Original article

Correlation between leg length discrepancy and asymptomatic sacroiliac joint dysfunction in young males

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Background: Sacroiliac joint dysfunction (SJD) is an important cause of low back pain (LBP), commonly overlooked. Although the association of leg length discrepancy (LLD) and LBP was established, no study has examined the association between LLD and asymptomatic SJD (ASJD).
Objective: To examine the correlation between LLD and ASJD in young males.
Methods: One hundred subjects wearing a comfortable and thin uniform were randomized into three rooms (consisting of leg length measurement, palpation and special test rooms). One high valid and reliable assessor was allocated in each room. All subjects were assessed three times (one time a room and then randomly assigned by a project manager to other rooms until reaching three times a test) to reduce potential biases and errors. Logistic regression was used to examine the association between the degree of LLD and ASJD. The association between ASJD and affected leg was examined by Chi-square test.
Results: The mean age and LLD of subjects were 20.3 ± 1.4 years and 6.3 ± 3.8 mm., respectively. The number of structural and functional LLD were found (50 subjects each type). The ASJD was found in 95 (46 structural, 49 functional) subjects. There was no significant correlation between the degree of LLD and ASJD (odds ratio = 0.99 (95% confident interval (0.78, 1.26), $P = 0.94$). However, the affected leg (short leg) associated with ASJD ($P < 0.001$).
Conclusions: Young males with mild LLD can have ASJD. The study suggests that the shorter leg in people with mild LLD could have higher chance for ASJD. Shoe lifts may be an optional procedure to prevent symptomatic SJD, especially structural LLD.

Keywords: Leg length discrepancy, sacroiliac joint, young males.

Up to 85.0% of the world population can experience low back pain (LBP) within their lifetime.(1) Pain, disability and activity limitation (e.g. while sitting, standing, walking, sleeping or working) are the most commonly reported symptoms of individuals experiencing LBP, which can lead to reduced quality of life.(1) LBP is the biggest contributor to disability-adjusted life years among musculoskeletal disorders (2) and is also a substantial cause of socioeconomic burden. Costs related to LBP have reached up to US$ 118.8 billion in the United States (US),(3) AU$ 9.17 billion in Australia (4) and approximately £ 11 billion in the United Kingdom (UK).(5)

Although LBP has several possible causes (e.g. herniated nucleus pulposus, spondylosis and spondylolisthesis), one commonly overlooked cause is sacroiliac joint problems.(6) Previous studies reported that up to 40.0% of LBP patients can be caused by sacroiliac joint dysfunction (SJD).(7, 8) A possible cause of SJD based on biomechanical analysis is leg length discrepancy (LLD) which can alter pelvic tilt and may lead to SJD.(9) In daily life, people are generally sitting, standing or walking. These activities can cause

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Received: January 13, 2021
Revised: March 29, 2021
Accepted: April 16, 2021

problems to sacroiliac joint and lumbar spine owing to LLD.[10 - 14] LLD can be found in up to 90.0% of the population.[15]

Although the association of LLD and LBP has been established[10], there is no previous rigorous study investigating the relationship between LLD and asymptomatic SJD (ASJD). Therefore, the aim of this study was to examine the association between LLD and ASJD in young males (18 - 25 years) in order to provide evidence in preventing symptomatic SJD from developing into LBP (commonly found in population aged 25 - 49 years).[2] The hypothesis is that LLD may be associated with ASJD. Given that males have lower average body fat than females[16], this study was conducted in males, thereby minimizing errors of palpation and leg length measurement. The objective of this study was to examine the correlation between leg length discrepancy and asymptomatic sacroiliac joint dysfunction in young males.

Materials and methods

Research methods and reporting of this cross-sectional study are in accordance with the Strengthening The Reporting of Observational studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies.[17] All processes were performed in accordance with the declaration of Helsinki. The protocol has been approved by the Ethics Committee of Naresuan University, Thailand.

