Effects of Somatic Dysfunction on Leg Length and Weight Bearing

Yasmin Qureshi, MHS (Ost), MPT, DPT; Andrew Kusienski, DO; Julienne L. Bemski, OMS III; John R. Luksch, DO; and Lacy G. Knowles, DO

From the departments of osteopathic principles and practice (Ms Qureshi) and sports medicine (Dr Kusienski) at the Nova Southeastern University College of Osteopathic Medicine in Fort Lauderdale, Florida; the Department of Family Medicine at Rowan University School of Osteopathic Medicine in Stratford, New Jersey (Dr Luksch); and the Department of Family Medicine at Baton Rouge General Medical Center in Louisiana (Dr Knowles). Student Doctor Bemski is a third-year osteopathic medical student at Nova Southeastern University College of Osteopathic Medicine.

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Address correspondence to Yasmin Qureshi, MHS (Ost), MPT, DPT, 3200 S University Dr, Clinical Suite #4372, Office #1457, Fort Lauderdale, FL 33328-2018.

Email: hussainq@nova.edu

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Context: Somatic dysfunctions of the pelvis, sacrum, and lumbar spine are common. Their association with leg length discrepancies has been observed; however, it is unclear which dysfunctions lead to mild changes in leg length or weight bearing distribution in asymptomatic individuals.

Objectives: To determine which somatic dysfunctions of the pelvic, sacral, and lumbar spine lead to minor leg length discrepancies and weight-bearing differences and to determine which of these dysfunctions are most common in the asymptomatic population.

Methods: Asymptomatic participants between the ages of 18 and 40 years without a recent history of trauma were enrolled. Participants were measured from the anterior superior iliac spine to the medial malleolus; only those with mild leg length discrepancies (less than a quarter inch) were included. Weight-bearing distribution through each lower extremity was measured on a quadruped scale. Participants were then evaluated for somatic dysfunctions of the pelvis, sacrum, and lower lumbar spine.

Results: Ninety-eight participants completed the study. The most common somatic dysfunctions were superior innominate shears, left-on-left sacral torsions, and right rotated lower lumbar spine segments. Several statistically significant associations were found. Most participants with right anterior innominate dysfunctions exhibited an ipsilateral longer leg and a contralateral shorter leg when measured in the supine position ($P=.05$). Participants with a left superior shear tended to exhibit a shorter left leg in the supine position ($P=.05$). For sacral somatic dysfunctions, participants with a left-on-left sacral torsion tended to exhibit a shorter left leg while standing ($P=.02$). In addition, a statistically significant association was found between right anterior innominate rotation dysfunctions and weight-bearing differences ($P=.02$). A greater percentage of patients with a right anterior innominate dysfunction bore more weight through their left lower extremity (45%).

Conclusion: Specific pelvic and sacral somatic dysfunctions have the potential to influence leg lengths, leading to mild disparities in length and in weight-bearing distribution through the lower extremities. (ClinicalTrials.gov number NCT01097109)

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The contribution of leg length discrepancies (LLDs) to the development of misalignment in the pelvis, sacrum, and lumbar spine, and vice versa, is widely supported in the literature,[1(p98),2,3(p218),4-11] as is their association with low back pain.[2,5,8,10-15] However, we have found few sources that identify specific somatic dysfunctions of the pelvis, sacrum, and lumbar spine that can lead to mild LLDs.[2,3] Furthermore, although LLDs have been associated with weight-bearing differences,[16] it has not been determined, to our knowledge, whether weight-bearing differences are more common with certain somatic dysfunctions of the pelvis, sacrum, and lumbar spine.

Some pelvic and sacral asymmetries are thought to be caused by LLD, including pelvic rotations; sacral base tilting with a deep sacral sulcus, a low iliac crest, or an anterior innominate rotation on the side of the shorter leg; and a compensatory posterior innominate rotation on the side of the longer leg.[1,2,3,11,12] The lumbar spine is thought to develop a convexity toward the side of the shorter leg.[1] Conversely, whereas somatic dysfunctions may result from LLDs, they may also cause or contribute to LLDs. For example, a certain dysfunction may lengthen a lower extremity.[9] In the present study, we first provide a background of LLDs and the structural examination, including consideration of weight-bearing distribution and the common compensatory pattern.

