Leg Length Discrepancy and Osteoarthritic Knee Pain in the Elderly: An Observational Study

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Context: Osteoarthritic knee pain is very common, as are leg length discrepancies (LLDs). The relationship between LLDs and osteoarthritic knee pain is not well understood.

Objective: To confirm a clinical impression that osteoarthritic knee pain is more common in the short (ie, superior-presenting) leg, as measured by supine physical examination of 3 bony landmarks: the medial malleoli, the anterior superior iliac spines, and the iliac crests. The secondary objective was to measure the relative positions of the 3 bony landmarks to better understand functional contributions to LLD.

Methods: A prospective single-occasion observational design was used. Patients who reported osteoarthritic knee pain during an office visit were recruited, and data were collected on 3 bony landmarks and which knee was usually most painful.

Results: Of the 32 participants who were recruited, 28 were women and 4 were men. Of the 17 participants who reported having right knee pain, 10 had a short right leg and 7 had a short left leg. Of the 15 participants who reported having left knee pain, 13 had a short left leg, 1 had a short right leg, and 1 had equal leg lengths. Knee pain was most severe in the short leg for 23 of 32 participants (71.9%). The most common pattern was for both iliac crests to be equal and the short leg to be concordant with a superior anterior superior iliac spine, which occurred in 23 of 32 participants (71.9%). In the present study population, the magnitude of LLD ranged from 0 to 2.1 cm.

Conclusion: Osteoarthritic knee pain was more common in the apparent short leg. More sophisticated studies, including investigations into the role of pelvic torsion in knee pain, as well as investigations for interoperator reliability and validity, are needed to build on the findings reported in this observational study.

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Osteoarthritis of the knee is a common clinical condition that increases in severity with age. Felson et al[1] found radiologic evidence of osteoarthritis of the knee in 27% of adults aged 70 years or younger and in 44% of elderly adults aged 80 years or older. Michael et al[2] estimated the prevalence of osteoarthritis in elderly persons aged 70 to 74 years to be as high as 40%. Osteoarthritis of the knee is the most common type of osteoarthritis.[3] Osteoarthritic knee pain usually presents with 1 knee being more symptomatic than the other. It is not well understood why 1 knee presents with more pain or more severe osteoarthritis than the other. Michael et al[2] hypothesized previous unilateral trauma to the joint. Another explanation for unilateral knee pain related to chronic joint osteoarthritis is chronic leg length discrepancy (LLD). In 1959, Stoddard[4] estimated that up to 70% of the population had LLD.

In 2010, Harvey et al[5] used radiologic imaging to measure the anatomic leg lengths of 3026 individuals at high risk for knee osteoarthritis. The authors found a strong association between LLD of 1 cm or greater and both symptomatic and radiologic knee osteoarthritis in the shorter leg. This finding supports my anecdotal impression that the "short" leg is most often more painful than the other leg in individuals with osteoarthritis of the knee. The radiologic method used by Harvey et al,[5] however, measured only anatomic leg length and did not account for functional contributions to leg length.

A simple method of evaluating LLD is for the physician to evaluate a supine patient on an examination table and compare the relative positions of the right and left medial malleolus bony processes in the coronal plane.[6] Using this physical examination technique, I have often observed that the knee on the apparent short leg is usually more painful. However, no formal observational data, to my knowledge, have been published to confirm this clinical impression. A small-scale observational study design was chosen for the present study because it was achievable within the confines of a busy clinical practice. The findings of the present study may then be used to garner funding for more sophisticated prospective studies, such as interoperator reliability studies and direct comparisons of the physical examination techniques used in this project with radiologic direct measures of anatomic leg length.

Beal[7] stressed the importance of measuring both functional and anatomic contributors to LLD. The supine physical examination method captures both anatomic and functional determinates of LLD by assessing the relative positions of 3 bony landmarks: the medial malleoli, the anterior superior iliac spines (ASISs), and the iliac crests.

