# Study of the Sagittal Anatomy of the Pelvis in Workers With Sacroiliac Pain

**Guillermo A. Ricciardi, Ignacio G. Garfinkel, Gabriel G. Carrioli, Daniel O. Ricciardi**
*Spine Team, Centro Médico Integral Fitz Roy, Autonomous City of Buenos Aires, Argentina*

**ABSTRACT**
**Introduction:** the sacroiliac joint causes pain in 10 to 25% of patients with mechanical low back pain or symptoms radiating to the lower limbs. In the absence of trauma, metabolic disease, and collagen disease, its role in the pathophysiology of low back pain is not yet fully understood. The objective is to study the sagittal pelvic anatomy through the measurement of pelvic incidence (PI) in patients with sacroiliac pain in the workplace compared to asymptomatic patients. **Materials and Methods:** a retrospective observational analytical study of adult patients with sacroiliac pain diagnosed with CT-guided block in an occupational pathology center during January 2015 and December 2018. The comparison group was a random sample of patients without pelvic or lumbosacral pathology studied with CT of the pelvis and spine during the same period. **Results:** the mean PI in patients with sacroiliac pain was 52.57 (SD 9) and 46.52 (SD 9) in the group of healthy patients. The difference was statistically significant with the higher PI values in patients with sacroiliac pain (p 0.042). **Conclusion:** patients with sacroiliac pain had a higher pelvic incidence than healthy patients, with a statistically significant difference in our study.
**Key words:** Pelvic incidence; sacroiliac pain; sagittal anatomy.
**Level of Evidence:** IV

**Estudio de la anatomía sagital de la pelvis de pacientes con dolor sacroilíaco en el ámbito laboral**

**RESUMEN**
**Introducción:** La articulación sacroilíaca es el origen del dolor en el 10-25% de los pacientes con lumbalgia mecánica. Si no hay traumatismos, tumores, enfermedades metabólicas ni colagenopatías, su papel en la fisiopatología del dolor lumbar aún no está completamente dilucidado. El objetivo fue estudiar la anatomía sagital de la pelvis a través de la medición de la incidencia pélvica en pacientes con dolor sacroilíaco en el ámbito laboral frente a personas asintomáticas. **Materiales y Métodos:** Estudio analítico, observacional, retrospectivo de pacientes con dolor sacroilíaco diagnosticados mediante un bloqueo guiado por tomografía computarizada en un centro de patología laboral, entre enero de 2015 y diciembre de 2018. El grupo de comparación fue una muestra aleatoria de personas sin enfermedad de la pelvis o lumbosacra estudiados con tomografía computarizada de pelvis y columna durante el mismo período. **Resultados:** La incidencia pélvica media en pacientes con dolor sacroilíaco fue 52,57 (DE 9) y 46,52 (DE 9) en el grupo de personas sanas. La diferencia fue estadísticamente significativa con valores mayores de incidencia pélvica en pacientes con dolor sacroilíaco (p 0,042). **Conclusión:** Los pacientes con dolor sacroilíaco presentaron una mayor incidencia pélvica que las personas sanas, con una diferencia estadísticamente significativa en nuestro estudio.
**Palabras clave:** Incidencia pélvica; síndrome de dolor sacroilíaco; anatomía sagital.
**Nivel de Evidencia:** IV

## INTRODUCTION

The sacroiliac joint (SIJ) is the origin of pain in 10-25% of patients with mechanical low back pain or symptoms radiating to the lower limbs.[1] Its role in the pathophysiology of low back pain is not yet fully elucidated when there are no trauma, tumors, metabolic diseases, or collagen diseases.[2]

Received on May 22nd, 2020. Accepted after evaluation on October 29th, 2020 • Dr. GUILLERMO A. RICCIARDI • guillermoricciardi@gmail.com https://orcid.org/0000-0002-6959-9301
**How to cite this article:** Ricciardi GA, Garfinkel IG, Carrioli GG, Ricciardi DO. Study of the Sagittal Anatomy of the Pelvis in Workers With Sacroiliac Pain. *Rev Asoc Argent Ortop Traumatol* 2021;86(6):747-754. https://doi.org/10.15417/issn.1852-7434.2021.86.6.1127

The SIJ has limited mobility, perhaps because only two-thirds of it has synovial characteristics. The rest has fibrocartilage and an intricate set of ligament connections that provide intrinsic stability. The rudimentary posterior capsule is reinforced by strong extrinsic ligaments. It is reasonable then that its main function is to provide stability and allow load transmission from the trunk to the lower limbs.[3]

