervical chiropractors, and the other with 39 years' experience in the prone assessment procedures preferred by most other chiropractors. A third investigator served as a data recorder for each examiner. Participants were assigned an identification number from 1 to 43 and then divided into 2 groups: even-numbered participants were assessed in the prone position first, and odd-numbered participants were assessed in the supine position first.

Leg length assessments were made using 2 identical, flat, padded, bench-type chiropractic tables. For the prone check (Fig 1), the participants approached the foot of the table and knelt on the foot of the table. The participants then lay prone, using their arms to pull the body cephalad until the ankles were at the foot of the table, attempting to remove any table positioning artifacts. For the supine check (Fig 2),

Fig 1. *Prone leg checking.*

Fig 2. *Supine leg checking.*

the participants approached the foot of the table and sat down at the foot of the table. They then used their arms to pull their seated bodies toward the head of the table until their ankles cleared the foot of the table, attempting to remove any table positioning artifacts. For both leg checking methods, participants removed all articles from their pockets before mounting the table. Both the prone and supine checks were performed by dorsiflexing the feet, then visually comparing the medial malleoli for any leg length discrepancy. The examiners were required to judge either the left or the right leg short and were not permitted to find the legs even.

Participants stood in line while waiting for their first check. If checked prone first, the participant would go to the back of the line and wait to be assessed in the supine position. If checked supine first, the participant would go to the back of the line and wait to be assessed in the prone position. About 10 minutes elapsed between observations. After each assessment procedure, the examiner would whisper the participant's identification number, which leg appeared short, and whether the examiner was confident or not confident in the finding into the data recorder. There was no conversation between the examiners and the participants, nor between the examiners. No clinical data were provided to the examiners. A towel was draped over each subject's pelvis, thighs, and knees to conceal any anatomic information from the examiners that may have affected their observation of LLI.

Results

A convenience sample of 43 asymptomatic and minimally symptomatic student volunteers were recruited. Five (11.6%) participants reported leg pain ranging from 1 to 6 on an 11-point scale (mean = 3). Three participants (7.0%) reported prior histories of lower extremity injuries and surgeries. The sample was 37% female, and their mean age was 25.5 years (range: 23–42).

Intermethod reliability data are summarized in Table 2. The supine leg checker found 25 of 43 legs (58.1%) short on the left; the prone leg checker found 26 of 43 legs (60.5%) short on the left. The 2 leg checks agreed there was a left short leg 13 of 43 times (30.2%) and a right short leg 12 of 43 times (27.9%). In 18 of 43 cases (41.9%), the leg check methods disagreed on the side of the short leg. The supine leg checker was confident 30 of 43 times (69.8%), and the prone leg checker was confident 28 of 43 times (65.1%).

For the complete data set, intermethod agreement was κ = 0.16; when both examiners were confident, κ = 0.00; when only 1 examiner was confident, κ = 0.24; and when neither examiner was confident, κ = 0.55.

Discussion

To our knowledge, this is the first study to compare LLI prone and supine assessments. According to the often-cited Landis and Koch scale for Kappa Statistic Strength of Agreement, 0.00-0.20 indicates slight; 0.21-0.40 equals fair; 0.41-0.60 indicates moderate; 0.61-0.80 equals substantial; and 0.81-1.00 indicates almost perfect.[38] According to this scale, intermethod agreement for the full data set in this study was slight. When both examiners were confident, their agreement was perfectly nil, increas-

Table 2. *Results*

Combined Data Set		Supine		N = 43
		Left	Right	Total
Prone	Left	13	9	22
	Right	9	12	21
	Total	22	21	43
Cohen's κ = 0.16				
Both confident		Supine		N = 20
		Left	Right	Total
Prone	Left	4	4	8
	Right	6	6	12
	Total	10	10	20
Cohen's κ = 0.00				
One confident		Supine		N = 18
		Left	Right	Total
Prone	Left	6	5	11
	Right	2	5	7
	Total	8	10	18
Cohen's κ = 0.24				
Neither confident		Supine		N = 5
		Left	Right	Total
Prone	Left	3	0	3
	Right	1	1	2
	Total	4	1	5

Cohen's κ = 0.55.

ing to fair when either 1 was confident and to "moderate" when neither was confident. Most likely the moderate intermethod agreement seen in the n = 5 subgroup, for which neither examiner was confident, was an artifact of the small sample size. In this study, examiner confidence did not seem to be related to the degree of intermethod agreement.