Study design

The subjects information sheet and consent form were sent to interested people to give them the opportunity to read it in advance prior to the recruiting appointment. Potential subjects were given the opportunity to discuss any issues relating to the study. Potential subjects were screened to confirm eligibility by a recruiting physiotherapist prior to receiving written consent. Three high reliable assessors (physiotherapists) were assigned into three rooms (one assessor per room) consisting of leg length measurement (room 1), palpation (room 2) and special tests (room 3).[18] Comfortable and thin uniforms were prepared for all subjects to reduce the errors of leg length measurements and special tests due to attire. Leg-length measurement, palpations and special tests were assessed three times in order to confirm the results and reduce potential errors. In order to prevent remembering the results of the assessors, a project manager was used to random a subject to an assessment room (assessed one time) and then alternated with other subjects from other assessment rooms until completing three times of each assessment room. The average of the three measurement of leg length measurement for spinomalleolar distance was used for data analysis. Each outcome measure was assessed using a standardized protocol that has previously been shown to have high intra-rater reliability.[18]

Subjects

One hundred subjects (based on the rho = 0.32, $\alpha = 0.05$ and $\beta = 0.90$)[18] were recruited in Phitsanulok Province, Thailand using the following criteria:

Inclusion criteria: Male subjects aged 18 - 25 year-old with normal body mass index (BMI = 18.5 - 22.9 kg/m^2)[19] and had LLD evaluated by true leg length measurement (spinomalleolar distance) and Webber Barstow test using a recruiting physiotherapist.[20 - 23]

Exclusion criteria: Signs and symptoms of low back pain and musculoskeletal disorders of lower limbs, current or previous treatment from any hospital and/ or clinic regarding low back pain and/or lower limbs, serious injuries due to trauma, history of fracture or dislocation or surgery of the spine or lower limbs, alcohol abuse, dementia and serious mental diseases.

Variables and measurement

Leg length measurement

True leg length measurement or spinomalleolar distance (acceptable validity and reliability [intraclass correlation coefficient ($ICC_{3,3}$) range 0.98 - 0.99] in measuring LLD) was used to assess the leg length of the subjects.[18, 22] The starting position of the assessment was comfortable supine lying with knees flexed approximately 45° and feet on the bed.[22] Then, the subject was instructed to lift his pelvis off of the table and gently lowering himself back down in order to having the normal position of pelvis and sacroiliac joint.[22] After that an assigned assessor took the subjects's legs to straight comfortably. A measuring tape was then used to measure from the apex of anterior superior iliac spine (ASIS) to the distal end of the medial malleolus in each leg [24,25] and recorded in millimeter (mm). The following is the classification of the level of LLD: mild (< 30 mm), moderate (30 - 60 mm) and severe (> 60 mm).

Palpation

The ASIS, posterior superior iliac spine (PSIS), iliac crest, greater trochanter and ischial tuberosity of subjects were palpated by a valid and reliable (kappa coefficient range 0.90 - 1.00) assessor in standing position to compare the level on both sides.[18] The subjects were exposed to reduce potential errors. During palpation, the eye level of the assessor was the same level of each bony landmark to reduce observational errors. The distance between the umbilicus and ASIS was measured by a valid and reliable ($ICC_{3,3}$ = 0.98) assessor in standing position using a tape to provide information in interpreting the torsion of pelvis in transverse plane (inflare/outflare). The results of palpations were interpreted for pelvic torsion in terms of sagittal (posterior/anterior innominate resulting from ASIS, PSIS and ischial tuberosity) and coronal (upslip or downslip resulting from iliac crest, greater trochanter and ischial tuberosity) planes.[18, 22, 26 - 28]

Special tests

Webber Barstow and long sitting tests were used to assess the types of LLD (structural or functional) and a hip rotation test was used for the dysfunction of sacroiliac joint.[18, 22]

Webber Barstow test/maneuver[22] is a valid and reliable (kappa coefficient = 0.92) clinical method to assess the inequality of leg length.[18, 23] A subject would lie down in supine position with both knees flexed to 45^{o}. The subject would lift their pelvis off the table and then gently lower down (bridging). The assessor would straighten the subject's and assess leg length inequality by comparing the level of the medial malleoli both sides.

Long sitting test/supine to long-sit test is a valid and reliable (kappa coefficient = 0.97) clinical test to classify structural or functional LLD.[18, 22] The test was conducted after the Webber Barstow test by helping the subject from supine lying to a long sitting position without moving subject's legs. Then, the assessor compared the level of the medial malleoli of the subjects. The results of both Weber Barstow and long sitting tests were used to identify between structural and functional LLD. For instance, right leg was longer than left leg (comparing the level of the medial malleoli) in both Webber Barstow and long sitting tests. The interpretation was this subjects has structural LLD. Conversely, if the right leg was longer than the left leg in Webber Barstow test but the left leg was longer than the right in the long sitting test, this subjects would be interpreted as functional LLD.