I conducted the present observational study to confirm the clinical impression that osteoarthritic-related knee pain is more common in the short limb, as determined by the relative positions of the medial malleoli bony landmarks in the supine position. The principle hypothesis of the present study was that in elderly patients, unilateral knee pain from apparent osteoarthritis is more common in the short leg, as measured by comparing the relative positions of the right and left medial malleoli processes in the coronal plane while supine. The secondary hypothesis was that the relative positions of the 3 bony landmarks will provide insight into functional contributions to LLD.

Methods

The present simple prospective, single-occasion, observational study was conducted by 1 examining osteopathic physician (D.R.N.). The informed consent and data collection processes were constructed to be achievable within the confines of a geriatric primary care office visit. During an office visit, if a patient reported knee pain and he or she met the inclusion criteria, verbal consent was obtained to collect observational information relating to leg length and knee pain. The duration of each patient's participation in the study was approximately 5 minutes.

The study setting was an outpatient clinic at the New Jersey Institute for Successful Aging, University of Medicine and Dentistry of New Jersey–School of Osteopathic Medicine (now reorganized as the Rowan University School of Osteopathic Medicine) in Stratford. The primary focus of the practice is geriatric primary care for persons aged 50 years or older, with the majority of patients in the practice being older than 65 years and of mixed ethnic backgrounds. Participants were recruited for the study from May 2011 through February 2012. The project was approved by the University of Medicine and Dentistry of New Jersey's Institutional Review Board.

To be eligible for the study, participants had to be aged 50 years or older and have knee pain. Recruitment for the study was triggered by the patient reporting knee pain during an office visit. For inclusion, the knee pain had to be chronic and consistent with osteoarthritic knee pain. Patients with knee pain from acute trauma, recent injury, infection, or crystalline arthropathies were excluded. Patients were excluded if they had a clinical diagnosis of dementia, were poor historians as a result of cognitive deficits, or were unable to give informed consent. Each patient could only participate once, a status confirmed by asking "Have we filled this questionnaire out before?" In keeping with institutional review board guidelines, a verbal consent mechanism was used, and thus no patient identifiers or protected health information were collected.

After eligibility was established and verbal consent obtained, the location of the knee pain was confirmed by asking "Which knee is most painful?" Patients could choose right knee, left knee, or neither (ie, knee pain was equally distributed). Next, the patient was asked to lie supine on the examination table. Once the patient was comfortably supine, he or she was asked to bend his or her knees, raise his or her pelvis off the table briefly, and then lower it back onto the treatment table to ensure that his or her pelvis was situated in a neutral untwisted position. The examiner then stood at the foot of the examination table and visually checked alignment of legs, pelvis, and torso to be sure the body was in a straight neutral position. If the legs, pelvis, or torso were not straight, then this procedure would be repeated.

The examining physician then held both ankles, placed his thumb into the inferior aspect of each medial malleolus bony landmark, and brought the thumbs together to visually compare the relative positions of each leg in the coronal plane with the relative positions of the thumbs and to determine if 1 side was superior or if both sides were equal. Then, each thumb was placed on the inferior aspect of the ASIS bony landmark to determine if 1 side was superior or if both sides were equal in the coronal plane. Next, the fingers or thumbs were placed at the very superior aspect of each iliac crest to determine if 1 side was superior or if both sides were equal. The relative bilateral positions of the 3 bony landmarks were recorded. To estimate the magnitude of LLD between the right and left leg, the examiner used calipers to measure the difference between the apex of the right and of the left medial malleolus bony landmarks in the coronal plane. This distance was recorded in centimeters. Data were then collected on each participant's sex, location of chronic knee pain, relative positions of the 3 bony landmarks, and estimated LLD. All participants were asked "Have you had a hip replacement for arthritis?", "Have you had surgery for a hip fracture?", and "Have you ever had a total knee replacement?"

For the purposes of the current study, the "short" leg was defined as the leg that appeared on visual inspection to be the more superior (cephalic) bony landmark in the coronal plane when the physician placed his thumbs on the inferior surfaces of the medial malleoli. Reciprocally, the "long" leg was defined as the more inferior (caudal) of the 2 medial malleoli bony landmarks in the coronal plane. The leg length was deemed to be "equal" when it was not obvious which medial malleoli was superior in the coronal plane.