Leg Length Discrepancies and Related Considerations

There are 2 categories of LLD: structural and functional. A structural LLD is associated with shortening of the bones,[13] which may be due to congenital defects (eg, shortening of the tibia or femur through slipped capital femoral epiphyses or congenital dislocation), total hip replacement, infections, tumors, paralysis, or trauma.[2,13] Long-term functional LLDs may become structural LLDs, owing to changes in the morphology of vertebral components such as the sacrum, and long-term loading inequalities may result.[8,17]

In individuals with somatic dysfunction in the absence of a history of musculoskeletal disease or history of trauma, LLDs are most often functional discrepancies,[17] thought to be a result of altered mechanics of the lower extremities secondary to a rotated pelvis caused by joint contractures or axial misalignments, including scoliosis,[9,13,14] or by altered positions of the sacrum[9,17] and the fifth lumbar vertebra (L5).[2] Specifically, somatic dysfunctions of L5 will change the position of the sacrum, leading to a functional shorter leg.[2] Functional LLD causes sacral base unleveling, also known as sacral declination.[15,18(p340)] This unleveling of the sacrum is caused by the femoral head of the longer leg driving the pelvis into a posterior rotation via forces placed through the acetabulum.[5] The sacral base will usually be deeper and tilt toward the side of the shorter leg; however, in some instances, the shorter leg may be opposite to the deeper sulcus.[1(p301)]

Standing postural radiography, which outlines sacral declination, is often used by chiropractors and osteopathic physicians to diagnose functional LLD.[1,2] Functional LLD is also confirmed in the clinic through the supine-to-long sitting orthopedic test, which evaluates for the presence of innominate rotations that may affect leg length.[19] The most accurate assessment in the clinical setting is by physically measuring the distance between the anterior superior iliac spine (ASIS) and medial malleolus.[13] This method of assessing LLD is widely used.[4,13,19-21] Some have argued that it has not been shown to be reliable,[2,20,22] whereas others report its reliability and validity.[13,23] Asymptomatic individuals who have had neither a history of trauma nor structural abnormalities such as scoliosis can also exhibit LLD.[9,26] Patients with functional LLDs are often left untreated if they are not associated with pain because an asymptomatic individual is not likely to seek treatment. In individuals with chronic pain, functional LLD may be due to compensations of posture.[2] Asymptomatic and compensatory functional LLD may lead to musculoskeletal problems with associated altered load-bearing patterns. These patients may

not require lift treatment; however, osteopathic manipulative treatment may be of benefit.

Currently, the criterion standard method for measuring structural LLD[13] is standing anteroposterior (AP) computed radiography.[20] Treatment involves the use of heel-lift orthotics.[5] Many reports[8,12,17,24] have stated that LLDs of less than 9.0 mm, 10.0 mm, and 12.0 mm are clinically irrelevant. Gofton and Trueman[25] reported that 12.5-mm to 25.0-mm differences are associated with the development of osteoarthritis of the hip. In contrast, Friberg[5] reported that differences of more than 5.0 mm are symptomatic and require management. Patterns of imbalance caused by as little as a 1.5-mm LLD have been recorded along the spine, requiring a heel lift.[2] Cummings et al[11] found that small LLDs of approximately 6 mm can cause pelvic obliquity. Leg length discrepancies less than 5 mm may not require management unless the patient has clinically relevant complaints, such as persistent low back pain, that have not responded to any other forms of treatment.[2]

Besides the evaluation of leg lengths, when assessing LLD it is important to evaluate which leg coincides with the dominant stance and dominant skill, because the finding may determine how individuals will distribute weight through their lower extremities and what types of somatic dysfunctions will be created as a result. With small leg length discrepancies in asymptomatic individuals, the somatic dysfunctions created in compensations may follow the common compensatory pattern (CCP). Therefore, it is important to crosscheck what is found during an osteopathic structural examination with what is expected in the CCP.

