Arch Health Sci Res. 2022;9(1):21-26
DOI: 10.5152/ArcHealthSciRes.2021.21038

Original Article

Evaluation of Lower Extremity Muscles Shortness, Flexibility, and Hypermobility in Adults with Asymptomatic Sacroiliac Joint Dysfunction

Ayşe Neriman NARİN[1], Beyza YAZGAN DAĞLI[2], Aysun VURAL CÖMERT[3], Betül BAHAR[4], Kutay Engin ÖZTURAN[5]

[1]Department of Physiotherapy and Rehabilitation, Bolu Abant İzzet Baysal University, Faculty of Health Sciences, Bolu, Turkey
[2]Department of Physical Therapy and Rehabilitation, Gazi University, Faculty of Health Sciences, Ankara, Turkey
[3]Department of Physical Therapy and Rehabilitation, Bolu Abant İzzet Baysal University, Institute of Higher Education, Bolu, Turkey
[4]Department of Therapy and Rehabilitation, Siran Vocational School of Health Services, Gümüşhane University, Gümüşhane, Turkey
[5]Department of Orthopaedic and Traumatology, Bolu Abant İzzet Baysal University, Faculty of Medicine, Bolu, Turkey

Cite this article as: Narin AN, Yazgan Dağlı B, Vural Cömert A, Bahar B, Özturan KE. Evaluation of lower extremity muscles shortness, flexibility, and hypermobility in adults with asymptomatic sacroiliac joint dysfunction. *Arch Health Sci Res.* 2022; 9(1): 21-26.

ABSTRACT

Objective: (a) To investigate the presence of sacroiliac joint dysfunction in asymptomatic individuals and (b) to compare lower limb muscle shortness, flexibility of hamstring and erector spinae muscles, and hypermobility between subjects with and without asymptomatic sacroiliac joint dysfunction.

Material and Methods: A total of 54 healthy young adults subjects were included in the study. The subjects were assessed with the sacroiliac joint diagnostic procedure. The seated flexion test, the standing flexion test, the Gillet test, and bilateral bony landmark examination were performed by an expert investigator. According to the positivity of at least 3 of these tests, the subjects were divided into 2 groups, the asymptomatic sacroiliac joint dysfunction group and the control group. The shortness of tensor fasciae latae and iliopsoas muscles was evaluated with the modified Ober test and the modified Thomas test. The straight leg raise test and fingertip-to-floor test were carried out for hamstring and erector spinae muscles flexibility, while hypermobility was assessed according to the Beighton criteria.

Results: The asymptomatic sacroiliac joint dysfunction was diagnosed in 38% of healthy adults. There was no statistical difference in the shortness of tensor fasciae latae and iliopsoas muscles between the asymptomatic sacroiliac joint dysfunction group and the control group ($P > 0.05$). Similarly, there was no difference between the groups in terms of the hamstring and erector spinae muscles flexibility, and the Beighton scores ($P > 0.05$).

Conclusion: This study emphasized that asymptomatic sacroiliac joint dysfunction might be seen in healthy young adults without the difference in shortness and flexibility in the lower extremity and hypermobility.

Keywords: Dysfunction, flexibility, hypermobility, sacroiliac joint, shortness

Introduction

The sacroiliac joint (SIJ) provides effective transfer of movement and load between the spine and the lower extremity.[1] A variety of conditions such as traumas, hypermobility, and muscles shortness can affect the movement and function in SIJ, which causes dysfunction.[2,3]

The SIJ dysfunction is defined as a relative hypomobility within a portion of the joint's range between the sacrum and the ilium.[4] According to some researchers, although the SIJ dysfunction is considered a common cause of low back pain, this does not essentially result in pain in clinical practice.[4,5] Because the SIJ dysfunction is not necessarily symptomatic, it is reported that dysfunction may be positive in subjects without lumbopelvic pain. Therefore, the entity of the SIJ dysfunction is asymptomatic in some cases.[4]

Trunk, hip, and lower extremity movements directly affect the SIJ movements. Anatomically, no muscle that acts directly across the SIJ. Instead, there are many muscle structures associated with ligaments, fasciae, the anterior superior iliac spine (ASIS), and the posterior superior iliac spine (PSIS).[3,6] Although there are many muscles involved in SIJ stability, the hamstring, iliopsoas, erector spinae, and tensor fascia latae (TFL) muscles may differ in some ways from other muscles. Since these muscles play a primary role in the spine and extremity movements (except TFL), cross multiple joints, and interact with each other during trunk and extremity movements owing to their fascial system connections, the mentioned muscles are emphasized in this study.[1]