The ASIS bony landmark was evaluated by means of the physician placing his thumbs on to the inferior surface of the ASIS bony landmarks bilaterally and determining, by visual inspection, the more superior (cephalic) bony landmark in the coronal plane. If the physician could not easily discern which ASIS bony landmark was superior, then the ASIS bony landmarks were deemed to be of equal prominence.

The superior iliac crest was assessed by means of the physician placing his thumbs or fingers on top of the superior aspect of the iliac spine symmetrically. The physician then determined by means of visual inspection which iliac crest was superior in the coronal plane. When the superior side could not easily be determined, then the iliac crests were deemed to be equal.

To reduce bias, leg length observations were never taken prior to recruitment. All measures were taken by the same examiner. The use of multiple examiners to establish inter- and intraoperator reliability and the use of blinding for data collection were beyond the scope of the present exploratory, observational study.

Statistical analysis was conducted with SPSS Statistics 18 program (SPSS Inc). To compare knee pain to bony landmark position, crosstabulation analysis using χ^2 tests was used. Statistical significance was set at to $P \leqslant .05$. Data were evaluated using frequencies and percentages. A one-way analysis of variance was used to compare the mean LLD and unilateral knee pain. The goal sample size was set at 30 participants because (1) the effect size was believed to be relatively large and (2) this number was an achievable goal for the size of the recruitment population.

Results

The 32 individuals who qualified for the project agreed to participate. Four study participants were men and 28 were women. All 4 men presented with right knee pain. Of the 28 women in the study, 13 presented with right knee pain and 15 presented with left knee pain. All 32 individuals completed the project, and there were no missing data points. No participant reported undergoing a surgical procedure for hip replacement or a hip fracture. Five participants reported undergoing total knee arthroplasty (TKA): 2 for the right knee, 1 for the left knee, and 2 for both knees. In response to the question "Which knee is most painful?", 17 reported the right knee, 15 reported the left knee, and none reported equal pain.

The right leg was short in 11 participants (34.4%), the left leg was short in 20 participants (62.5%), and leg lengths were equal in 1 participant (3.1%). The ASIS bony landmark was superior on the right in 12 participants (37.8%), on the left in 18 participants (56.3%), and equal in 2 participants (6.3%). The iliac crest bony landmark was superior on the right in 6 participants (18.8%), superior on the left in 1 participant (3.1%), and equal in 25 participants (78.1%). Because the observations are all determined relative to the opposite side, the results for the long leg, inferior ASIS, and inferior iliac crest mirror these results.

Table 1 presents the predominant side of knee pain alongside the prominence of the 3 bony landmarks. Of the 17 participants with more right knee pain, 10 had a short right leg, and 7 had a short left leg. Of the 15 participants with more left knee pain, 13 had a short left leg, 1 had a short right leg, and 1 had equal leg lengths. Analysis of knee pain location and medial malleoli position by crosstab analysis using χ^2 suggested a statistically significant relationship (P=.006). In the medial malleolus study cohort, osteoarthritic knee pain was most severe in the short leg in 23 of 32 participants (71.9%). Right knee pain was associated with a right superior ASIS in 11 participants, a left superior ASIS in 5 participants, and equal ASIS landmarks in 1 participant. Left knee pain was associated with a right superior ASIS in 1 participant, a left superior ASIS in 13 participants, and equal ASIS bony landmarks in 1 participant. An analysis of knee pain location and ASIS position by crosstab analysis using χ^2 also suggested a statistically significant relationship (P=.003). Right knee pain was associated with a right superior iliac crest in 6 participants, a left superior iliac crest in 1 participant, and equal iliac crests in 10 participants. All 15 participants with left knee pain had equal iliac crests. An analysis of knee pain location

Table 1.
Predominant Side of Knee Pain and Prominence of 3 Bony Landmarks in 32 Patients With Unilateral Chronic Osteoarthritis, No. (%)