Pelvic incidence (PI), the angle described by Duval-Beaupère, determines the position of the upper endplate of S1 and its relationship with the center of rotation of both hips.[4] It is unique and individual and provides information on the sagittal anatomy of the pelvis. It is variable during growth and stable in skeletal maturity. The invariance of this angle in the adult is subject to the stability of the sacroiliac junction.[4,5] The average PI is 55° ± 10° with a wide normal range (35° to 85°).[6]

Patients with very low PI have a short anteroposterior pelvic axis configuring a "vertical pelvis", the femoral heads are located below the upper endplate of S1. In contrast, very high PIs with a long anteroposterior axis configure a horizontal pelvis, with femoral heads positioned anterior to the upper endplate of S1.[7]

Patients with a low PI have a lower reserve of pelvic retroversion as opposed to those with a very high PI. Pelvic retroversion, a key compensatory mechanism in the adaptation to the standing posture of the human being, depends on the mobility of the hips and the muscular action of the glutes and extensor muscles of the spine. These allow extending the hips and horizontalizing the upper endplate of the sacrum, and they intervene in sacroiliac mobility together with the pyramidalis and biceps femoris.[3-9]

We posed the following research question: are there differences in the sagittal anatomy of the pelvis, as measured by PI, between patients with sacroiliac pain and asymptomatic people?

The objective was to study PI in patients with sacroiliac pain in the workplace, comparing them with asymptomatic people. The secondary objective was to study the value of PI in symptomatic patients, according to treatment time until the resolution of symptoms (<4 weeks or >4 weeks).

## MATERIALS AND METHODS

We carried out a retrospective, analytical, observational study of adult patients with sacroiliac pain diagnosed with computed tomography(CT)-guided sacroiliac block in an occupational pathology referral center, between January 2015 and December 2018. A random sample of people without pelvic or lumbosacral disease evaluated in our center by CT of the pelvis and spine during the same period was used as a comparison group.

The inclusion criteria were patients evaluated with CT of the lumbosacral spine and pelvis, with a scout view lateral scan that allowed visualization of the lumbosacral region and both hips. The exclusion criteria were: 1) disease of the pelvis and both hips, 2) sacroiliac syndrome secondary to lumbosacral fusion, vertebral deformity, collagen diseases, tumors, infections, and use of thoracolumbar orthosis, 3) radiographic image of advanced sacroiliitis (grades 3 and 4 of the modified New York classification), 4) recent high-energy pelvic trauma (<1 year), 5) multiple previous workplace accidents (2 or more different accidents in one year), 6) incomplete medical records or studies that were technically inadequate for measurement.

The patients treated with CT-guided sacroiliac block were grouped considering only those with a positive response. A "positive response" was defined as a >75% reduction in the pre-block pain score according to the visual analog scale after the intervention for more than two hours.[10]

All patients with sacroiliac pain in our center underwent the same diagnostic and therapeutic scheme in collaboration with the kinesiology team. In the event of a first episode of positive sacroiliac symptoms (painful palpation, positive pain-provoking maneuvers), conservative treatment was indicated:

1. Acute phase (1-3 days): rest, nonsteroidal analgesics.
2. Recovery phase (3 days to 8 weeks): joint mobilization, physical therapy.
3. Maintenance phase: changes in postural dynamics.

Patients with persistent symptoms after 10 sessions underwent a CT-guided sacroiliac block for diagnostic and therapeutic purposes.

## Procedure technique

The patient is in the prone position; landmarks of superficial anatomy, midline, and iliac crest are marked. The skin is infiltrated locally with 1% lidocaine, a 22G spinal needle is entered into the sacroiliac joint, corroborating with tomographic sections as shown in Figure 1. 1 ml of 0.5% bupivacaine (40 mg), 2 ml of lidocaine, and 3 ml of triamcinolone are infiltrated.

