Commentary

Heuristic exploration of how leg checking procedures may lead to inappropriate sacroiliac clinical interventions

Robert Cooperstein MA, DC*

Professor, Director of Technique, Director of Research, Palmer Chiropractic College West, San Jose, CA 95134

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Abstract Several primary studies have shown that an anatomical short leg predicts anterior rotation of the ipsilateral ilium, whereas anatomical long leg predicts posterior rotation of the ilium on the long leg side. At the same time, in chiropractic and other manual therapy professions, it is widely believed that the leg check finding of a short leg is associated with posterior ilium rotation, and a long leg with anterior ilium rotation. The purpose of this commentary is to explore the consequences of this paradox for the manual therapy professions, insofar as leg checking procedures are commonly used to derive appropriate vectors for chiropractic manipulation/adjustive procedures.

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Introduction

Cooperstein and Lew¹ published an article gathering the evidence that anatomical leg length inequality (aLLI) is a risk factor for pelvic torsion. Specifically, the ilium tends to rotate posteriorly on the side of an anatomical long leg and anteriorly on the side of an anatomical short leg. This effect is dose related, so that greater amounts of aLLI result in more pelvic torsion. This appears to be a postural strategy that attempts to level the pelvis despite the asymmetry in leg length by lowering the sacral base on the side of the long leg and

raising it on the side of the short leg. Mitigating against pelvic obliquity enables the lumbar spine to remain straighter than would otherwise be the case, reducing the need to expend muscle energy to maintain postural balance. Although the article of Cooperstein and Lew primarily intended to review the basic science data on how pelvic torsion is associated with LLI, they did suggest the need to derive the clinical implications of these basic science data: “Given that many clinicians and technique systems believe that posterior innominate rotation occurs on the short leg side, the possibility exists that sacroiliac adjusting procedures may be using inappropriate vectors with a negative impact on patient outcomes”.¹ This current article intends to explore the clinical implications of the basic science data.

Simply put, here is the conundrum: with an *anatomical* short leg, research convincingly demonstrates a

* Palmer Chiropractic College West, 90 East Tasman Dr, San Jose, CA 95134. Tel.: +1 408 944 6009; fax: +1 408 944 6118.

E-mail address: cooperstein_r@palmer.edu (R. Cooperstein).

tendency for anterior iliac rotation, whereas with a *functional* short leg, there are clinical grounds (discussed below) to expect posterior iliac rotation on the side of the short leg. Because it is not entirely clear in which direction one would expect the ilium to rotate given the finding of an unspecified short leg (anatomical or functional?), it is difficult to decide upon an appropriate vector of correction. Clearly, an appropriate clinical intervention would logically depend on whether an observed short leg is a structural or functional short leg.

Before getting into details, it would be best to sketch the argument that this present article develops:

- Basic science data demonstrate that an anatomical short leg predicts *anterior* ilium rotation.
- However, the conventional clinical wisdom among manual therapists is that a functional short leg predicts *posterior* ilium rotation.
- The usual explanation of the putative association of functional short leg and posterior ilium rotation is not consistent with the anatomy of the pelvis.
- Nonetheless, there is an alternative, more defensible model for such an association.
- Predicting in which direction the ilium rotates when there is LLI depends on whether it is aLLI or functional LLI (fLLI).
- There are some low-tech methods for discriminating aLLI from fLLI.
- Lacking such a discrimination, manual therapists performing leg checks as an important element of pelvic mechanical assessment are likely choosing (at best) random vectors for low back interventions.

The putative mechanism by which a functional short leg is associated with posterior ilium rotation

The usual explanation of this is that posterior rotation of the ilium, occurring about a horizontal axis through the sacroiliac joint, moves the acetabulum anteriorly and superiorly, thus creating a short leg that would be seen during the performance of a prone or supine leg checking procedure. The problem with this explanation is that iliac rotation occurring in this manner would also move the ipsilateral pubic bone in this same direction, thus luxating the symphysis pubis. Fig 1 shows the putative short leg mechanism, but also the dislocation of the front of the pelvis that would result. Moreover, it was demonstrated as long ago as 1936² and brought to bear on contemporary chiropractic technique by Hildebrandt³ that torsion occurs

Fig 1. Posterior ilium rotation may swing the hip superiorly, but would also luxate the symphysis.

around a horizontal axis through the symphysis, rather than through the sacroiliac or hip joints, as others have surmised (Fig 2).