Corresponding author: Ayşe Neriman NARİN, e-mail: nayseyilmaz@gmail.com

Received: March 15, 2021
Accepted: October 7, 2021
Available Online Date: November 20, 2021

As the hamstring muscle has an anatomical connection with the sacrotuberous and the ischial tuberosity, Peebles and Jonas[7] argued that hamstring muscle plays an integral role in the intrinsic stability of the SIJ. Moreover, Wingerden et al[8] emphasized the association of hamstring tension with reduced SIJ stability. Similarly, Yoo[9] showed that the erector spinae muscles aponeurosis was linked to the sacrum and dorsal SIJ ligaments. Additionally, they emphasized that the erector spinae could produce the nutation movement for SIJ stability. Biomechanically, it is reported that the tightness of iliopsoas, TFL, hamstring muscles, and the iliotibial band could change the SIJ biomechanics thereby and may bring about dysfunction.[10,11] However, the biomechanical effect of erector spinae muscles flexibility on SIJ dysfunction has not been focused on enough in previous studies. Although TFL and iliopsoas muscles have essential roles in normal joint movements of the hip and knee, there is a paucity in recent studies investigating the relationship between these muscles and SIJ dysfunction.[6,12] It has been reported that general joint hypermobility may cause lumbopelvic dysfunction by affecting the biomechanics between the pelvis and spine.[13] It can also affect the extensibility of some lower extremity muscles by destabilizing the pelvis. Although general hypermobility is frequently investigated in dancers with low back pain, there are no data on how general hypermobility is affected in individuals with SIJ dysfunction.[13,14]

The aims of this study were (a) to investigate the presence of SIJ dysfunction in asymptomatic individuals and (b) to compare lower limb muscle shortness, the flexibility of hamstring and erector spinae muscles, and hypermobility between subjects with and without asymptomatic SIJ dysfunction.

Material and Methods

Design and subjects

This cross-sectional descriptive study was carried out at Bolu Abant İzzet Baysal University University between November 2017 and December 2018. Bolu Abant İzzet Baysal University Ethics Committee approved the study (2017/79). Written and verbal consent were obtained from all subjects, and this study was performed in line with Helsinki Declaration.

A total of 54 healthy young adults who are physiotherapy and rehabilitation students participated in this study. (1) Being in the 18-25 years of age range and (2) willingness to participate accounted for inclusion criteria. Subjects were excluded if they had (1) a history of back, leg, and pelvic surgery; (2) low back pain and pelvic pain within the last 6 months including examination; (3) any lower limb injuries in the past 6 months; (4) any condition limiting gait; and (5) any neurological, genetic, or systemic disease affecting the musculoskeletal system.

Procedure

Sacroiliac joint dysfunction was described through the differential diagnostic procedures which were specified in previously published studies.[4,15,16] Arab et al[17] who examined a test cluster of 4 SIJ mobility tests (the Gillet test, the standing flexion test, the sitting flexion test, and the prone knee flexion test) reported high inter-tester reliability in the presence of 2 positive tests (95% CI: 0.49-1.07). Additionally, Timm[16] identified the presence of the SIJ dysfunction in elite rowers through palpation assessment of anatomical landmarks.

Considering these studies, the diagnosis of the SIJ dysfunction was determined by at least 3 positivity of the sitting flexion test, the standing flexion test, the Gillet test, and the bilateral bony landmark examination in our study.[4,15-17] The SIJ evaluation of all subjects was performed by an examiner physical therapist (PhD) having more than 10 years of experience in the field of manual therapy. According to these test results, the subjects were divided into 2 groups as the asymptomatic SIJ dysfunction (A-SIJD) group and the control group. After the diagnostic process, subjects were not informed whether they had SIJ dysfunction.