Hip rotation test is a valid and reliable (kappa coefficient = 0.95) clinical test to evaluate SJD, commonly performed after the Webber Barstow maneuver.[18, 22] The assessor marked a line at the same level of the medial malleoli both sides. Then, the assessor took one leg of the subject and abducted 30^{o} prior to performing full hip external rotation. The assessor then took the subject's leg to starting position and compared the mark between the medial malleoli. The function of the sacroiliac joint was normal when the mark of the rotated leg was longer than the previous and abnormal when the mark was shorter or no change. The sacroiliac joint function was confirmed by taking the leg abduction 30^{o} with full hip internal rotation. Prior to the confirmation, the assessor needed to shake the rotated leg to allow the sacroiliac joint to be normal by comparing the marks which might be at the same line as the starting. The function of the sacroiliac joint was normal when the mark of the rotated leg was shorter than the previous and abnormal when the mark was longer or no change. Both legs were evaluated using the same methods.

Data management

Subject data were kept safely from any third party to maintain the subjects' privacy. All collected documents have been stored in a secure place. All electronic data are also confidentially stored in a password protected computer. Data can only be accessed by members of the research team. The study only will be published in a completely unattributable format or at an aggregate level in order to ensure that no subject can be identified. All data will be destroyed after being kept for 10 years at the Faculty of Allied Health Sciences, Naresuan University.

Statistical analysis

Data were analysed using IBM SPSS version 17. Missing data were not found. Continuous variables were expressed as mean ± standard deviation owing to normal distribution. Categorical variables were presented as absolute values and percentages. Logistic regression was used to examine the association between the degree of LLD (continuous independent variable measured in mm.) and ASJD (dependent variable, binary: present or absent). The association between ASJD (binary: present or absent) and affected leg (binary: short or long side) was examined by Chi-square test. Types of LLD and pelvis torsion are tabulated in Table 1. $P < 0.05$ was considered as statistical significance.

Results

One-hundred males (mean age 20.3 ± 1.4 years) participated in this study. The mean of LLD was 6.3 ± 3.8 mm. By performing the Webber Barstow and long sitting test, we found equal number of subjects who had structural and functional LLD (50:50). The SJD was presented in 95 (46 in structural and 49 in functional LLD) subjects (assessed by hip rotation test). Types of pelvic torsion among ASJD subjects are presented in Table 1.

For subjects presenting with a structural LLD, 28 had ASJD in the shorter leg and 18 in the longer leg. As for the functional LLD group, 24 and 25 subjects had ASJD in the shorter and longer legs, respectively.

Table 2 shows associations between degree of LLD and asymptomatic SJD. There was no significant correlation between the degree of LLD and ASJD (odds ratio = 0.99 [95% confident interval (CI) (0.78, 1.26)], $P = 0.94$). However, the affected leg significantly associated with ASJD ($P < 0.001$). In another word, the short leg significantly correlated with ASJD among young males.

For subgroup analyses (Table 2), the correlation between the degree of LLD and ASJD was not found in structural [odds ratio = 1.04 (95% CI (0.76, 1.42)], $P = 0.81$) and functional LLD [odds ratio = 1.91 (95% CI (0.39, 9.45)], $P = 0.43$). However, the affected leg significantly associated with ASJD ($P < 0.001$) in both subgroups. In another word, the short leg significantly correlated to ASJD among young males.

Table 1. Types of pelvis torsion among ASJD subjects.

Types of pelvic torsion	**Structural LLD (n)**	**Functional LLD (n)**	**Total (n) (%)**
Anterior innominate	12	10	22 (23.2)
Posterior innominate	6	7	13 (13.7)
Upslip	15	18	33 (34.7)
Downslip	13	14	27 (28.4)
Total	46	49	95 (100.0)
Inflare	22	20	42 (44.2)
Outflare	24	29	53 (55.8)
Total	46	49	95 (100.0)

LLD = leg length discrepancy; ASJD = asymptomatic sacroiliac joint dysfunction

Table 2. Associations between degree of LLD and asymptomatic SJD.