Cooperstein⁴ has drawn attention to the purely anatomical objections to this traditional model of the chiropractic short leg. As an alternative explanation, he suggests that righting reflexes on the side of a posterior-inferior (PI) medial ilium would likely increase the tone of the ipsilateral suprapelvic muscles, notably quadratus lumborum and the erector spinae, thus drawing up the leg in the prone or supine position and creating a short leg (Fig 3). This muscular short leg model drew experimental support from research done using a novel table optimized for the detection and investigation of LLI⁵ and is supported by writings of Schneider⁶ and of Travell and Simons.⁷

In this article, calling attention to the possible clinical significance of intrapelvic structural distortion

Fig 2. Pelvic torsion about an axis through the symphysis pubis.

Fig 3. Standing low hip predicts prone short leg.

is not meant to minimize or neglect the possible importance, perhaps greater importance, of functional pathology in the pelvis, such as sacroiliac fixation or restriction. It is likely that structural and functional pelvic pathology are codetermining, and it is not entirely clear whether clinical interventions primarily based on static or dynamic analysis would be more likely to achieve a better clinical outcome. This article simply addresses the common practice, in and outside of chiropractic, of deriving mechanical vectors for clinical interventions (side-posture sacroiliac manipulation, prone and supine drop table sacroiliac maneuvers, pelvic blocking maneuvers, muscle-balancing protocols, and instrument adjusting) from leg checking procedures. It does not address the clinical utility of such practices, so much as the internal validity of the protocols in common use.

The short leg question

Because the appropriate clinical intervention apparently depends on whether the patient's short leg is anatomical or functional, it follows that it is necessary to discriminate between the two.⁸⁻¹⁰ Radiology, and more specifically scanogram radiograph, is generally regarded to be the criterion standard for identifying aLLI. Although the accuracy of the scanogram has been put in question¹¹ and at least one author has opined that he prefers the tape measure method (TMM),¹² radiology remains the reference standard against which other LLI detection methods are generally compared. According to some authorities, plain radiology, which involves radiometric analysis of an upright pelvic radiograph, is a reasonable substitute

for, or even preferred to, either plain or computed tomographic scanograms.^{11,13}

Radiological procedures for detecting LLI are costly, both in terms of economic costs and the potential hazards of exposing the patient to ionizing radiation. Thus, clinicians would generally prefer a lower-cost, noninvasive method of detecting LLI. Visual method like supine and prone leg checks as generally performed by chiropractors do not convincingly distinguish aLLI from fLLI; quantifying the result by using tools like the Chiroslide^{14,15} does not address that problem. Among the low-tech methods that have been put forth, at least 4 merit consideration.

Low-tech methods to detect aLLI

Compressive leg check^{16,17}

In this instrumented, prone leg checking procedure, moderate cephalad force is applied to the feet. One hypothesis is that this pressure overwhelms the impact of functional differences in suprapelvic muscle tone on the relative y-axis position of the lower extremities, so that any apparent LLI would represent an anatomical difference. As another hypothesis, our experience in performing this test suggests that there may be some difference in the compressibility of the joint spaces of the lower extremities that becomes manifest with cephalad pressure.

Sitting/standing indirect leg check

Bordillion and Day,¹⁸ as further clarified by Cooperstein,¹⁹ describe a method of detecting aLLI that depends on observing changes in the relative position of the PI iliac spines in going from the seated to the standing position. If the difference in seated PI iliac spine positions changes going from sitting to standing (whether the difference increases or decreases in magnitude), then the most likely explanation is that there is aLLI. It is not known to what degree the observed changes are proportional to the amount of aLLI; but it is reasonable to think that such differences may have at least qualitative significance, that is, identify the side of an anatomical short leg.

Tape measure methods^{12,20-33}

A variety of TMMs (also called *direct methods*) has been described, with one end of the measure applied to either the anterior superior iliac spine (ASIS), umbilicus, or xiphoid process and the other brought to either the medial or lateral malleolus. Woerman and Binder-Macleod,³³ in one of the oldest and more rigorous of studies that compared a variety of TMMs

to a radiological reference standard, preferred measuring from the ASIS to the medial malleolus. However, careful reading of this original report, in which 20 examiners measured only 5 patients, does not seem to bear out this conclusion. That stated, the tendency in studies that followed this was to use and prefer this method; and this bias has crept into orthopedic textbooks and teaching curricula. Studies comparing the results of a TMM vs a radiological criterion standard tend to find it not more accurate than plus or minus 5 mm³⁴ and quite unreliable (or imprecise).