The results of the present study were, broadly speaking, consistent with 2 other studies that compared aspects of supine versus prone leg length assessment procedures: (1) Rothbart and Estabrook[36] studied the association of chondromalacia patellae and pronation using prone and supine examination procedures, and (2) Rhodes et al,[22] in an arm of their study, assessed the agreement of supine and prone leg checks with radiographic measurement of LLI, as well as with each other.

In Rothbart and Estabrook's study, 70 of 75 (93.3%) pronators exhibited pelvic obliquity, with an inferior innominate bone on the pronated side; 68 of 75 (90.7%) pronators were found to have a short leg on the side of the inferior innominate bone while prone, but manifested no LLI when supine.[36] To explain these results, the authors opined that when prone, the abdomen in essence suspends the pelvis, so that contact with the table does not attenuate any influence of pelvic position on functional LLI. By comparison, in the supine position, slight hip extension stretches the hip flexors, resulting in an anterior pelvic tilt. This anterior pelvic tilt, in conjunction with posterior to anterior pressure on the distal sacrum, supposedly mitigates the pelvic obliquity, reversing functional LLI (Fig 3).

Although we have no reason to doubt Rothbart and Estabrook's observation that the patient's legs appear more even in length when supine, their explanation based on mitigated pelvic obliquity is purely hypothetical. As an alternative explanation (Fig 1), we hypothesize that pressure on the posterior superior iliac spines (PSISs) while supine mitigates pelvic torsion (not obliquity), thus damping the functional LLI (LLIf) that is commonly attributed to pelvic torsion.[31] Conversely, there is less, if any, pressure on the anterior superior iliac spines (ASISs) in the prone position (as explained by Rothbart and Estabrook), so there would be no mitigation of pelvic torsion in that position. Under these assumptions, LLIf in the supine position would more likely reflect biomechanical factors other than pelvic torsion, including but not limited to an upper cervical subluxation.[35,39] In this article, the term *subluxation* is used to denote a small joint misalignment, as might be seen on a radiograph. This chiropractic usage of the term is quite different from the medical definition of subluxation as a partial dislocation.[40]

In their n = 50 study primarily intended to determine whether prone or supine measures of LLI correlated better with radiographic estimates, Rhodes et al provided partial data comparing the results of supine and prone assessments.[22] In 13 cases, the supine and prone measures disagreed as to the side of the short leg; in 11 cases, the supine leg check recorded even legs, whereas the prone check recorded an inequality (left/right data not provided); in 1 case, the prone leg check recorded the legs as even while the supine check recorded uneven legs (side unidentified). Although Rhodes et al did not comment on the remaining 25 subjects, in these cases the leg checks presumably either agreed on the side of the short leg or agreed that the legs were even in the supine and prone positions. In very broad terms, granted the incomplete data reporting, it might be stated that only about half the time did the prone and supine measures agree. Because reporting method agreement in percentage terms is misleading, as it does not correct for chance agreement, the present authors thought it might be instructive to construct a hypothetical data table (Table 3) for the Rhode et al study based on both their actual data and hypothetical data consistent with the authors' discussion and the data reported. The heuristic intermethod agreement in this study, using some interpolated data, was $\kappa = 0.18$, very similar to the $\kappa = 0.24$ seen for the unstratified agreement in the current study.

Although the lack of agreement of prone and supine leg checking methods seen in the current study and in that of Rhodes et al[22] remains without explanation, the results suggest that the patient being prone or supine affects LLIf in potentially different ways. In short, prone and supine methods of detecting LLI are not equivalent and appear to identify different clinical phenomena, to wit, different types of LLIf. LLIo is the mathematical sum of LLIf and LLIa.