Weight-Bearing Distribution

Leg length discrepancies may lead to weight-bearing differences in each lower extremity. Skeletal misalignment can alter the joint load distribution, which consequently affects joint contact pressure distribution of adjacent or distant joints.[27] Furthermore, altered joint loading is a critical risk factor for joint degeneration.[25,28,29] Gofton and Trueman[25] hypothesized that early correction of LLDs might avert or delay the onset of osteoarthritis. There is some contention as to which lower extremity will bear more weight. Mahar et al[30] found that simulated LLDs of 10 mm were associated with more weight bearing through the longer extremity, and this finding was confirmed by other studies. In contrast, and more recently, White et al[32] found that in true and simulated LLD, more weight was borne through the shorter extremity. Which lower extremity bears more weight may depend on where the individual is compensating his or her posture or the degree of the LLD.

Sharpe[12] recommends that when LLDs are detected in asymptomatic individuals, patients should be advised that the shorter leg may cause future symptoms and therefore should be corrected. Furthermore, Sharpe[12] recommended that leg length measurement be routine in all patients complaining of low back pain, hip pain, atypical flank pain, and lower extremity pain. Because LLDs are associated with pelvic obliquity and may lead to weight-bearing differences in the lower extremities, it is probable that weight-bearing differences can lead to somatic dysfunctions of the pelvis, sacrum, and lumbar spine and vice versa.

Dominant Lower Extremity

There are different thoughts as to what constitutes the dominant lower extremity: that which dominates in skill or that which dominates in stance. The most widely accepted theory is that the dominant lower extremity is the extremity associated with fine motor skills, such as kicking a soccer ball. Others believe that the dominant lower extremity is the leg on which one bears more weight and provides the most stability. Another term for dominant lower extremity is *preferred foot*, which is defined as the "preferential use of one foot to act and manipulate objects."[34,35] The lower extremity that bears more weight in standing is usually opposite to the preferential foot.[34] Yet others differentiate the skill-dominant leg from the stance-dominant leg.[36] In the present article, we use the term *stance dominant* when referring to the

lower extremity that bears more weight. Regardless of the terminology, most individuals are right-footed.[33]

Common Compensatory Pattern

The CCP was developed by Gordon Zink.[1,2] The underlying principles of the CCP are in the myofascial system's absorption and redistribution of forces to compensate for gravity, affecting handedness, the birthing process, asymmetry of visceral organs, and the Earth's rotation.[1] Most healthy individuals without a history of trauma will exhibit a compensatory postural pattern that can be identified through postural landmarks. The typical pattern for the pelvic-sacrolumbar area is a left posterior innominate rotation, a left-on-left sacral torsion, and a right rotation of the lower lumbar spine.[2]

Objective

The purpose of the present quantitative study was to investigate whether minor LLD and weight-bearing differences in an asymptomatic population were associated with specific pelvic, sacral, and lower lumbar somatic dysfunctions. In addition, we evaluated which pelvic, sacral, and lumbar somatic dysfunctions occur more commonly in asymptomatic individuals and compared the findings with those commonly seen in the CCP.

Methods

Participants

Participants were recruited from the student population at Nova Southeastern University College of Osteopathic Medicine (NSU-COM) via announcements and fliers. On obtaining approval from the institutional review board at Nova Southeastern University and registering the study with ClinicalTrials.gov (number NCT01097109), we screened interested individuals and obtained informed consent. Those who had a history of traumatic osseous or soft tissue injuries to the lower extremities (hip, knee, or ankle) in the previous 12-month-period were excluded because of possible antalgic postural compensations.[32] The remaining participants were healthy men and women.

Investigators

Investigator 1 (A.K.), an osteopathic physician with more than 8 years of experience performing osteopathic structural examinations and a notable amount of osteopathic manipulative medicine (OMM) in his practice, assessed participants for somatic dysfunctions of the pelvis, sacrum, and L4 and L5.

Investigators 2 and 3 were predoctoral fellows. Investigator 2 (L.G.K.) manipulated the software and recorded data from the quadruped scale, and investigator 3 (J.R.L.) obtained demographic information and performed leg length measurements.