Block indirect method^{20,26,27,33,35}

The block (or indirect) method determines how many blocks of known magnitude are required to level the pelvis in a person with apparent pelvic obliquity. A pelvic inclinometer of some type may be used to assess pelvic obliquity and changes thereof, or iliac crest heights may be assessed purely visually. In most studies where the block method has been compared with a TMM, it has been found to be more reliable and more accurate than the TMM, within about 2 mm of the reference standard.

Allis leg check³⁶

In this visual test, the supine subject's knees are flexed to about 45° while the toes are closely approximated. The knees are sighted both from the foot of the table and the side of the table for asymmetry in either height or position along the y-axis of the body. Cooperstein et al,³⁶ having performed a mathematical simulation of this test, concluded that it lacked validity, primarily because of the difficulty of knowing the relative position of the hips.

Clinical importance of distinguishing aLLI from fLLI

The question of whether the PI medial ilium is associated with an anatomical long leg or a functional short leg would hardly be a burning one if the incidence of aLLI were small. However, the preponderance of studies show that aLLI is common and that its incidence increases in a symptomatic compared with an asymptomatic population.³⁷ The most oft-cited study is that of Friberg,³⁷ who found that about 44% of asymptomatics receiving scanogram radiograph exhibited 5 mm or more aLLI, whereas the percentage increased to about 75% in a symptomatic population. Knutson⁸ reviewed other studies on the prevalence of aLLI. Aggregating 8 such studies that he judged to be reliable, with a population of N = 573, the mean aLLI

was 5.21 mm (SD, 4.1 mm). This is very consistent with the results of Friberg's seminal study.

Therefore, given the high prevalence of aLLI, simply assuming that observed LLI is functional rather than anatomical runs the risk of leading to incorrect vectors in using manual therapy to address clinical conditions, signs, or symptoms. Although it is not the purpose of the present article to review the evidence that the direction of a manipulative or mobilization procedure affects the clinical outcome, the author does believe this to be true; some data suggest that particular lines of drive or correction make a difference, for example, in prescribing exercises³⁸ and in pelvic blocking procedures.^{39,40}

Mainstream chiropractic techniques that depend in part on an analysis of LLI

The major mainstream chiropractic techniques that derive adjustive vectors and treatment protocols in part from the determination of a functional short leg include Thompson Technique, Pierce-Stillwagon Technique, Activator Methods Chiropractic Technique, Applied Kinesiology, Sacro-Occipital Technique, and Diversified Technique. These are listed in Table 1, which also provides a brief description of how the information provided by the functional short leg analysis is used.

Additional considerations

As stated above, there are some data suggesting that particular lines of drive or correction make a difference. Under the assumption that it is true and that lines of drive intended to reduce pelvic torsion are preferred to those that do not, chiropractors practicing any of the techniques above, as well as osteopaths (eg, DiGiovanna et al^{52,p310}) and physical therapists (eg, Manheimer and Lampe⁵³) who share their understanding that a short leg predicts a posteriorly rotated ilium and a long leg predicts an anteriorly rotated ilium, would be using the wrong vector when the patient actually has aLLI.

The text box performs a heuristic calculation of how frequently mechanical vectors chosen by conventional leg check results might be appropriate, including consideration of the impact of some inaccuracy in leg checking procedures. The mathematical results should be seen more as an indicator of the clinical problem posed by this analysis rather than a futile exercise in scientism, an overly ambitious effort to come up with an exact number. Very approximately, if leg checking were perfectly accurate, then routine deployment of the

Table 1 Technique systems using functional short leg analysis to derive adjusting vectors