Diagnostic Process

1. The sitting flexion test: The inferior margins of right and left PSIS were palpated while subjects bent forward from a sitting position until their hands reached the floor. If one PSIS moved in a superior direction compared to the contrary side, the test was positive.[4,15]
2. The standing flexion test: The inferior aspect of PSIS was palpated while the subject bent forward from standing position without knees flexion. The test was positive if one PSIS moved more cranially than the opposite[15] (Figure 1).
3. The Gillet test: The thumbs were placed simultaneously on the inferior aspect of the PSIS and the second sacral tubercle. The subject performed hip knee flexions in sequence (right and left side) and the PSIS moving was compared.[18] A positive result was described

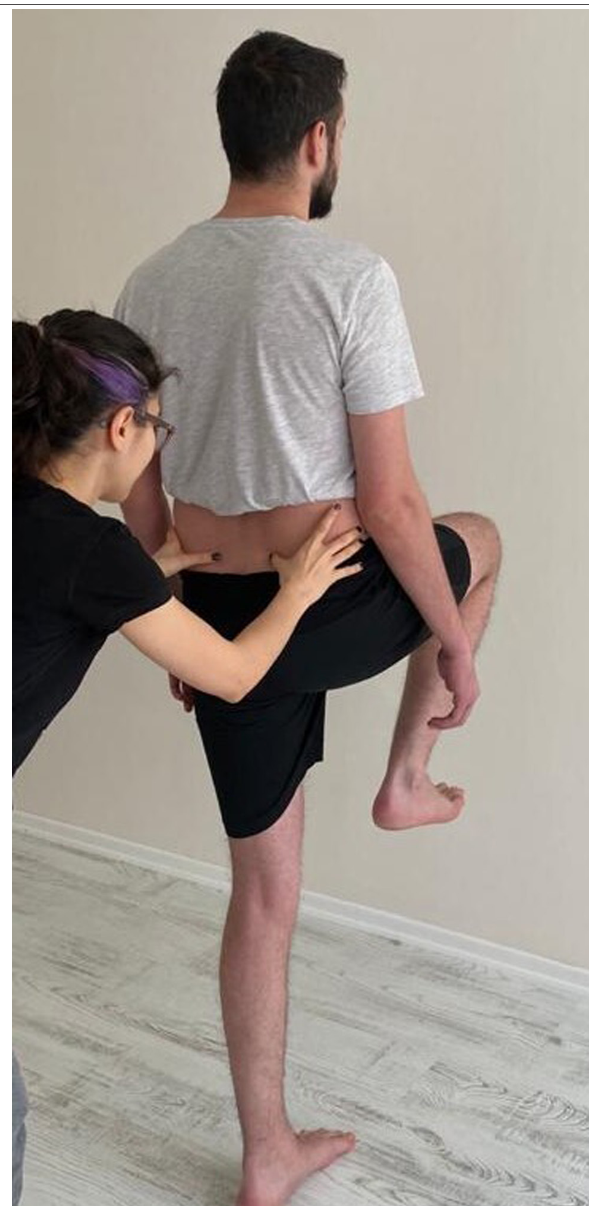

Figure 1. The standing flexion test.

when PSIS did not move posterior–inferiorly or moved minimally during the knee flexion on the ipsilateral side[4] (Figure 2).

4. The examination of an anatomical landmark palpation (ASIS, PSIS): The difference in symmetry in anatomical landmarks was indicative of the positive result.[15,16]

Measurements

Three additional examiners blinded to groups placement collected data of muscle shortness, flexibility, and hypermobility. All measurements were repeated 3 times for each subject, and the mean values were recorded for numeric data. The demographic and physical characteristics of the subject were recorded using the general information form.

Muscle Shortness

Tensor fascia latae length was evaluated by using the modified Ober test. In the side-lying position, the tested limb of the subject was moved into flexion, abduction, and extension. While the pelvis was stabilizing, the subject's limb was lowered into adduction until it stopped or the pelvis started to tilt downward. If the hip remained in abduction relative to the neutral position, it was a sign of TFL shortness. Also, it was recorded as the presence or absence of TFL shortness.[19]

Iliopsoas length was evaluated by the modified Thomas test. The subject sat on the edge of the treatment table and rolled back onto the table. The subject held both knees to the chest with the arms and then the tested lower extremity was lowered to the floor. If the lumbar spine and pelvis stability were reduced (contact of the lumbar spine with the table), the test was positive.[20]