	Most Painful Knee		
Bony Landmark	Right (n=17)	Left (n=15)	Total
Medius Malleolus[a]			
Right	10 (31.3)	1 (3.1)	11 (34.4)
Left	7 (21.9)	13 (40.6)	20 (62.5)
Equal	0	1 (3.1)	1 (3.1)
Anterior Superior Iliac Spine[b]			
Right	11 (34.4)	1 (3.1)	12 (37.5)
Left	5 (15.6)	13 (40.6)	18 (52.2)
Equal	1 (3.1)	1 (3.1)	2 (6.2)
Illiac Crest[c]			
Right	6 (18.8)	0	6 (18.8)
Left	1 (3.1)	0	1 (3.1)
Equal	10 (31.3)	15 (46.8)	25 (78.1)

[a] Side with the medius malleolus in the superior position (ie, apparent short leg). P=.006.
[b] Side with the anterior superior iliac spine in the superior position (ie, innominate rotated posteriorly). P=.003.
[c] Side with the iliac crest in the superior position. P=.019.

and iliac crest position by crosstab analysis using χ^2 suggested a weaker but still statistically significant relationship (P=.019).

Knee pain was congruent with the short leg in 23 of 32 participants (72%); knee pain was congruent with a superior ASIS in 24 (75%); however, knee pain was congruent with a superior iliac crest in 6 (19%). Whereas medial malleoli were equal in 1 participant and the sides of ASIS were equal in 2 participants, the iliac crests were equal in 25 of 32 participants.

In the subgroup of 5 participants who had undergone TKA (ie, answered "yes" to the question "Have you ever had a total knee replacement?"), 5 had a short leg. In other words, a history of TKA was 100% congruent with unilateral knee pain in the apparent short leg. For the other 2 bony landmarks, knee pain was 80% congruent with a superior ASIS in 4 of 5 participants (80%), but was congruent with a superior iliac crest in 1 of 5 participants (20%). However, neither the side of knee pain nor the side of the apparent short limb was congruent with the side of the TKA. Of the 2 participants who underwent right TKA, 1 had right knee pain and 1 had left knee pain. The 1 participant who underwent left TKA had left knee pain. Of the 2 participants with bilateral TKA, 1 had right and 1 had left knee pain.

Table 2 lists the pattern of the 3 bony landmarks. The first, second, and third letters of each pattern describe the medial malleolus, ASIS, and iliac crest, respectively, in terms of right, left, or equal orientation (ie, in terms of which side appeared in superior presentation). The most common pattern was for both iliac crests to be equal and the short leg to be concordant with a superior ASIS (presented in *Table 2* as the L-L-E or the R-R-E pattern)—this pattern occurred in 23 of 32 participants (71.9%). In 28 of 32 participants (87.5%), medial malleolus and ASIS bony landmarks on the same side were congruent with each. In 25 of 32 participants (78%), the iliac crest heights were approximately equal. Only in 1 participant in the entire sample were all 3 bony landmarks equal.

The magnitude of LLD ranged from 0 to 2.1 cm in the study cohort. Of the 32 participants, 10 (31.3%) had an LLD of 1 cm or less and 22 (68.8%) had an LLD of 1 cm or more. For the entire group, the mean (standard deviation [SD]) LLD was 1.15 (0.424) cm. For the participants with right knee pain (n=17), the mean (SD) LLD was 1.59 (0.337) cm (95% confidence interval, 0.985-1.332 cm). For the participants with left knee pain (n=15), the mean (SD) LLD was 1.33 (0.518) cm (95% confidence interval, 0.846-1.420 cm).