Technique System	Functional Short Leg Analysis
Drop table techniques: Thompson Technique ^{41,42} ; Pierce-Stillwagon Technique ⁴³	Drop table practitioners use the so-called Derifield leg check to obtain both cervical and sacroiliac listings. In the pelvic Derifield pelvic leg check, a comparison is made between prone LLI seen with the knees extended and with the knees flexed to about 90°. In both cases, the ilium is said to have gone posteriorly on the side of the prone short leg.
Sacro-Occipital Technique ^{44,45}	Sacro-Occipital Technique practitioners often treat patients by inserting padded wedges under the prone or supine patient. As a general rule, one block is inserted near the iliac crest and another at about the level of the greater trochanter. The wedges are inserted to a large extent according to the side of the short leg, which is presumed to identify a PI ilium.
Activator Methods Chiropractic Technique ⁴⁶⁻⁴⁸	Activator Methods Chiropractic Technique, like the drop table techniques, uses the Derifield leg check variation to determine the side of so-called pelvic deficiency. Thus, the side of a short leg, as detected using during a prone leg check, is presumed to identify the side of a PI ilium.
Applied Kinesiology and spin-off Kinesiology techniques ⁴⁹	The Kinesiologies agree that a short leg is associated with a PI ilium. They would add that there is an underlying pattern of either weak muscles that allow pelvic torsion or strong muscles that effect pelvic torsion. For example, weak thigh flexors would allow posterior pelvic rotation, whereas hypertonic thigh flexors would effect anterior pelvic rotation.
Diversified Technique ⁵⁰	Although Diversified Technique is not as clearly defined as the other listed techniques, ⁵¹ being less associated with a specific technique developer or constituted body of writings, most of its practitioners would generally agree that a short leg predicts a PI ilium.

short leg = PI ilium rule would result in the wrong vector for adjustment 62.5% of the time, that is, most of the time.

Although we have so far presumed a perfectly accurate leg check, we must consider the possibility that the low-tech procedures used for detecting LLI may be inaccurate, especially for LLI less than 5 to 6 mm. There are very few studies assessing the validity (ie, accuracy) of visual methods of leg checking. Rhodes et al⁵⁴ found poor agreement with a radiological criterion standard. The high validity found by Cooperstein et al^{16,17} for compressive leg checking used a novel, atypical method that is not generally practiced. However, if we generously assume that traditional leg checking methods used by chiropractors and other manual therapists are reasonably accurate, we must consider the possibility that such assessment would produce an outcome that is literally worse than one resulting from the choice of random lines of drive.

Heuristic exploration of often how leg checking procedures may lead to inappropriate sacroiliac clinical interventions

In an asymptomatic population, presumably receiving preventive or maintenance care, we would expect almost 50% of patients to exhibit at least 5 mm of aLLI³⁶; and thus, we may assume that *most* of these would receive the wrong mechanical vector. In a symptomatic population, with 75% having aLLI of at least 5 mm,³⁶ even more patients would be expected to receive the wrong mechanical vector. Let us now

assume that half of the low back patients are asymptomatic and half are symptomatic. Then, 50% of the asymptomatic patients (25% of all the patients) get the wrong adjustment; and 75% of the symptomatic patients (37.5% of all patients) get the wrong adjustment. Thus, a total of 62.5% patients would get the wrong adjustment. Now, let us assume that leg checking is not always accurate. Paradoxically, because deploying the short leg = PI rule would be expected to generate the wrong line of drive more often than not, the more inaccurate leg checking is, the higher the percentage of patients that would receive a putatively *correct* line of drive. Indeed, at the limit, with *perfectly inaccurate* leg checking, we would have an as-good-as-it-gets outcome of 62.5% patients receiving the correct vector.

Limitations of this commentary

Although an anatomical long leg predicts a posterior ilium, it does not guarantee it; in other words, it is simply a risk factor for a posterior ilium. In taking a skeptical view of the short leg = PI rule, the furthest thing from this author's mind was replacing it with some other rule, such as long leg = PI ilium. It is important to acknowledge that anatomical factors serve more as risk factors for certain outcomes, rather than absolute causes for automatic effects.

This article discusses the implications of the relationship between LLI and pelvic structural distortion, so as to optimize the selection of vectors for sacroiliac manipulation. It did not attempt to address

issues relevant to dynamic assessment of the pelvis, such as locomotor pathology, sacroiliac fixation or restriction, or lumbopelvic-lower extremity kinetic chains. It is not clear whether the classic chiropractic emphasis on pelvic misalignment, which also finds ample expression in the other manual therapy professions, is more or less likely to result in enhanced clinical outcomes than these more functional approaches. A prudent clinician would be well advised to consider both structural and functional pathology, especially their interaction.