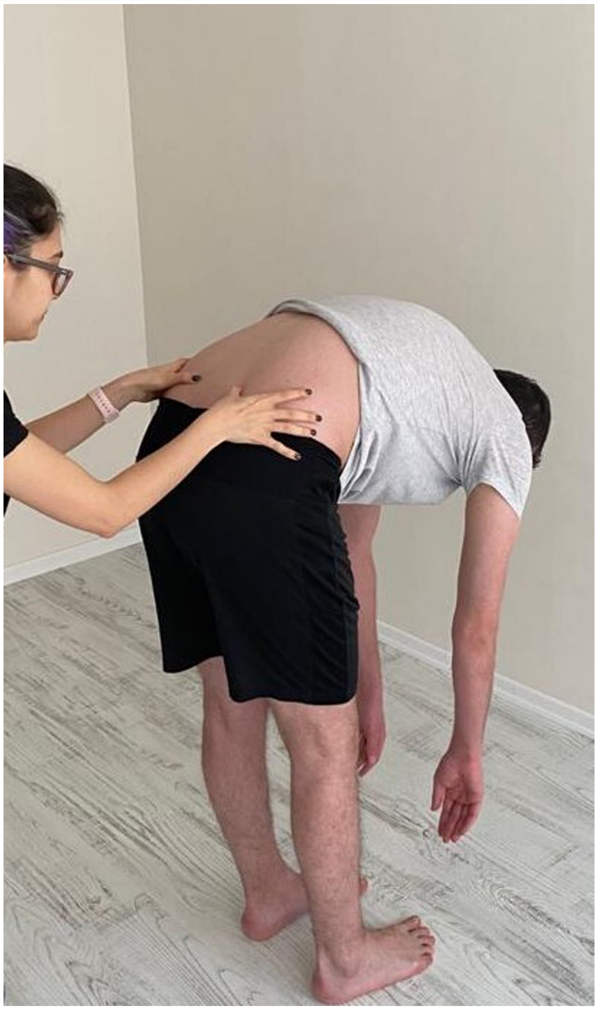

Figure 2. The Gillet test.

Muscle Flexibility

Hamstring muscle flexibility was assessed with the straight leg raise (SLR) test when the subject was lying in the supine position. While the subject's pelvis was stabilized manually, the examiner raised passively one of the lower limbs toward the direction of flexion. When the subject felt resistance in the posterior thigh or flexed the knee, the distance between the lateral condyle of the femur and the treatment table was measured by the use of a flexible tape measure. The procedure was repeated 3 times for right and left lower extremities, and the average of the results was recorded.[21,22]

Fingertip-to floor (FTF) test was carried out with the subject standing at a height of a 40-cm box. The subject bent forward with knees extended position, and the distance between the third fingertip and the box was measured with a tape measure which has an accuracy of 0.5 cm. Negative values were recorded if the subject could not reach the box. Contrary, if the person was able to reach under the top surface of the box, the distance was noted as a positive value.[23,24]

Hypermobility

Hypermobility was evaluated according to the Beighton criteria, which was quantified by measuring the range of motion of the fifth metacarpophalangeal joints (passive dorsiflexion beyond 90° for all joints), thumbs (passive dorsiflexion to the flexor side of the forearm), elbows (hyperextension beyond 10°), knees (hyperextension beyond 10°), and lumbar spine (palms and hands rest flat on the floor). Other regions except the lumbar spine were evaluated symmetrically, and 1 point was given for each movement performed. Subjects scoring 5 and above out of 9 were considered to be hypermobile.[25]

Statistical analyses

Statistical analyses were performed with windows-based SPSS Statistics Program, version 21.0 (IBM Corp, Armonk, New York, USA). The Shapiro–Wilk's test was used to assess for the normal distribution of variables.

The difference between mean age, height, weight, body mass index, muscle flexibility (FTF test and SLR test) between the A-SIJD group and control group was analyzed by using the independent sample *t*-test. Mann–Whitney *U*-test was applied for the evaluation of hypermobility between the groups. Chi-square test was used for gender, dominant side, and muscle shortness (modified Ober test and modified Thomas test) for both groups. In all analyses, $P < .05$ was considered statistically significant.

Results

Asymptomatic sacroiliac joint dysfunction was determined in 21 (38.9%) of the 54 healthy young adults. In terms of gender, 48.4% of females and 26% of males had SIJ dysfunction. The SIJ motion test results of the subjects are given in Table 1. The characteristics of the subjects were found to be statistically similar in terms of both groups ($P > .05$) (Table 2).

The presence of muscle shortness was expressed as a percentage. There was no statistical difference in the shortness of iliopsoas and TFL between groups (Table 3). In terms of FTF, left and right side SLR, both groups were similar ($P > .05$).