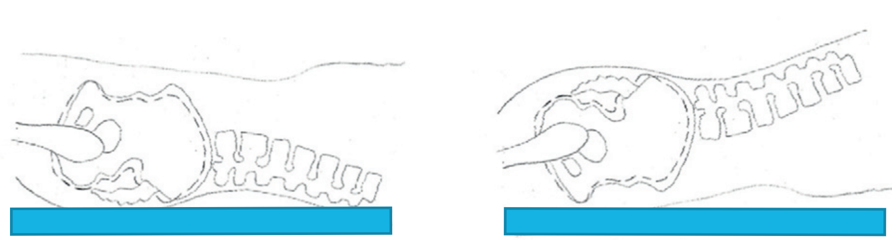

Fig 3. *Supine lying (left) mitigates pelvic torsion caused by pressure on the anterior superior iliac spines (ASISs), diminishing functional leg length inequality (LLIf). Prone lying (right) does not mitigate pelvic torsion or LLIf resulting from it, because the ASISs are suspended off the table.*

Table 3. *Rhode's Data, Partially Hypothetical*

		Prone			N = 50
		Left	Even	Right	Total
Supine	Left	8	1	6	15
	Even	6	5	5	16
	Right	7	0	12	19
	Total	21	6	23	50

Cohen's $\kappa = 0.18$.

Because LLIa is a constant, differences in LLIo as seen in the supine compared with the prone position would then result from differences in the way the supine and prone positions affect LLIf. This model is consistent with traditional biomechanical concepts related to leg checking procedures, in which upper cervical technique doctors tend to use supine and most other doctors use prone leg checking procedures, although it most certainly cannot be said to validate them.

Upper cervical chiropractors believe atlas subluxation produces neurological imbalance of the central nervous system, resulting in spastic contracture of the skeletal muscles[41]; this is thought to affect the reticular formation in the brainstem, resulting in disinhibition of caudal structures, and ultimately has an impact on spinal muscle tone, resulting in LLIf. Knutson expanded the concept by hypothesizing that atlanto-occipital fat pad impingement could result in suboccipital muscle hypertonus, provoking a tonic reflex[42] resulting in a functional short leg.[43] Upper cervical practitioners have added that this in turn may result in postural distortion and displacement of the body's center of gravity, 1 outcome of which may be pelvic distortion and "leg disparity."[44] Thus, neural imbalance in the extra-pyramidal connections is thought to be the primary pathology. There are some data consistent with, although not necessarily confirming, this model. Seemann reported decreased leg length inequality, as measured by anatometer, following National Upper Cervical Chiropractic Association (NUCCA) atlas adjustments.[39,45,46]

Outside of upper cervical technique, most other chiropractors use prone leg checks, which they construe to provide information about pelvic torsion.[31] Previous proposals include an explanation for the association of LLIf with the postural configuration of the pelvis[1,47]: pelvic obliquity in the standing position, which may result from pelvic torsion, inaugurates a righting reflex that increases the tone of the paraspinal muscles on the inferior hemipelvis side. Although this cannot elevate it in the standing position, it would be expected to pull the hemipelvis superiorly (ie, laterally flex it relative to the spine) in the prone position, drawing the ipsilateral leg cephalad.[1,47-49] In this model the failed effort to true the pelvis in the weight-bearing position paradoxically succeeds in the prone position by laterally flexing the pelvis on the spine, producing a functional short leg. In addition to explaining how a primary posterior ilium rotation may result in a functional short leg, Reviews of the literature have also suggested that an anatomic short leg may be associated with anterior innominate rotation.[29]

To link these considerations with the variable impact of prone and supine leg length assessment procedures, we must consider how the patient's body position influences the observation of LLIf. As stated earlier, the authors have suggested that pressure on the PSISs while lying supine mitigates pelvic torsion, thus damping the LLIf commonly attributed to pelvic torsion. By comparison, lying prone would not be expected to mitigate this effect. There is no obvious reason why lying prone or supine would differentially affect the putative impact of upper cervical subluxation on LLIf.