Table 2.
Pattern of 3 Bony Landmarks and Orientation of Knee Pain in 32 Patients With Chronic Osteoarthritis, No. (%)[a]

Bony Landmark Orientation	Most Painful Knee		
	Right (n=17)	Left (n=15)	Total
L-L-E	2 (6.3)	13 (40.6)	15 (46.9)
R-R-E	8 (25.0)	0	8 (25.0)
L-R-E	0	1 (3.1)	1 (3.1)
L-L-R	2 (6.3)	0	2 (6.3)
R-L-R	1 (3.1)	0	1 (3.1)
L-E-L	1 (3.1)	0	1 (3.1)
E-E-E	0	1 (3.1)	1 (3.1)
R-R-R	2 (6.3)	0	2 (6.3)
L-R-R	1 (3.1)	0	1 (3.1)

[a] The first, second, and third letters of each pattern represent the relative positions of the medial malleolus (MM), anterior superior iliac spine (ASIS), and iliac crest, respectively, in terms of right (R), left (L), or equal (E) orientation (ie, superior presentation). For example, L-L-E means the left MM appeared superior (ie, short leg was on the left) to the right MM, the left ASIS was superior relative to the right ASIS (ie, left innominate rotated posteriorly), and the 2 iliac crests were approximately equal relative to each other.

Comment

Discrepancies in leg length may cause a variety of musculoskeletal problems. Kakushima et al[8] induced a 3-cm LLD in healthy participants by means of a heel-raising orthotic device and reported an increase in lateral bending of the thoracic and lumbar spinal segments during walking compared with participants with no heel lift. The authors[8] speculated that persons with LLD may develop spinal degenerative disorders resulting from increased lateral bending stresses. Leg length discrepancy of more than 2 cm has been shown to increase oxygen consumption, heart rate, and minute ventilation, and LLD of more than 3 cm causes quadriceps fatigue during ambulation in older adults.[9] Conservative correction of LLD of 1 cm or less has been reported to relieve chronic low back pain.[10] Conversely, Soukka et al[11] questioned the association of mild LLD and low back pain. Leg length discrepancy has been moderately associated with chronic knee pain and hip pain, even when controlling for the presence of osteoarthritis and history of joint problems.[12] Crosby[13] presented a pilot study of 6 individuals with chronic obstructive pulmonary disorder who experienced improved pulmonary function when LLD was corrected.

The findings of the current study support the hypothesis that osteoarthritic knee pain in the elderly population is more common in the apparent short leg, as defined by comparing the medial malleolus bony landmarks in the coronal plane while the patient lies supine. This observation is consistent with that of a previous study showing that progressive osteoarthritis of the knee is more common in the anatomic short leg, as determined by radiographic measurements.[5] It is well known that osteoarthritis in the knee results in cartilage loss and joint space narrowing, which anatomically shortens the leg.[14] Put more simply, the more painful knee is likely to have the more severe osteoarthritis and therefore will be anatomically shorter. Nonetheless, leg length is determined by both anatomic and functional factors.[7,15]

Findings from this observational study suggest functional factors play a major role in LLD. Only 5 individuals in the current study had a prior history of TKA, and no participant had a history of hip replacement or hip fracture repair. The 5 individuals with a history of TKA had the painful knee on the side of the apparent short leg, suggesting that a history of TKA does not necessarily confound the proposed rule that the more painful knee usually presents in the apparent short leg. Usually, TKA anatomically lengthens the limb. In one study of TKA, the procedure was found to lengthen the leg in 76% of patients by about 5 mm.[16]

It is interesting that the medial malleolus and ASIS bony landmarks were observed to be congruent for 28 of 32 participants (87.5%). This finding suggests that functional factors contributed substantially to LLD in the study population. Whereas it has long been known that both functional and anatomic factors contribute to LLD,[7,17] the respective contributions of anatomic and functional mechanisms to total LLD remain poorly understood and essentially unstudied. One known functional cause of LLD is pelvic torsion, which occurs when the left and right innominate bones rotate in opposed directions around a horizontal axis running through the pubic symphysis.[18] Because of the anatomic location of the acetabulum on the innominate bone relative to the ASIS bony landmark, anterior rotation of the innominate shifts the ASIS, hip joint, and medial malleolus inferiorly, functionally lengthening the leg. Likewise, when the innominate rotates posteriorly, the ASIS, hip joint, and medial malleolus shift superiorly, functionally shortening the leg.[19] When pelvic torsion plays a dominant role in LLD, the medial malleolus and ASIS bony landmarks in the same leg move congruently (ie, shift together, either superiorly or inferiorly). However, when LLD is primarily due to anatomic differences in the leg length, the physical distance between the ASIS and medial malleolus bony landmarks will either be increased in the long leg or decreased in the short leg. This inequality is why, during physical examination, the medial malleoli and ASIS bony landmarks will appear to be discordant when LLD is dominated by anatomic differences. This inequality is especially evident when the iliac crests are level, because iliac crest inequality could be the result of other variables influencing LLD. Therefore, the congruence of the medial malleolus and ASIS bony landmarks for 28 of 32 participants (87.5%) suggests that functional factors played a dominant role in LLD for the current study cohort.