In the A-SIJD group, there were 6 subjects with a Beighton score of 5 and above. Besides, 8 subjects with hypermobility were found in the control group. There was no significant difference in both groups in terms of hypermobility ($P > .05$) (Table 3).

Table 1. The Positive and Negative SIJ Test Results of Subjects

Tests	Positive, n (%)*	Negative, n (%)*
Sitting flexion test (%)	12 (22.2)	42 (78.8)
Standing flexion test (%)	16 (29.6)	38 (70.4)
Gillet test (%)	14 (25.9)	40 (74.1)
Landmark palpation (%)	24 (44.4)	30 (55.6)
SIJ dysfunction (%)	21 (38.9)	33 (61.1)

*Descriptive statistics (frequency distribution). SIJ, sacroiliac joint.

Table 2. Characteristics of Subject in the A-SIJD and Control Groups

Characteristics	A-SIJD Group (n = 21)	Control Group (n = 33),	*P*
	Mean ± SD	Mean ± SD	
Age (y)	22.33 ± 1.27	22.36 ± 2.2	.955$^{\beta}$
Height (m)	1.62 ± 0.77	1.66 ± 0.06	.057$^{\beta}$
Mass (kg)	59 ± 8.31	61.86 ± 6.70	.169$^{\beta}$
BMI (kg/m^2)	21.91 ± 2.09	22.56 ± 2.56	.340$^{\beta}$
	n (%)	n (%)	
Gender			
Females	15 (71.4)	16 (48.4)	.096‡
Males	6 (28.6)	17 (51.6)	
Dominant side			
Right	21 (100)	33 (100)	-
Left	0	0	

A-SIJD, asymptomatic sacroiliac joint dysfunction; BMI, body mass index; $^{\beta}$the independent *t*-test; ‡Chi-square test (gender and dominant side).

Discussion

This study suggested 38.9% of healthy young adults have asymptomatic SIJ dysfunction. Musculoskeletal assessments related to hypermobility, muscle shortness, and flexibility in subjects with asymptomatic SIJ dysfunction were similar to the results of healthy subjects.

Although the number of males and females in both groups were similar in our study, an average of half of the females had SIJ dysfunction, while this rate was about one-fourth in males. In various studies, it has been reported that factors such as fertility, lifestyle, or heavy workload in females may be counted among the causes of susceptibility to SIJ dysfunction.[26,27] Although these factors were not examined in our study, considering the physiology and social role of women, they may constitute one of the reasons for the tendency of SIJ dysfunction seen in females in our study.

Table 3. Comparison of Muscle Shortness, Flexibility, and Hypermobility Results Between A-SIJD and Control Group

Variables	A-SIJD Group (n = 21)	Control Group (n = 33)	*P*
	n (%)	*n* (%)	
Muscle shortness			
M.Iliopsoas	9 (42.9)	14 (42.4)	.975‡
M.TFL	2 (9.5)	3 (9.1)	.957‡
	Mean ± SD	Mean ± SD	
Muscle flexibility			
FTF (cm)	1.92 ± 14.50	−.24 ± 12.25	.556$^{\beta}$
SLR right (cm)	45.56 ± 3.41	46.28 ± 3.91	.552$^{\beta}$
SLR left (cm)	45.56 ± 3.37	46.86 ± 4.25	.310$^{\beta}$
Beighton Scale Score	2.42 ± 2.08	2 ± 2.07	.378§

‡Chi-square test; $^{\mathrm{B}}$the independent *t*-test; §Mann–Whitney *U*-test; A-SIJD, asymptomatic sacroiliac joint dysfunction; FTF, fingertip-to-floor test; SLR, straight leg raise test.

Arab et al[3] reported that hamstring muscle shortness could be a compensatory mechanism for decreased SIJ stability in patients with symptomatic SIJ dysfunction. Our data did not indicate any significant difference in the length of right and left side hamstring muscles between the group with A-SIJD and the control group. These studies included individuals with symptomatic SIJ dysfunction in addition to low back pain, thereby it may be a reason for the presence of short hamstrings contrary to our study. Saunders et al[28] concluded that the SIJ dysfunction may predispose to a hamstring strain. Conversely, in the study by Fox,[29] changes in the SLR and the sit and reach test after SIJ manipulation in symptomatic individuals were examined, and no results were found to support the connection between hamstring flexibility and the SIJ. The assessment methods of hamstring muscle length and the results of the present study were similar to Fox's[29] study. Slipman et al[12] described the pattern of muscle imbalances in individuals with SIJ dysfunction. This pattern is comprised of the shortness of the postural muscles such as iliopsoas, hamstring, and TFL.[12] Although it has been reported that these deviations reduced the mobility of the SIJ by altering the horizontal position of the sacrum and its articular facets, our study did not provide a result to explain this biomechanics.[12,30] Though the dynamic role of the muscles supporting the lumbosacral spine is known to be significant in the biomechanics of the SIJ, in our study, explaining the dysfunction with the static functions of the muscles such as shortness and flexibility may explain the lack of support for this result.[31]