Equipment

We used a quadruped scale with 4 digital force plates. This scale provides numeric and graphic data regarding weight distribution, total weight, and percentage weight-bearing difference between the left and right lower extremities and is accurate to 1/100 of a pound.[41]

Procedures

Testing was performed during 2 consecutive days in April 2010. The 3 investigators used the same methods on each participant. First, investigator 3 collected demographic information, including age, sex, date of birth, dominant hand, and approximate height, and each participant completed a short questionnaire to confirm that they met the inclusion criteria, which included being in the age range of 18 to 40 years and being asymptomatic. Next, the investigator took standing and recumbent leg lengths measurements using a measuring tape. The measurement in inches was taken from the ASIS to the medial malleolus. Because we sought an asymptomatic population, only participants with mild LLD (less than a quarter inch) were included; participants with an LLD of

Figure 1.
Quadruped scale with foot silhouette used to measure total weight and weight distribution through each lower extremity.

more than a quarter inch (approximately 6 mm) were excluded from the study.

The participants then removed their footwear and stepped on the scale with their feet in the foot silhouettes, and investigator 2 recorded the total weight and weight-bearing distributions through each lower extremity (*Figure 1*). Last, each participant met with investigator 1 for manual diagnosis of somatic dysfunctions of the pelvis, sacrum, and lower lumbar spine. The following tests were used to make a determination of somatic dysfunction: (1) pelvis: compression test with the participant in the supine position and static palpation of the ASIS and posterior superior iliac spine (PSIS) landmarks; (2) sacrum: static palpation of the 4 poles along with respiratory motion with the participant in the prone position; and (3) lumbar spine (L4-L5): static palpation with the participant prone and dynamic motion testing with the participant lying on his or her side.

The findings were analyzed by investigator 1, who documented the corresponding diagnoses in the pelvis, sacrum, and lower lumbar spine.

Statistical Analysis

Dependent *t* tests were run to test associations among continuous variables, such as LLDs when standing vs supine. In addition, we created 2×2 tables with categorical variables for LLDs and somatic dysfunctions, as well as weight-bearing differences and somatic dysfunctions. Associations of these variables were tested using a Pearson χ^2 test. For small sample sizes we used the Fisher exact test. Similar 2×2 tables and tests were performed for weight-bearing distribution and somatic dysfunctions. All data management and statistical analyses were done using SAS software, version 9.2 (SAS Institute Inc).

Results

Of the 98 participants, 47 were women and 51 were men. The average age was 25 years (range, 21-41 years). Right-hand dominance was observed in 92 participants and left-hand dominance in 6. Right-stance dominance was observed in 56 participants, left-stance dominance in 35, and equivalent stance in 7. A mild left shorter leg in a standing position was seen in 54 participants, mild right shorter leg in 25, and 19 exhibited equal leg lengths while standing.

Figure 2 and *Figure 3* show the most commonly diagnosed pelvic and sacral dysfunctions, respectively. The most common pelvic dysfunction for this sample was a left superior innominate shear. Twenty-five participants (26%) exhibited this dysfunction either alone (n=13) or with another pelvic dysfunction present (n=12), where the most common sacral dysfunction was a left-on-left sacral torsion (34 [35%]). Almost 30% of the subjects (28) had a combination of more than 1 pelvic dysfunction (eg, a sagittal and transverse plane dysfunction combined). *Figure 4* shows the most common somatic dysfunctions of the lower lumbar spine. An extended, rotated, and sidebent right dysfunction was the most common somatic dysfunction of the lumbar spine (22 [22%]) but was not statistically significantly more

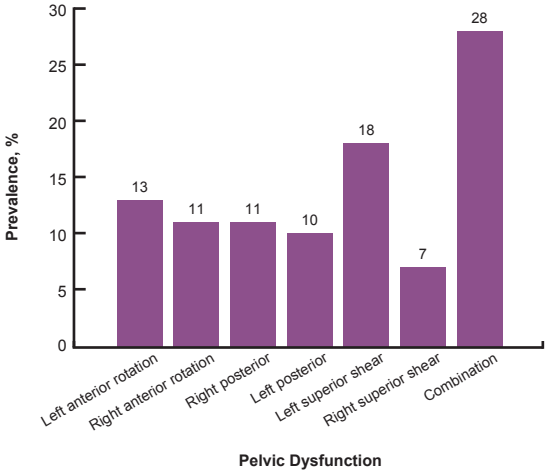

Figure 2.
Prevalence of pelvic dysfunctions among individuals with mild leg length discrepancies (N=98).