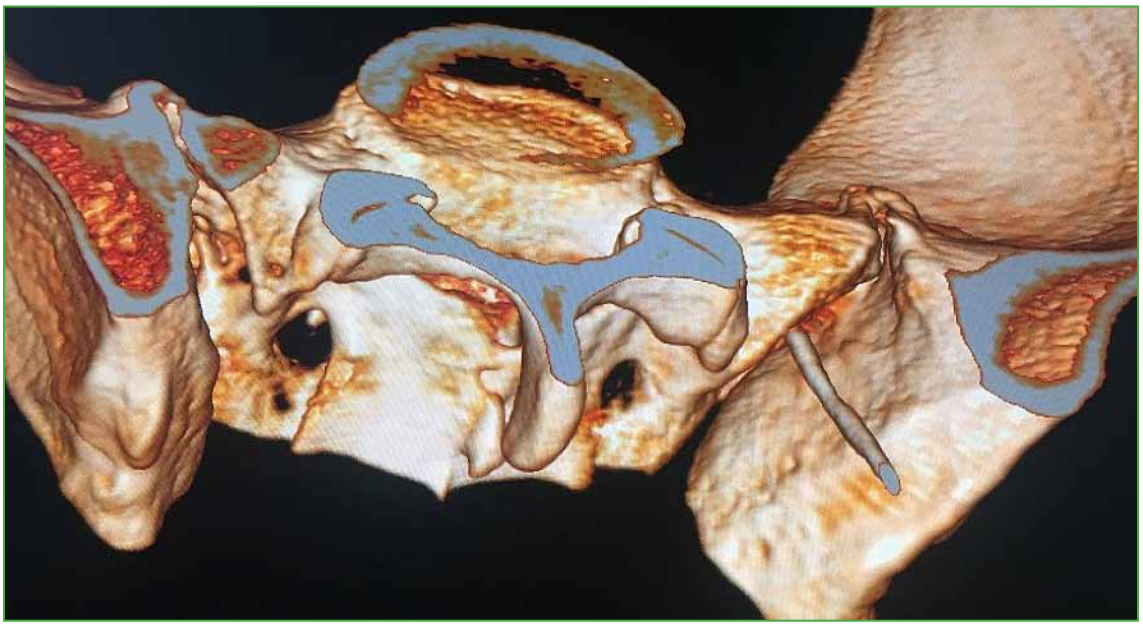

**Figure 1.** Multiplanar computed tomography reconstruction image.

## Study variables

The following variables were recorded from the file of medical records and images:

*Demographic variables:* age and sex.

*Radiographic variables:*

- PI (angle between the center of rotation of both hips and the perpendicular to the center of the upper sacral endplate) (Figure 2).[5]

- Radiographic classification of sacroiliac pathology according to the modified New York criteria: grade 0 = normal, grade 1 = image suggestive of sacroiliac inflammation, grade 2 = sclerosis or localized degenerative changes, without joint space compromise, grade 3 = advanced compromise, sclerosis, geodes, reduced joint space, bony bridges, grade 4 = sacroiliac ankylosis.[11]

*Clinical variables:*

- Traumatic history: trauma (direct or indirect), cyclical efforts (by repetition).

- Days of treatment after CT-guided sacroiliac block: this numerical variable was configured as a nominal variable for analysis in two groups according to the presence or absence of symptoms (persistent or recurrent) 30 days after the block.

Through the SPSS Statics 25 program, a random sample of patients was selected from the total number of patients. These patients were studied with lumbopelvic CT, which showed that no disease of the pelvis or lumbosacral spine was observed in these patients during the study period, which corroborated the previous hypothesis that there were no statistically significant differences with respect to age and sex.

In addition, patients with sacroiliac pain were divided into two groups according to the days of treatment after CT-guided sacroiliac block, to compare their PI value and the presence or absence of symptoms (persistent or recurrent) 30 days after the block.

Radiographic measurements were performed with the Surgimap for Windows Version 2.3.0 program.[12]


**Figure 2.** Radiographic measurement of pelvic incidence.

## Statistical analysis

The categorical variables were expressed in number and percent relative frequency, and were analyzed with the chi-square or Fisher tests. The interval variables were described with the average and its measure of dispersion (standard deviation, SD). For the comparison of continuous variables, Student's t-test or Wilcoxon's rank-sum test were used, according to the expressed distribution. A p-value $<0.05$ was considered statistically significant. The SPSS Statics 25 program was used for the analysis.

## RESULTS

Between January 2015 and December 2018, 830 CT scans of the lumbopelvic region were performed. Sixty-six patients had a CT as a guide for sacroiliac analgesic blocks; of this last group, 45 were excluded due to lumbosacral fusion (5 cases), use of a thoracolumbar orthosis (4 cases), previous pelvic fracture (10 cases), sacroiliac osteosynthesis (10 cases), incomplete studies (5 cases), repeated blocks (6 cases), and negative response (5 cases). Thus, a group of 21 patients was formed.

Of 764 people with lumbar spine and pelvic CT without disease in any of those regions, 20 were excluded because they did not have a lateral scan, and 30 because the hips were not completely visualized in the image.