Although several researchers explained that the muscles playing a role in the stability of the SIJ are associated with SIJ dysfunction, there was a paucity of studies investigating muscle imbalance in the asymptomatic subjects. Ayanniyi et al[32] examined the prevalence of asymptomatic SIJ dysfunction in children and its relationship to leg length difference. According to the results of this study, it was found that 20% of the population had A-SIJD, and this was associated with the difference in the leg length,[32] whereas the leg length discrepancies were not evaluated in our study. Additionally, there was no difference in terms of muscle shortness between subjects with A-SIJD and healthy controls. The subjects in our study consisted of young adults, and they did not experience low back pain, which might have prevented lower extremity muscle contracture or shortness. As mentioned in previous studies, we consider that the asymmetry of anatomic landmarks is a predisposing factor for symptomatic SIJ dysfunction progression in the elderly age of subjects.

Boudreau et al[33] confirmed in their case report that joint hypermobility is one of the factors contributing to musculoskeletal joint complaints. According to the study of Timm et al.[16] one of the possible reasons why sacroiliac dysfunction is common in professional rowers is hypermobility. Based on all of these results mentioned above, in our study in which we investigated hypermobility in A-SIJD subjects, no significant result was found. This might be due to the low percentage of hypermobility in the study population. Studies in the literature contradicted our study in terms of associating hypermobility with existing musculoskeletal problems and specifically focusing on joint hypermobility.

This study has some limitations. Despite the insufficiency of analysis of prior and post hoc tests, the small number of participants is one of the main limitations of this study. The Beighton criteria is a reliable and valid tool used to assess general hypermobility.[25] Since we focused on the muscles associated with the pelvis and sacrum in this study, the Beighton criteria may be inadequate in terms of evaluating specifically lower extremities. Considering the stabilizing effect of muscle strength, the absence of muscle strength assessment might have limited our results. It is uncertain whether the tests used to identify SIJ dysfunction will be diagnostically accurate and reliable.[15] In addition to the low level of objectivity of the diagnostic tests, the inability to establish a cause–effect relationship due to the design of our study is another limitation.

Conclusion

Our results showed that the young adult population without low back pain and pelvic pain could have A-SIJD. Besides, no difference was observed in subjects with A-SIJD in terms of lower extremity muscle shortness, flexibility, and hypermobility compared to healthy subjects. Considering all these data, our study emphasized that A-SIJD might be seen in healthy subjects without the difference in shortness and flexibility in the lower extremity muscles and hypermobility. We think that in asymptomatic subjects, the asymmetry of anatomic landmarks and the limited mobility between the sacrum and ileum may associate with musculoskeletal problems that individuals may experience in their future. When asymptomatic individuals begin to present symptoms, incorporating the muscles evaluated in our study into assessment or treatment programs may be helpful for healthcare professionals working in the treatment of SIJ dysfunction. Connecting the SIJ to the muscles through various tissues such as fascia and ligament might require us to consider SIJ dysfunction with a broad perspective. Therefore, evaluating not only muscle focus but also different aspects such as fascial limitation may contribute to our better understanding of asymptomatic sacroiliac dysfunction.

Ethics Committee Approval: The study protocol was approved by Bolu Abant İzzet Baysal University Ethics Committee (Approval Date: 08.06.2017 and Approval Number: 2017/79).

Informed Consent: Written and verbal consent were obtained from all subjects, and this study was performed in line with Helsinki Declaration.

Peer Review: Externally peer-reviewed.