Type of LLD	**Odds ratio (95% confident interval)**	***P*-value**
LLD	0.99 (0.78, 1.26)	0.94
Structural LLD	1.04 (0.76, 1.42)	0.81
Functional LLD	1.91 (0.39, 9.45)	0.43

LLD = leg length discrepancy; SJD = sacroiliac joint dysfunction; r = rho

Discussion

ASJD can develop to symptomatic SJD in the future. Modifying factors that can contribute to ASJD could prevent the development of symptomatic SJD and LBP.(7, 8) A considerable factor of SJD and LBP is LLD (inducing stress force to sacroiliac joint and lumbar spine).(10 - 14) Although the mean of LLD (6.3 ± 3.8 mm) in this study can be classified as mild (< 30 mm),(29) LLD $\geq$ 6 mm can be associated with LBP among meat cutters (standing for work).(10) As little as 5 mm of LLD can be a cause of biomechanical changes in both kinematics and dynamic leg length of the lower limbs during walking (30) contributing to symptomatic lower limb osteoarthritis.(31) Therefore, the mild LLD should not be overlooked.(14) It should be noted that all potential subjects had LLD after performing true leg length measurement (spinomalleolar distance) and Webber Barstow test.

The findings of this study suggest that the shorter leg in individuals with structural and functional LLD can have higher chance for ASJD than the longer leg. The findings have shown the similar trend of problem in the short leg to the previous cohort study which reported that the short leg was associated with knee osteoarthritis.(31) The potential mechanism is the shorter leg has to carry weight bearing rather than the longer leg during standing (static phase), leading to pelvic, spinal pain and/or lower limbs pain in the long term.(13) Additionally, the shorter leg has to travel a greater distance to reach the ground and has a higher impact velocity during gait.(31)

Mild LLD is a considerable cause of compensatory gait pattern (increases rearfoot plantarflexion and decrease knee and hip flexion angles in the shorter leg and increases rearfoot dorsiflexion and knee and hip flexion angles in the longer leg) and can lead to musculoskeletal problems.(14) During gait, the shorter leg can induce pelvic obliquity down, lumbar spine side bending and contralateral rotation. This can be a cause of structural stresses on passive spinal tissues.(12) Unfortunately, there is no study investigating the effect of the short leg in sacroiliac region. However, pelvic torsion resulting from previous studies(12, 14) may lead to structural stress in sacroiliac region.

Owing to LLD, the abnormal patterns of the weight bearing during standing, walking and running would be compensated, leading to adapted structural changes (e.g. anterior/posterior innominate, upslip/downslip and inflare/outflare of pelvis), impairments (e.g. abnormal gait and SJD) and musculoskeletal disorders (e.g. LBP, scoliosis, hip and knee pain).(12 - 14, 30 - 35) A current systematic review found that shoe lifts can reduce pain and improve function in patients with LLD.(29) Furthermore, two guidelines have recommended shoe lifts in patients with symptomatic LLD. There are several advantages of the shoe lifts in terms of simple, non-invasive and inexpensive procedures with no reporting serious adverse events.(29) Finally, shoe lifts can reduce chronic LBP and functional disability in patients with LLD $\leq$ 10 mm (33) and in patients with foot pronation.(36) Therefore, shoe lifts could be an optional procedure to prevent symptomatic SJD and other musculoskeletal problems in the individuals with structural LLD. Unfortunately, an appropriate magnitude of correction or effective strategy is still unclear.(29) Further studies on the combination of different methods (e.g. static clinical assessments, imaging and dynamic leg length measurement during gait) can improve validity and reliability for LLD detection. However, dynamic leg length measurement during gait has reported as a non-valid method to assess mild structural LLD. (37) Finally, a wider age group and females should be conducted to increase the generalizability.

Conclusion

Young males with mild LLD can have ASJD. There was no correlation among the degree of LLD, ASJD and affected leg. The findings have suggested that the shorter leg in people with mild LLD could have higher chance for ASJD. Shoe lifts may be an optional procedure to prevent symptomatic SJD, especially structural LLD.

Acknowledgements

Authors would like to thank the Faculty of Allied Health Sciences, Naresuan University for the funding to support this work. The funder had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Conflict of interest

The authors, hereby, declare no conflict of interest.

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