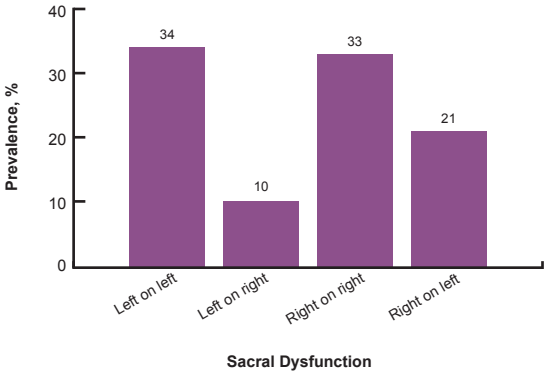

Figure 3.
Prevalence of sacral dysfunctions among individuals with mild leg length discrepancies (N=98).

common than the other possible somatic dysfunctions. Overall, neutral somatic dysfunctions of the lower lumbar spine were the most common (36 [37%]) but not statistically significantly more common than flexed (29 [30%]) and extended (32 [33%]) somatic dysfunctions. Furthermore, 60 of 98 participants (61%) exhibited lower lumbar spine rotation and sidebending to the right.

A 2×2 Pearson χ^2 test indicated that of those participants with right anterior innominate dysfunctions, most exhibited a longer leg on the right or a shorter leg on the left when in a supine position ($\chi^2_{1(n=11)}=3.84$; $P=.05$; *Figure 5*). The participants with a left superior shear exhibited a left shorter leg in the supine position ($\chi^2_{1(n=18)}=3.95$; $P=.05$). For sacral somatic dysfunctions, as seen in *Figure 6*, participants with a left-on-left sacral torsion tended to exhibit a shorter left leg when standing ($\chi^2_{1(n=34)}=5.26$; $P=.02$).

The Fisher exact test determined a statistically significant association between right anterior innominate rotation dysfunctions and weight-bearing distribution ($P=.02$). A higher percentage of patients with a right anterior innominate dysfunction bore more weight on their left (10 [48%]) than on their right (6 [29%]) or neither (5 [24%]). There were no other statistically significant associations observed between somatic dysfunction and leg lengths or somatic dysfunction and weight-bearing distribution.

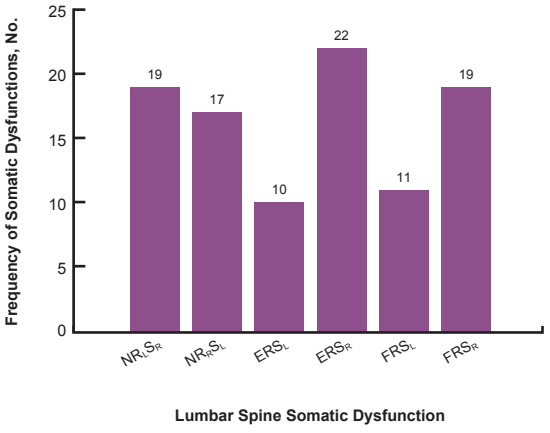

Figure 4.
Frequency of lumbar spine somatic dysfunctions among individuals with mild leg length discrepancies (N=98).
Abbreviations: E, extended; F, flexed; N, neutral; R, rotated; R_L, rotated left; R_R, rotated right; S_L, sidebent left; S_R, sidebent right.