Author Contributions: Concept – A.N.N., B.Y.D., A.V.C., B.B.; Design – A.N.N., B.Y.D.; Supervision – A.V.C., B.B., K.E.Ö.; Resources – A.N.N., B.Y.D., K.E.Ö., B.B.; Materials – A.N.N., A.V.C., B.B.; Data Collection and/or Processing – A.N.N., B.Y.D., A.V.C.; Analysis and/or Interpretation – A.N.N., B.Y.D.; Literature Research – B.Y.D., A.V.C., B.B.; Writing Manuscript – A.N.N., B.Y.D., A.V.C., B.B., K.E.Ö.; Critical Review – A.Y.D., B.Y.D., K.E.Ö.

Acknowledgments: The study was performed at Bolu Abant İzzet Baysal University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Bolu, Turkey.

Conflict of Interest: The authors declare that there is no conflict of interests.

Financial Disclosure: The authors declared that this study has received no financial support.

References

1. Vleeming A, Schuenke MD, Masi AT, Carreiro JE, Danneels L, Willard FH. The sacroiliac joint: an overview of its anatomy, function and potential clinical implications. *J Anat*. 2012;221(6):537-567. [CrossRef]
2. Al-Subahi M, Alayat M, Alshehri MA, et al. The effectiveness of physiotherapy interventions for sacroiliac joint dysfunction: a systematic review. *J Phys Ther Sci*. 2017;29(9):1689-1694. [CrossRef]
3. Arab AM, Nourbakhsh MR, Mohammadifar A. The relationship between hamstring length and gluteal muscle strength in individuals with sacroiliac joint dysfunction. *J Man Manip Ther*. 2011;19(1):5-10. [CrossRef]
4. Soleimanifar M, Karimi N, Arab AM. Association between composites of selected motion palpation and pain provocation tests for sacroiliac joint disorders. *J Bodyw Mov Ther*. 2017;21(2):240-245. [CrossRef]
5. Laslett M. Evidence-based diagnosis and treatment of the painful sacroiliac joint. *J Man Manip Ther*. 2008;16(3):142-152. [CrossRef]
6. Hamidi-Ravari B, Tafazoli S, Chen H, Perret D. Diagnosis and current treatments for sacroiliac joint dysfunction: a review. *Curr Phys Med Rehabil Rep*. 2014;2(1):48-54. [CrossRef]
7. Peebles R, Jonas CE. Sacroiliac joint dysfunction in the athlete: diagnosis and management. *Curr Sports Med Rep*. 2017;16(5):336-342. [CrossRef]
8. van Wingerden JP, Vleeming A, Buyruk HM, Raissadat K. Stabilization of the sacroiliac joint in vivo: verification of muscular contribution to force closure of the pelvis. *Eur Spine J*. 2004;13(3):199-205. [CrossRef]
9. Yoo WG. Effects of individual strengthening exercises for the stabilization muscles on the nutation torque of the sacroiliac joint in a sedentary worker with nonspecific sacroiliac joint pain. *J Phys Ther Sci*. 2015;27(1):313-314. [CrossRef]
10. Newman DP, McLean BC, Scozzafava AM. Evaluation and management of sacroiliac dysfunction utilizing an evidence-based algorithmic approach: a case study. *Cureus*. 2020;12(8):e9907. [CrossRef]
11. Shoukat H, Arshad HS, Sharif F, Fatima A, Shoukat F. Effects of different stretching times on range of motion in patients with hamstring tightness: a randomised control trial. *Ann King Edw Med Univ*. 2017;23(4):554-559. [CrossRef]
12. Slipman CW, Whyte WS, Chow DW, Chou L, Lenrow D, Ellen M. Sacroiliac joint syndrome. *Pain Phys*. 2001;4(2):143-152.
13. Roussel N, De Kooning M, Schutt A, et al. Motor control and low back pain in dancers. *Int J Sports Med*. 2013;34(2):138-143. [CrossRef]
14. Roussel NA, Nijs J, Mottram S, Van Moorsel A, Truijen S, Stassijns G. Altered lumbopelvic movement control but not generalized joint hypermobility is associated with increased injury in dancers: a prospective study. *Man Ther*. 2009;14(6):630-635. [CrossRef]
15. Klerx SP, Pool JJM, Coppieters MW, Mollema EJ, Pool-Goudzwaard AL. Clinimetric properties of sacroiliac joint mobility tests: a systematic review. *Musculoskelet Sci Pract*. 2020;48:102090. [CrossRef]
16. Timm KE. Sacroiliac joint dysfunction in elite rowers. *J Orthop Sports Phys Ther*. 1999;29(5):288-293. [CrossRef]