Although most studies find prone leg checking reasonably reproducible, there are few data pertaining to its accuracy. This article, in suggesting that the accurate discrimination of functional from anatomical LLI might improve clinical outcomes, presupposes that such a discrimination is routinely possible, which may or may not be true.

The entire rationale for this commentary on the relationship of LLI to appropriate vectors for sacroiliac interventions depends on the assumption that there are indeed optimum vectors for any of the mechanical treatment procedures used by manual therapists. There are legitimate grounds to question this assumption, as I did when in 2001 I asked the following question: "If, as so many have said, a good treatment outcome depends on an accurate diagnosis, then how can we explain fairly uniformly good outcomes, given huge variation in diagnostic inputs?"⁵⁵ In addition to the problems we have seen in achieving diagnostic specificity, there are similar problems in staking claim to treatment specificity, as exemplified in the works of Ross et al.^{56,57} These investigators showed that cavitations during manipulation are often multiple and may occur at spinal locations other than where the segmental contact is applied. Perle and Kawchuck⁵⁸ and Perle⁵⁹ have also effectively weighed in on the issue and likelihood of adjustive specificity.

In addressing the interaction of diagnostic and adjustive specificity failure,⁶⁰ I once wrote (somewhat heuristically): "There is a roughly equal likelihood of getting the right diagnosis but addressing the wrong segment, and getting the wrong diagnosis but addressing the right segment (assuming, of course, there really is a 'right' segment)." Notwithstanding these problems concerning specificity, based on the literature such as it is and also my own experience as a clinician, I still believe that doing the "right" thing gets a better outcome than doing the "wrong" thing, but even doing the wrong thing is *usually* (but not always) better than doing literally *nothing*.⁶¹ In the end, the author is unaware of any data that the information supplied by

leg checking procedures enhances the clinical outcome of manipulation procedures. Thus, even assuming functional and structural LLI can be discriminated, there is no guarantee of a better clinical outcome.

Conclusions

Looking at the chiropractic profession alone, most of the techniques on the list of the 10 most practiced according to a National Board of Chiropractic Examiners survey⁶² use traditional leg checking procedures, such that these may very well be featured in the majority of office visits. From this, it follows that most patients receiving adjustments based on short leg determination might be receiving inappropriate (or at least suboptimal) vectors of adjustment, commonly termed *lines of drive*. At best, doctors and other health care practitioners deriving mechanical vectors from leg checking procedures, associating a short leg with a posteriorly rotated ilium, would be manipulating or mobilizing the low back using essentially random (or worse) lines of drive. What little evidence we have on the importance of the mechanical vector suggests that these random clinical interventions would be likely to produce suboptimal clinical outcomes. To improve clinical outcomes based in part on the information provided by leg checking, it will be necessary to take into account whether the patient exhibits aLLI or fLLI, perhaps by means of one or more of the low-tech methods described above.

Doctors practicing chiropractic techniques such as Diversified, Thompson, Pierce-Stillwagon, Activator Methods, Applied Kinesiology, and Sacro-Occipital Technique might best reconsider the role of leg checking procedures in their determination of vectors to be used in manipulating and mobilizing (eg, blocking) their patients. There is no reason to question the fact that there is a high prevalence of aLLI, nor is there any reason to question the research that links aLLI to anterior ilium rotation. Thus, all doctors practicing these or similar techniques, or who ascribe to the short leg = PI dictum (no matter what techniques they practice or professions to which they belong), are challenged by these findings to rationalize their customary mechanical vectors of correction. We look forward to their response to this line of reasoning.

Of course, there is no particular reason to depend on leg checks to mechanically analyze pelvic structural distortion. Indeed, one can directly palpate the pelvis for structural asymmetry, rather than infer anything

from a leg checking procedure. Cooperstein⁶³ has described a seated test for pelvic torsion, modeled after the work of Levangie⁶⁴ and others, as well as a prone palpatory test for sacral rotation based upon the work of Kuchera⁶⁵ and other osteopaths. He has also described how padded wedges can be used to derive an appropriate mechanic vector for sacroiliac intervention.^{40,66} It may be that the primary importance of leg checking is to identify aLLI, as a risk factor for a variety of somatic conditions; and that the benefit of trying to interpret a putative functional short leg is outweighed by the possibility of misinterpretation.

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