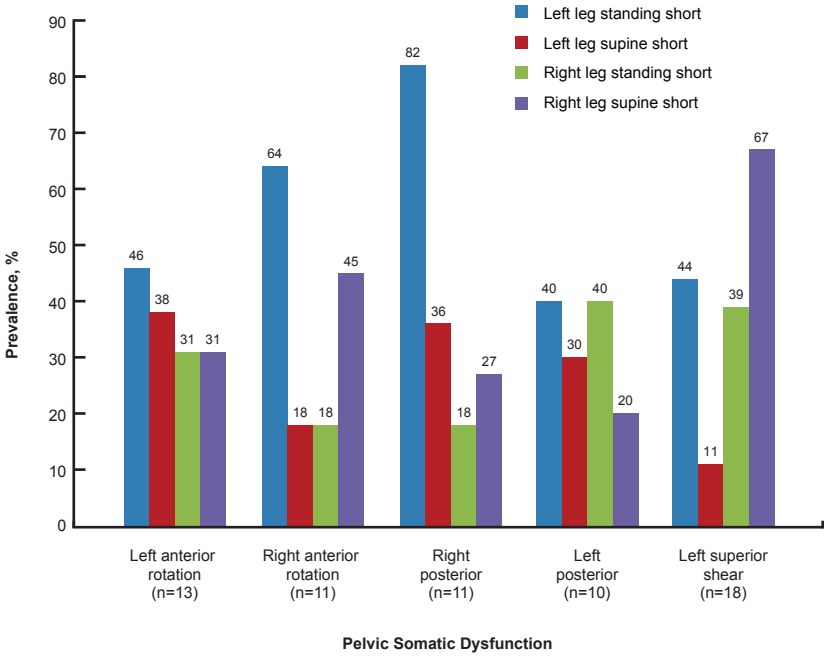

Figure 5.
Prevalence of pelvic somatic dysfunctions by leg length discrepancies among individuals with mild leg length discrepancies (N=98).

Other associations observed included differences in measuring leg length in supine vs standing positions. An independent group's *t* test found a statistically significant difference between measuring LLDs when standing vs supine ($P=.04$). Actual measurements of leg length in the supine position were always smaller in value (inches) than in the standing position, regardless of whether it was shorter or longer.

While associations were found between somatic dysfunctions and LLDs and weight-bearing distribution, we did not observe any relationship involving the lower lumbar spine. Thirty-five participants (36%) with an LLD exhibited lower lumbar spine sidebending toward the shorter leg, and 43 (44%) demonstrated sidebending toward the longer leg. In addition, 34 (35%) exhibited lower lumbar spine rotation toward the side of the shorter leg, while 45 (46%) exhibited lower lumbar spine rotation toward the side of the longer leg. Equal leg lengths were observed in 19 participants (20%). Only 44 participants (45%) exhibited L5 rotation opposite to the rotation of the sacrum.

Discussion

The findings of this study do not completely align themselves with the most common CCP somatic dysfunctions. Interestingly, though, the sacrum and lower lumbar spine dysfunctions—left-on-left sacral torsion and right rotation of L4 and L5—were what one would expect to find in the majority of an asymptomatic population. Although these were the most commonly found dysfunctions, only 45% of participants' sacral dysfunctions resulted in the lower lumbar spine rotating in the opposite direction to the sacrum, a finding widely reported in the osteopathic literature.[2] In further disagreement with the CCP was the most common somatic dysfunction