17. Arab AM, Abdollahi I, Joghataei MT, Golafshani Z, Kazemnejad A. Inter- and intra-examiner reliability of single and composites of selected motion palpation and pain provocation tests for sacroiliac joint. *Man Ther*. 2009;14(2):213-221. [CrossRef]
18. Cooperstein R, Blum C, Cooperstein EC. Assessment of consistency between the arm-fossa test and Gillet test: a pilot study. *J Chiropr Med*. 2015;14(1):24-31. [CrossRef]
19. Kesminas R, Burbulevičiūtė J, Sipavičienė S. Ober's test and modified Ober's test are reliable means of measuring iliotibial band using both goniometer and inclinometer. *Reabilitacijos mokslai*. 2015;2(13). [CrossRef]
20. Wakefield CB, Halls A, Difilippo N, Cottrell GT. Reliability of goniometric and trigonometric techniques for measuring hip-extension range of motion using the modified Thomas test. *J Athl Train*. 2015;50(5):460-466. [CrossRef]
21. Medeiros DM, Cini A, Sbruzzi G, Lima CS. Influence of static stretching on hamstring flexibility in healthy young adults: systematic review and meta-analysis. *Physiother Theor Pract*. 2016;32(6):438-445. [CrossRef]
22. Ayala F, de Baranda PS, De Ste Croix M, Santonja F. Comparison of active stretching technique in males with normal and limited hamstring flexibility. *Phys Ther Sport*. 2013;14(2):98-104. [CrossRef]
23. Ekedahl H, Jönsson B, Frobell RB. Fingertip-to-floor test and straight leg raising test: validity, responsiveness, and predictive value in patients with acute/subacute low back pain. *Arch Phys Med Rehabil*. 2012;93(12):2210-2215. [CrossRef]
24. Czaprowski D, Kędra A, Pawłowska P, Kolwicz-Gańko A, Leszczewska J, Tyrakowski M. The examination of the musculoskeletal system based only on the evaluation of pelvic-hip complex muscle and trunk flexibility may lead to failure to screen children for generalized joint hypermobility. *PLoS One*. 2015;10(3):e0121360. [CrossRef]
25. Armstrong R, Greig DM. The Beighton score as a predictor of Brighton criteria in sport and dance. *Phys Ther Sport*. 2018;32:145-154. [CrossRef]
26. Telli H, Hüner B, Kuru Ö. Determination of the prevalence from clinical diagnosis of sacroiliac joint dysfunction in patients with lumbar disc hernia and an evaluation of the effect of this combination on pain and quality of life. *Spine*. 2020;45(8):549-554. [CrossRef]
27. Madani SP, Dadian M, Firouznia K, Alalawi S. Sacroiliac joint dysfunction in patients with herniated lumbar disc: a cross-sectional study. *J Back Musculoskelet Rehabil*. 2013;26(3):273-278. [CrossRef]
28. Saunders J, Hungerford B, Wisbey-Roth T, Cusi M, Van der Wall H. Recurrent hamstring injuries in elite athletes: a paradigm shift to mechanical dysfunction of the sacroiliac joint as one causation. *Int J Hum Mov Sports Sci*. 2019;7(2):33-42. [CrossRef]
29. Fox M. Effect on hamstring flexibility of hamstring stretching compared to hamstring stretching and sacroiliac joint manipulation. *Clin Chiropr*. 2006;9(1):21-32. [CrossRef]

30. Soisson O, Lube J, Germano A, et al. Pelvic belt effects on pelvic morphometry, muscle activity and body balance in patients with sacroiliac joint dysfunction. *PLoS One*. 2015;10(3):e0116739. [CrossRef]
31. Staude VA, Radzishevska YB, Dupliy DR. EMG activity of stabilizing muscles in sacroiliac joint in patients with sacroiliac dysfunction. *Trauma*. 2018;19(4):29-40. [CrossRef]
32. Ayanniyi O, Raji FS, Adegoke BO. Prevalence of asymptomatic sacroiliac joint dysfunction and its association with leg length discrepancies in male students in selected junior secondary schools in Ibadan. *Afr J Med Med Sci*. 2008;37(1):37-42.
33. Boudreau PA, Steiman I, Mior S. Clinical management of benign joint hypermobility syndrome: a case series. *J Can Chiropr Assoc*. 2020;64(1):43-54.