Finally, from this population, an exact random sample of 21 patients was selected as a comparison group.

There were no statistically significant differences regarding age (p 0.330) and sex (p 1000) between both groups. The average PI in patients with sacroiliac pain was 52.57 (SD 9) and 46.52 (SD 9) in the other group. The difference was statistically significant with higher PI values in patients with sacroiliac pain (p 0.042). The results are summarized in Table 1. No significant differences were obtained according to age, sex, trauma history, and radiographic classification of the SIJ between patients with symptoms that lasted ≤30 days post-block and those with symptoms that persisted beyond 30 days (Table 2).

Table 3 shows the individual data (age, sex, and PI value) of the patients with sacroiliac pain and those of the comparison group included in the analysis.

**Table 1.** Variables according to the diagnosis

| | Patients with sacroiliac pain (n = 21) | Healthy people (n = 21) | p |
|---|---|---|---|
| Age, average (SD)<br>CI95% | 34 (8)<br>30-38 | 37 (10)<br>32-42 | 0.330 |
| Sex, n (%)<br>Male<br>Female | <br>13 (61.9)<br>8 (38.1) | <br>14 (66.7)<br>7 (33.3) | 1.000 |
| Pelvic incidence, average (SD)<br>CI95% | 52.57 (9)<br>48-56 | 46.52 (9)<br>42-51 | **0.042** |

SD = Standard Deviation

**Table 2.** Variables depending on the duration of symptoms.

| | ≤30 days (n = 9) | >30 days (n = 12) | p |
|---|---|---|---|
| Age, average (SD)<br>CI95% | 31(9)<br>25-38 | 36 (8)<br>31-40 | 0.229 |
| Sexo, n (%)<br>Male<br>Female | <br>7 (78)<br>2 (22) | <br>6 (50)<br>6 (50) | 0.367 |
| Pelvic incidence, average (SD)<br>CI95% | 53 (9)<br>45-59 | 53 (9)<br>47-58 | 0.956 |
| New York Classification, n (%)<br>Grade 0-1<br>Grade 2 | <br>7 (78)<br>2 (22) | <br>8 (67)<br>4 (33) | 0.659 |
| Trauma, n (%)<br>Trauma (direct or indirect)<br>Cyclical efforts | <br>7 (78)<br>2 (22) | <br>10 (83)<br>2 (17) | 1.000 |

SD = Standard Deviation

**Table 3.** Individual data of patients with sacroiliac pain and asymptomatic.

| n | Group | Age | Sex | Pelvic incidence |
|---|---|---|---|---|
| 1 | Sacroiliac pain | 24 | M | 38 |
| 2 | Sacroiliac pain | 37 | M | 42 |
| 3 | Sacroiliac pain | 29 | F | 44 |
| 4 | Sacroiliac pain | 42 | M | 44 |
| 5 | Sacroiliac pain | 19 | M | 45 |
| 6 | Sacroiliac pain | 44 | M | 46 |
| 7 | Sacroiliac pain | 48 | M | 47 |
| 8 | Sacroiliac pain | 39 | M | 47 |
| 9 | Sacroiliac pain | 23 | F | 47 |
| 10 | Sacroiliac pain | 29 | F | 49 |
| 11 | Sacroiliac pain | 28 | F | 51 |
| 12 | Sacroiliac pain | 31 | M | 51 |
| 13 | Sacroiliac pain | 32 | M | 54 |
| 14 | Sacroiliac pain | 34 | F | 58 |
| 15 | Sacroiliac pain | 48 | M | 58 |
| 16 | Sacroiliac pain | 38 | F | 58 |
| 17 | Sacroiliac pain | 25 | M | 61 |
| 18 | Sacroiliac pain | 32 | M | 61 |
| 19 | Sacroiliac pain | 37 | M | 65 |
| 20 | Sacroiliac pain | 44 | F | 65 |
| 21 | Sacroiliac pain | 33 | F | 73 |
| 22 | Asymptomatic | 44 | M | 28 |
| 23 | Asymptomatic | 29 | M | 29 |
| 24 | Asymptomatic | 26 | F | 29 |
| 25 | Asymptomatic | 39 | M | 39 |
| 26 | Asymptomatic | 36 | F | 40 |
| 27 | Asymptomatic | 31 | F | 42 |
| 28 | Asymptomatic | 23 | F | 43 |
| 29 | Asymptomatic | 32 | F | 43 |
| 30 | Asymptomatic | 47 | M | 46 |
| 31 | Asymptomatic | 59 | M | 48 |
| 32 | Asymptomatic | 49 | M | 48 |
| 33 | Asymptomatic | 43 | M | 48 |
| 34 | Asymptomatic | 30 | M | 49 |
| 35 | Asymptomatic | 47 | M | 52 |
| 36 | Asymptomatic | 56 | M | 53 |
| 37 | Asymptomatic | 40 | F | 55 |
| 38 | Asymptomatic | 45 | M | 55 |
| 39 | Asymptomatic | 23 | M | 56 |
| 40 | Asymptomatic | 26 | M | 57 |
| 41 | Asymptomatic | 30 | M | 57 |
| 42 | Asymptomatic | 23 | F | 60 |