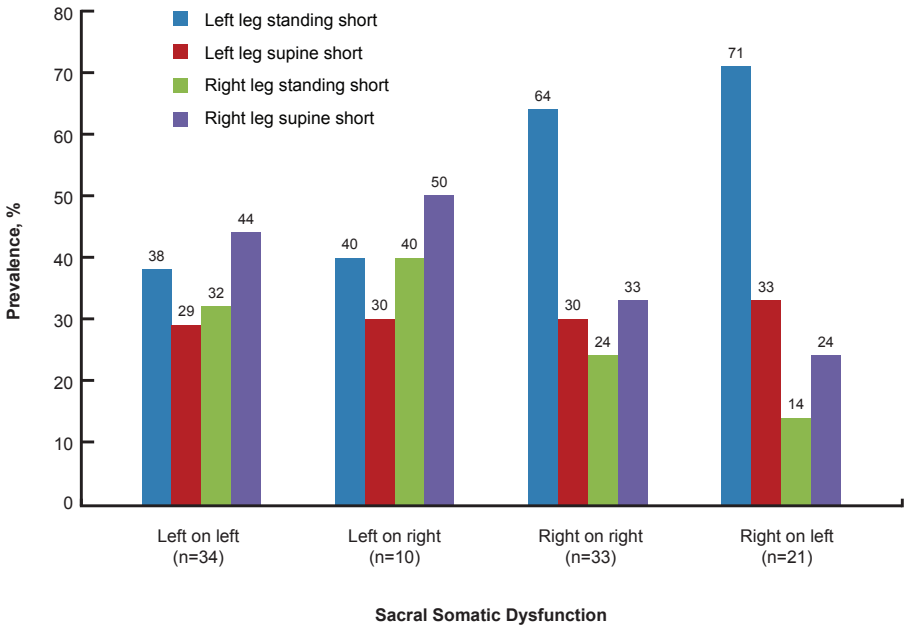

Figure 6.
Prevalence of sacral somatic dysfunctions by leg length differences among individuals with mild leg length discrepancies (N=98).

found in the pelvis: a superior shear in contrast to the commonly found innominate rotations.

While right anterior innominate dysfunctions were significantly associated with an ipsilateral longer leg (or contralateral shorter leg), left anterior innominate dysfunctions were not associated with either a left or a right shorter leg in the supine position. According to published literature,[1,3,11,37] right anterior innominate rotation will occur with ipsilateral shorter lower extremities. An explanation for this finding is that with small LLDs, the innominate bone may attempt to rotate anteriorly to lengthen the shorter leg to approximate the leg closer to the ground for more even weight-bearing distribution in a standing position (ie, compensating for the compensation).[19]

The sacrum and lumbar spine may also compensate in an unexpected way with small LLDs. Perhaps compensations occur elsewhere, such as through rotation of the femur or tibia or through slight adjustments at the hip, knee, and ankle joints. Compensation may occur differently when the LLD is small or if an individual is asymptomatic, thereby not adjusting his or her posture secondary to pain. Further, minor LLDs may not be as obvious when measured in a supine position as they are in a standing position. The current study showed, for example, that the leg length was always diminished in the supine position compared with its measurement in the upright position. In agreement with this finding, the apparent longer leg in the standing position may appear to retract when in the supine position. An alternative explanation is that in individuals who do not compensate for their LLDs, such as those with minor LLDs, the innominate bone may not accommodate for the LLD. Therefore, an anterior innominate rotation could be the driving force behind leg lengthening or it could be compensating for a true shorter leg in attempts to lengthen it.

We cannot sufficiently explain why we did not find that left anterior innominate rotations were associated with an ipsilateral longer leg, as we did with right anterior innominate rotations, perhaps because there were only a small number of participants who exhibited a left anterior innominate rotation.

Understandably, a left superior shear was associated with a left shorter leg in the supine position. Correcting functional LLD with an OMM technique, sometimes referred to as "the leg pull," is a technique that osteopathic physicians who perform OMM are familiar with. This finding validates the leg length assessment techniques used in OMM practice, promotes routine leg length assessment for those who exhibit small LLDs, and reaffirms that visualization of the whole person is of utmost importance. Notably, a right superior shear was not correlated with a right shorter leg in the supine position, possibly owing to the small number of participants who exhibited a right superior shear.

While pelvic dysfunctions have been associated with LLD in the literature, specific sacral dysfunctions have not, to our knowledge. The current study found that left-on-left sacral torsions are associated with a left shorter leg in the standing position. The type of sacral dysfunction that is associated with a shorter or longer leg does not seem to be specified in our review of the literature; rather, it generally states the antithesis of this finding—an anterior sacral base is associated with a shorter leg on the same side.[1(p301)] A left-on-left sacral torsion would tend to exhibit an anterior sacral base on the right. Our findings are completely opposite to this where we found that a left-on-left sacral torsion (right deep base) is correlated with a shorter left leg. Although osteopathic physicians diagnose sacral dysfunctions, they do not usually quantify the severity of the dysfunction. Perhaps in patients with asymptomatic mild sacral torsions, the compensation affects different areas and manifests differently. Another explanation may be that asymptomatic sacral dysfunctions lead to LLD rather than the LLD leading to the dysfunction through a compensatory motion of the sacrum, pelvis, or lumbar spine. Further studies comparing different severities of torsions along with painful sacral dysfunctions vs asymptomatic dysfunctions may assist in further support of this phenomenon.