To continue with this unifying theoretical model, although speculative in nature, it would be expected that the LLIf observed when there is an upper cervical spinal subluxation, which presumably is not influenced by the patient's body position, might be increased, decreased, or exactly offset were a subject with pelvic torsion to assume the prone position. This would depend on whether the upper cervical and pelvic impacts were on the same or opposite legs, and could account for the lack of agreement between the prone and supine methods. This unifying model might also shed some light on the Rhodes et al study.[22] The 11 of 50 (22%) patients in the Rhodes et al study who had even legs supine, but manifested LLI when prone, presumably had pelvic torsion, but not upper cervical subluxation. The 13 of 50 (26%) patients whose prone and supine results were opposite presumably had a cervical subluxation shortening 1 leg, but a pelvic torsion producing a greater shortening of the other leg. The 25 of 50 (50%) patients for whom no discrepancy was reported (with examiners agreeing on the side of the short leg or agreeing there was none) may either have lacked subluxation or had subluxation and torsion that had ipsilateral, additive impacts, shortening the same leg.

Limitations

This study did not have a validity arm; thus, the accuracy of the leg checkers was not known. The largely asymptomatic persons who participated in this study were not necessarily similar in their leg checking findings to patients who are seen in other clinical situations. The examiners were required to judge either the left or right leg short and were not allowed to state they were even. On the other hand, the option of the examiner to state confidence was lacking served as a surrogate identifier for having found the legs even. The method of examiners rating their confidence to determine the impact on interexaminer reliability has been used previously.[50-52] However, in this study we did not have each examiner perform both prone and supine leg checks. One reason for this was a concern that an examiner's findings for the second check could have been biased by recall of the findings for the first check. More importantly, it seemed unlikely that an examiner would have equal expertise in the 2 types of leg checking. In our experience, clinicians use either the prone or supine position, but not both, depending on whether they are full-spine or upper cervical chiropractors. We specifically sought examiners who were very experienced in the different methods and feared we would weaken the study were we to have asked each of them to also use a method in which they were far less experienced.

There was undoubtedly some degree of anatomic LLI of varying magnitude among the participants; although this presumably did not affect the component of LLIo attributable to LLIf, we cannot rule out putative interaction between LLIa and LLIf. This study did not include inter-examiner or intra-examiner modules, because prior studies had reported substantial reliability for both prone and supine leg checking procedures.[1,4] Although the leg checkers were very experienced in their respective prone and supine procedures, different leg checkers using somewhat different methods may have obtained different results. The lack of agreement between prone and supine leg checking results in this study may have been attributable either to variance between the methods per se or to different impacts of the patient's body position on LLIf; the design of the study did not allow discrimination between these alternative possibilities. The attempt to explain the discrepancy of the prone and supine measures of LLI was purely hypothetical, although consistent with traditional modeling of chiropractic leg checking procedures. Likewise, the secondary analysis of the data from what appears to be the only other study comparing prone and supine positions[22] is at best heuristic because of incomplete data reporting in the original publication.

Future research should deploy objective and quantified measurements of LLI using a valid method to eliminate at least 1 of the current study's limitations: potential examiner error. Knee injuries, ankle injuries, shin splints, or other lower extremity findings may also affect the results of leg checking. Future studies should also either take these into account or use them as exclusion criteria to maintain sample homogeneity. Moreover, research linking either upper cervical or pelvic torsion to leg checking findings is warranted to determine if such considerations have an impact on clinical outcomes.

Conclusions

The findings of this study suggest that supine and prone leg length assessment procedures appear to measure different phenomena, and their results in this study were not interchangeable. There may be mechanical reasons that the supine body position mitigates against LLIo attributable to pelvic torsion, whereas the prone position may increase its observability. The discrepancy between prone and supine leg checking results may then reflect that placing the patient in the prone position may increase, decrease, reverse, or exactly offset the LLIo that is seen in the supine position.

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No funding sources or potential conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): R.C.
Design (planned the methods to generate the results): R.C., M.L.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): R.C.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): M.L.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): R.C.
Literature search (performed the literature search): R.C.
Writing (responsible for writing a substantive part of the manuscript): R.C., M.L.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): M.L.
Other: R.C. served as principal investigator and obtained institutional review board approval.

Practical Applications

- This study found that supine and prone assessments for leg length inequality did not agree.
- The supine and prone positions may have different impacts on functional leg length inequality.
- Assessment for leg length inequality in the prone position may detect consequences of pelvic torsion, whereas supine assessment may detect consequences of upper cervical segmental misalignment.

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