Other functional mechanisms that contribute to LLD are sacral base unleveling, sacral torsion, and sacral shear.[7,20] When these mechanisms occur, the right and left iliac crests are expected to be uneven, as observed by comparing the relative positions of the crests when the patient lies supine. When the right innominate bone is shifted superiorly, the right iliac crest will appear superior relative to the left iliac crest. This position functionally shortens the right leg by shifting the hip joint superiorly. However, in our study cohort, the iliac crest heights were approximately equal 78% of the time. This finding suggests that sacral torsion and sacral sheer are not predominant functional factors influencing LLD in our study cohort.

Obviously, a knee or hip joint that cannot be fully extended—or a knee joint that is substantially deviated medially or laterally—would contribute to LLD. These factors are unlikely to have played a major role in the present study because all participants could fully extend their knee and hip joints, and no participants appeared to have grossly deviated medial or lateral knee joints. Nevertheless, such factors should be measured in future, more sophisticated, larger-population studies of LLD and osteoarthritis.

It is worth considering the interaction and resulting patterns of the 3 bony landmarks (*Table 2*). The most common pattern in the present study was for the medial malleolus and ASIS bony landmarks to be either congruently superior or congruently inferior on the same side and the iliac crests to be approximately equal. This pattern was observed in 23 of 32 participants (71.9%). This pattern suggests that pelvic torsion (innominate rotation) is a mechanism that influences LLD.

An obvious study limitation is that the examiner was not always blind to which knee was most painful prior to measurement, resulting in potential bias influencing the observations. This bias was minimized partially by not assessing leg length before enrollment. The present study was an observational study conducted in the course of routine office visits with no funding; because a patient presenting with knee pain triggered study enrollment, it was impossible to blind the physician to the predominant side of the knee pain. More often than not, patients will tell the physician which knee hurts at presentation, thus preventing blinding prior to data collection. Other limitations are the present study's small sample size, lack of a second examiner to compare or validate the observations of the physical examinations, and lack of a control cohort for comparison. Despite these limitations, useful observations can be obtained during clinical practice—prospective controlled clinical trials and even simple interoperator validation studies are time consuming and cost money. Observational data are helpful for better framing future study questions and justifying funding for more sophisticated randomized controlled clinical trials.

Further, a small body of published literature supports the methods used in the current study. Stovall et al[21] showed how palpation of anatomic bony landmarks was more reliable than motion testing, tender point assessment, and pain provocation. The measurement of the medial malleolus bony landmark that is taken when the patient is supine may be especially reliable because there is no space between the examiner's thumbs when superior or inferior deviation is visually determined. Fryer[19] found that by selecting patients who had an LLD of approximately 0.4 cm or greater and by using multiple assessment rounds, investigators who used palpation for supine medial malleolus asymmetry achieved near-perfect intra- and interexaminer reliability, with κ values of 0.94. The present study takes a similar approach by deeming landmarks to be equal when visual inspection cannot easily determine which side is superior or inferior. This method in theory eliminates participants with insubstantial differences between bony landmarks. Whereas 1 participant in our study cohort was deemed to have equal leg lengths, the rest had an estimated LLD of 0.6 cm or greater, which mirrors the protocol set up respectively by Fryer[19] and Harvey et al[5]; investigators in the latter study used all LLDs of less than 0.5 cm as the reference group in their study of osteoarthritis of the knee. In other words, Harvey et al[5] deemed an LLD of less than 0.5 cm as not clinically meaningful and thus conceived of any participants who had this measure as a control group.