M = male, F = female.

## DISCUSSION

The sacroiliac joint is a common cause of lumbosacral pain, especially in patients with repetitive and asymmetric load activities.[13] Definitive diagnosis requires a careful approach to differentiate it from other painful topographies, such as the lumbar spine and hip, pain radiating to the gluteal region, and, especially, conditions that can compromise the SIJ, such as ankylosing spondylitis, inflammatory bowel disease, psoriatic arthritis, infections, tumors, metabolic disorders, degenerative disease, iatrogenic conditions, and collagen diseases.[3,14]

Several factors have been attributed to its etiology, such as degenerative disease, joint laxity, and trauma. Nagamoto et al. evaluated sacroiliac joint mobility in patients with degenerative lumbar disease and observed that joint movement in this group was significantly greater than in healthy volunteers.[15] This could be related to the susceptibility of these patients to the development of sacroiliac pain.[16] In our study, we decided to control these variables excluding those patients with previous lumbosacral disease, fusion, and orthosis.

In a study of joint kinematics in patients with sacroiliac pain and healthy controls, Adhia et al. observed variations in joint biomechanics.[17]

In recent decades, multiple authors have demonstrated the value of studying the sagittal anatomy of the pelvis and spine.[4-9] PI and spinopelvic parameters have been evaluated in multiple spinal diseases, such as spondylolisthesis and vertebral deformities. Likewise, the importance of its evaluation in the planning of surgeries for hip joint replacement and femoroacetabular impingement has been determined. Cho et al. studied the sagittal sacropelvic morphology and the spinopelvic balance in patients with sacroiliac pain during the postoperative period of lumbar fusion surgeries. They found no differences in the measurement of PI between patients with sacroiliac pain and asymptomatic patients. However, they obtained statistically significant differences in the increase in pelvic retroversion in the postoperative period of patients with sacroiliac symptoms.[18] In our study, we did not measure spinopelvic parameters that estimate the degree of pelvic retroversion, such as pelvic tilt or sacral slope, because these are measurements taken on dorsal decubitus CT.

Our study posed a concern not yet exposed in the current literature when studying the sagittal morphology of the sacropelvic region of patients with sacroiliac pain. We did not obtain differences between the average PI of our population and the values proposed in the literature.[5,6] However, the significantly higher PI value in patients with sacroiliac pain compared to asymptomatic patients (p .046) raises the future need to deepen the study of the spinopelvic parameters of these patients.

The weaknesses of our study are associated with its retrospective nature and the small number of patients. To the detriment of the statistical power of the study, we decided to control for variables that could operate as confounding factors, excluding patients with previous diseases of the pelvis and spine, multiple occupational accidents, and high-energy pelvic trauma.

We consider it relevant to carry out studies with a higher level of evidence that allow us to estimate the relationship between PI and the risk of sacroiliac pain.

## CONCLUSION

Patients with sacroiliac pain had a higher PI than healthy people, with a statistically significant difference in our study. We did not obtain differences based on the duration of the symptoms. We consider our contribution to the sagittal anatomy of the pelvis in patients with sacroiliac pain is interesting because it provides information that is unprecedented in the literature and provides considerations for the development of new hypotheses in the genesis of sacroiliac pain.

Conflict of interest: The authors have no conflicts of interest to declare.