Although sacral declination may prompt osteopathic physicians who practice OMM to investigate for LLDs, a simple left-on-left torsion has not been previously shown to influence leg lengths, to our knowledge. Left-on-left sacral torsions occur frequently as part of the CCP. Our finding may suggest that minor leg length shortening can occur secondary to left-on-left sacral torsions, which may affect other structures in the lower extremities and warrant assessment of the lower extremities and leg lengths. These findings are consistent with those in the literature, in which small LLDs ranging from 1.5 mm to 6 mm have been shown to be symptomatic,[5] thereby influencing pelvic obliquity[11] and leading to patterns of imbalance that require treatment.[2] It has been suggested that the management of discrepancies less than 5 mm not be performed unless symptomatic,[2] but other recommendations suggest that patients with asymptomatic LLDs should be treated to prevent future symptoms.[13]

In relation to weight-bearing distribution, participants who exhibited a right anteriorly innominate rotation while standing bore more weight through their left lower extremity. Although no statistically significant relationships were found pertaining to standing leg lengths and somatic dysfunctions, perhaps this finding can be related back to the literature. A right anterior innominate rotation is associated with a shorter lower extremity as reported by many sources,[1,3,11,37] and then weight bearing through the longer leg is also supported by many studies, which have reported that individuals bear weight more through the longer extremity.[16,25,29-31,34,35] Participants who exhibited a longer right leg in a standing position tended to bear more weight through the right lower extremity, with a difference of 26% between extremities. In contrast, participants with a longer left leg bore more weight

through the right lower extremity (the shorter leg); however, there was only a 16% difference in weight-bearing distribution between extremities in this example. Although these findings are notable, they were not statistically significant.

Most of the participants in the present study bore more weight through their right lower extremity (46%) than through their left (29%) or through both (25%). This finding seems to contradict previous findings on footedness, where most individuals have been thought to be right-footed,[36] with a more skilled right lower extremity and a more stance-dominant left lower extremity.

Limitations

The limitations of this study are two-fold. One is that there was only 1 investigator diagnosing the somatic dysfunctions in all participants. Having 1 osteopathic physician may have been good for homogeneity of diagnostic technique across participants, but a different osteopathic physician may have discovered different somatic dysfunctions in a given participant. Regardless of the experience of the osteopathic physician performing the evaluation, interrater reliability with regard to OMM has been shown to be fair to moderate.[43,44] However, if more than 1 osteopathic physician is used to cross-check participants, the interrater reliability is known to be poor.[44-46] In addition, biologic tissues alter in compliance when palpated; therefore, an interrater model may not have proved more reliable.

The other main limitation lies in the sample. Although 98 participants completed the study, the analysis of subcategories of somatic dysfunctions resulted in reducing the sample into these categories and thus reducing the overall power of the study. In addition, the sample consisted of osteopathic medical students enrolled at a college of osteopathic medicine. These participants spent many hours of their days in a sitting position, which may have contributed to common somatic dysfunctions and similar diagnoses, thus potentially skewing the results.

Recommendations

Investigations of the most frequent somatic dysfunctions in individuals with large LLDs as well as studies of the long-term effects of both small and large LLDs on the joints of the lower extremities would be beneficial. In addition, investigating the common somatic dysfunctions associated with LLD using the criterion standard of leg length measurement, AP computed radiographs, may further this area of research.

Conclusion

Common somatic dysfunctions of the pelvis and sacrum can affect leg length, and specific somatic dysfunctions of the pelvis can affect weight-bearing distribution through the lower extremities. Osteopathic physicians who diagnose and manage somatic dysfunctions should include a routine assessment for LLDs during osteopathic structural examinations. Osteopathic physicians should also continue to assess the sacropelvic joints in asymptomatic patients because minor LLDs may cause misalignment of these areas.

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Author Contributions

Ms Qureshi; Drs Kusienski, Knowles, and Luksch; and Student Doctor Bemski provided substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; Ms Qureshi, Dr Kusienski, and Student Doctor Bemski drafted the article or revised it critically for important intellectual content; and Ms Qureshi gave final approval of the version of the article to be published.

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