In the present study, LLD was estimated by means of calipers, which were used to measure the difference between the 2 medial malleolus bony landmarks in the coronal plane. This instrument proved to be a limitation for 2 reasons: the exact apex of each bony process was difficult to measure and intraexaminer reliability was not established. It is much easier to determine if 1 bony landmark is superior relative to another than to measure the magnitude of their difference. The data suggest that the magnitude of LLD found in the current study cohort was between 0.5 and 2 cm. Greater measures of LLD (in the range of 2.5 to 5 cm) have been reported to be associated with long leg arthropathy.[22] Golightly et al[12] reported a cross-sectional study of osteoarthritic knee and hip pain and found that LLD was moderately associated with knee pain and less strongly associated with hip pain. However, Golightly et al[12] conservatively defined LLD as being 2 cm or greater and used the distance between the ASIS and medial malleolus to define LLD. Of 3012 individuals assessed, 206 had an LLD of 2 cm or greater, and location of pain was not associated with either a long or a short leg.[12] This study[12] suggests that the magnitude of LLD may have different effects on knee osteoarthritis and osteoarthritic knee pain. Because mechanical stresses are likely to change at different magnitudes of LLD, it is plausible that different effects occur. However, more investigation needs to be conducted to explore this theory.

Although many published methods exist for assessing leg length,[10,12,15,19,23] there is no standardized method. Defrin et al[10] determined anatomic leg length by using an ultrasonographic device to reveal the top of the femoral head, marking the patient's skin, and measuring the distance from that mark to the floor. Researchers attempted to address both anatomic and functional factors contributing to LLD by means of other methods, such as comparing the relative positions of a right and a left anatomic landmark, such as the medial malleoli,[19] measuring the positions of the femoral heads on a standing postural x-ray study,[23] or indirectly measuring LLD by placing blocks under 1 heel until the sacrum appeared to be level.[15] Unfortunately, the latter 3 methods[15,19,23] did not reveal to investigators how much of the LLD is from anatomic or functional factors, just the total effect.

Other investigators have used a supine method for assessing LLD.[12,19] One method is to have the participant lie supine and assess the distance between the ASIS and the distal medial malleolus landmarks with a tape measure.[12] The supine method used in the present study was also used by Fryer.[19] To my knowledge, the merits of standing vs supine measurements have never been evaluated. Likewise, the respective effect of anatomic and functional elements on overall LLD remains grossly underevaluated. Many methods for determining LLD do not even account for functional differences; they measure only anatomic differences. The findings of the current study suggest that functional determinants may be more influential than previously thought, especially in LLD that measures 2 cm or less.

Knowing the respective contributions of anatomic and functional factors that determine LLD is important for optimal treatment. In theory, functional factors that contribute to LLD should be more manageable by means of osteopathic manipulative treatment. However, if the functional changes are actually compensatory for an anatomic asymmetry, then intervention may not be indicated. Heel lift therapy[10] or manipulation could theoretically undo a beneficial compensatory pattern. Responding to a case report of a patient with low back pain who was treated with heel therapy, Magoun[24] wrote that the treating physicians should have taken into account more than anatomic postural radiographic studies alone. Without first correcting for dysfunction in the pelvis, Magoun[24] argued, the treating physicians obtained an inaccurate measure of LLD, and thus the heel therapy exacerbated the patient's low back pain.

Conclusion

The present study raises a number of questions regarding LLD. The observations confirm the primary hypothesis—namely, that osteoarthritic knee pain in the elderly is more common in the short leg as determined by the relative position of the medial malleolus bony landmarks while the patient lies supine. The location and patterns of the bony landmarks observed suggest that functional mechanisms, such as pelvic torsion, contribute markedly to mild to moderate LLD in the elderly. More sophisticated studies, including investigations into the role of pelvic torsion in knee pain, as well investigations for interoperator reliability testing and validity, are needed to build on the findings reported in the present study.

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