I. G. Garfinkel ORCID ID: https://orcid.org/0000-0001-9557-0740
G. G. Carrioli ORCID ID: https://orcid.org/0000-0003-4160-9712
D. O. Ricciardi ORCID ID: https://orcid.org/0000-0002-1396-9115

## REFERENCES


1. Cohen SP. Sacroiliac joint pain: a comprehensive review of anatomy, diagnosis, and treatment. *Anesth Analg* 2005;101(5):1440-53. https://doi.org/10.1213/01.ANE.0000180831.60169.EA
2. Schmidt GL, Bhandutia AK, Altman DT. Management of sacroiliac joint pain. *J Am Acad Orthop Surg* 2018;26(17):610-6. https://doi.org/10.5435/JAAOS-D-15-00063
3. Thawrani DP, Agabegi SS, Asghar F. Diagnosing sacroiliac joint pain. *J Am Acad Orthop Surg* 2019;27(3):85-93. https://doi.org/10.5435/JAAOS-D-17-00132
4. Duval-Beaupère G, Schmidt C, Cosson P. A barycentremetric study of the sagittal shape of spine and pelvis: the conditions required for an economic standing position. *Ann Biomed Eng* 1992;20(4):451-62. https://doi.org/10.1007/BF02368136
5. Legaye J, Duval-Beaupère G, Hecquet J, Marty C. Pelvic incidence: a fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves. *Eur Spine J* 1998;7(2):99-103. https://doi.org/10.1007/s005860050038
6. Vialle R, Levassor N, Rillardon L, Templier A, Skalli W, Guigui P. Radiographic analysis of the sagittal alignment and balance of the spine in asymptomatic subjects. *J Bone Joint Surg Am* 2005;87(2):260-7. https://doi.org/10.2106/JBJS.D.02043
7. Le Huec JC, Aunoble S, Philippe L, Nicolas P. Pelvic parameters: origin and significance. *Eur Spine J* 2011;20 Suppl 5(Suppl 5):564-71. https://doi.org/10.1007/s00586-011-1940-1
8. Schwab F, Lafage V, Boyce R, Skalli W, Farcy JP. Gravity line analysis in adult volunteers: age-related correlation with spinal parameters, pelvic parameters, and foot position. *Spine (Phila Pa 1976)* 2006;31(25):E959-67. https://doi.org/10.1097/01.brs.0000248126.96737.0f
9. Schwab F, Lafage V, Patel A, Farcy JP. Sagittal plane considerations and the pelvis in the adult patient. *Spine (Phila Pa 1976)* 2009;34(17):1828-33. https://doi.org/10.1097/BRS.0b013e3181a13c08
10. Mitchell B, McPhail T, Vivian D, Verrills P, Barnard A. Diagnostic sacroiliac joint injections: Is a control block necessary? *J Sci Med Sport* 2010;12:e5-e6. https://doi.org/10.1016/j.jsams.2009.10.012
11. Van der Linden S, Valkenburg HA, Cats A. Evaluation of diagnostic criteria for ankylosing spondylitis. A proposal for modification of the New York criteria. *Arthritis Rheum* 1984;27(4):361-8. https://doi.org/10.1002/art.1780270401
12. Lafage R, Ferrero E, Henry JK, Challier V, Diebo B, Liabaud B, et al. Validation of a new computer-assisted tool to measure spino-pelvic parameters. *Spine J* 2015;15(12):2493-502. https://doi.org/10.1016/j.spinee.2015.08.067
13. Peebles R, Jonas CE. Sacroiliac joint dysfunction in the athlete: diagnosis and management. *Curr Sports Med Rep* 2017;16(5):336-42. https://doi.org/10.1249/JSR.0000000000000410
14. Zelle BA, Gruen GS, Brown S, George S. Sacroiliac joint dysfunction: evaluation and management. *Clin J Pain* 2005;21(5):446-55. https://doi.org/10.1097/01.ajp.0000131413.07468.8e
15. Nagamoto Y, Iwasaki M, Sakaura H, Sugiura T, Fujimori T, Matsuo Y, et al. Sacroiliac joint motion in patients with degenerative lumbar spine disorders. *J Neurosurg Spine* 2015;23(2):209-16. https://doi.org/10.3171/2014.12.SPINE14590
16. Yoshihara H. Sacroiliac joint pain after lumbar/lumbosacral fusion: current knowledge. *Eur Spine J* 2012;21(9): 1788-96. https://doi.org/10.1007/s00586-012-2350-8
17. Adhia DB, Milosavljevic S, Tumilty S, Bussey MD. Innominate movement patterns, rotation trends and range of motion in individuals with low back pain of sacroiliac joint origin. *Man Ther* 2016;21:100-8. https://doi.org/10.1016/j.math.2015.06.004
18. Cho DY, Shin MH, Hur JW, Ryu KS, Park CK. Sagittal sacropelvic morphology and balance in patients with sacroiliac joint pain following lumbar fusion surgery. *J Korean Neurosurg Soc* 2013;54(3):201-6. https://doi.org/10.3340/jkns.2013.54.3.201