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Original Research Article

Is there any coexistence of sacroiliac joints dysfunction with dysfunctions of occipito-atlanto-axial complex? Part II: The biomechanical aspect

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ABSTRACT

Introduction: As the sacroiliac joints (SIJ) join two kinematic chains, the pelvis and the vertebral column, their functional disorders cause secondary changes in the musculoskeletal system. Other reasons concerning a connection between its distant parts are tensegrity principles that govern tension distribution in tendons, muscles, fasciae and ligaments. Our hypothesis was that due to a biomechanical connection between SIJ and cervico-cephalic joints (CCJ), dysfunctions in the SIJ can determine dysfunctions in the CCJ.
Aim: The aim of this study was to assess various types of SIJ dysfunctions (ilio-sacral and sacro-iliac) and their possible coexistence with CCJ dysfunctions.
Materials and methods: The study group comprised 80 patients with low back pain, 40 of whom were diagnosed with SIJ dysfunctions. The examination of the suboccipital region by Kaltenborn and Evjenth was conducted by a researcher who was unaware of the results of the pelvis examination. StatGraphics Centurion XV was employed for data analysis.
Results and discussion: CCJ dysfunctions were detected in almost all subjects. There was a statistically significant difference in mobility and in gliding of the C_0–C_1 segment between both groups. The restricted mobility on the left side of the C_0–C_1 segment was statistically significant. The detected abnormal stability on the right side of the C_1 motion segment in the study group did not correlate with the side of the SIJ dysfunction.
Conclusions: There was no dominant dysfunction of the SIJ. The prevalence of dysfunctions of the upper cervical motion segments was high in the study group. There was a tendency towards larger numbers of dysfunctions concerning the right CCJ than the left one observed in patients with SIJ dysfunctions.

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1. Introduction

As the sacroiliac joints (SIJ) join two kinematic chains, the pelvis and the vertebral column, their functional disorders cause secondary changes in the musculoskeletal system. Other reasons for a connection between its distant parts are tensegrity principles that govern tension distribution in tendons, muscles, fasciae and ligaments.[1,4,5,21,22,23,24]

The connection between SIJ and the cervico-cephalic joints (CCJ) of the vertebral column is often discussed because of their function as the opposite last links in the biomechanical chain of the vertebral joints.

Although it is obvious that compensatory mechanisms in the musculoskeletal system exist, in particular in the vertebral column and pelvis, their function and biomechanical basis are still underestimated and provoke more questions than answers. As the main biomechanical function of the vertebral column is to form a vertical axis for the human body and to enable the head and extremities to work properly in space both in dynamic and static vertical positions, knowledge concerning the range of its dysfunction is of vital importance for planning further treatment.

2. Aim

The aim of this study was to assess the prevalence of sacroiliac dysfunctions and iliosacral dysfunctions in patients with SIJ malfunctions. Moreover, it aimed at investigating whether there is any coexistence of SIJ dysfunctions and the dysfunction of upper cervical motion segments. The assumed hypothesis was that due to a biomechanical connection between them, dysfunction in the SIJ can determine dysfunction in the CCJ.

3. Materials and methods

3.1. *Patients*

This study was carried out with 80 patients admitted to the Department of Medical Rehabilitation at the Medical University of Łódź due to low back pain.

In total, 40 patients met the inclusion criteria for the study group (G1) as they had SIJ dysfunctions diagnosed during the initial examination. The other 40 patients served as the control group (G2) since their SIJ functioned properly. The demographic description of all these patients is shown in Table 1.

Table 1 – Demographic description of the study group (G1) and the control group (G2).

Demographic parameters	G1	G2
Total	40	40
Female	28	23
Male	12	17
Mean age (years)	35.8±9.7	38.7±11.2

3.2. *Examination*

All patients completed an examination chart comprised of questions concerning personal data, age, job and its characterization, physical activity, medical diagnosis and current complaints (i.a., since when had complaints been present and how they had been hitherto treated).

To be included in this study group, patients had to meet the criteria for the SIJ dysfunction by Greenman.[7,8,13] These are a positive Piedellu test in a sitting and/or standing position, asymmetry in the topographical anatomy of the pelvis (sacrum, ilia), irritation of the sacrotuberous ligament and/or iliolumbar ligament, and posterior sacroiliac ligament.

An examination of the occipito-atlanto-axial region was carried out for each patient by a researcher who was not aware of the results of the lumbar-pelvic-iliac region examination. It consisted of testing of global mobility in the C_0–C_1 and C_1–C_2 segments with a goniometer, palpation of gliding in the C_0–C_1 and C_1–C_2 segments by Kaltenborn,[10] testing of indicatory muscles for the C_1 and C_2 segments, and testing the ligaments of CCJ by Kaltenborn.[10]

A lack of motion meant jamming in a joint; a very restricted motion meant the range of motion reduced by 5–10°; a lightly restricted motion meant the range of motion reduced by 0–5°; and hypermobility meant the range of motion more than the normal one by 5° or more.

In the sagittal plane, patients flexed and extended their heads to test the rectus capitis posterior major and the rectus capitis posterior minor as indicatory muscles for the C_1 segment. Muscle strength was estimated by the researcher in a subjective manner. In the horizontal plane, patients rotated their heads to the right and to the left to test the obliquus capitis superior and the obliquus capitis inferior as indicatory muscles for the C_2 segment. Muscle strength was assessed by a comparison between left and right head rotations.

3.3. *Statistical analysis*

StatGraphics Centurion XV was used for data analysis. Statistical significance was accepted at an $\alpha \leq 0.05$.

Parametric and nonparametric statistical tests were employed depending on the distribution of the data.

The fraction test was employed to determine the distribution of SIJ dysfunctions. The tests of proportions were used to compare the levels of the CCJ dysfunction in correlation with the SIJ function. The correlations between the SIJ dysfunction and the upper cervical motion segments, as well as between the sides of dysfunction, were estimated employing the arccosine test. The χ^2 test was used to analyze gliding motions in the CCJ and muscles strength. Fisher's exact test was used to correlate the parameters of cervical segments stability and Yule's coefficient to correlate the side of the SIJ dysfunction with the side of dysfunction in the upper cervical motion segments.

4. Results

4.1. *The distribution of SIJ dysfunctions*

There was no difference in the presence of sacroiliac (21 patients) and iliosacral (19 patients) dysfunctions in the study group (Tables 2 and 3). There was also no difference between the side of the dysfunction – right side (21 patients), left side (19 patients).

Dysfunctions of the upper cervical motion segments were detected in all patients with SIJ dysfunctions. In the G2 group dysfunctions of the C_0–C_1 and C_1–C_2 segments were detected in 32 (out of 40) and 38 (out of 40) patients, respectively. Statistical analysis demonstrated differences in the mobility of the C_0–C_1 segment ($p=0.0038$) and no difference in the mobility of the C_1–C_2 segment between both groups. Types of the C_0–C_1 segment dysfunctions are presented in Table 4.

Moreover, the number of patients with restricted mobility on the left side of the C_0–C_1 segment was significant in the study group (Table 5). There was no correlation between the side of dysfunction in the SIJ and the side of restricted mobility in the CCJ.

Table 2 – Subgroups of the sacroiliac dysfunctions of SIJ.

Dysfunction	Number of patients
Anterior torsion to the left	12
Anterior torsion to the right	4
Posterior torsion to the left	1
Posterior torsion to the right	3
Unilaterally flexed to the left – inferior shear	1
Unilaterally flexed to the right – inferior shear	0
Unilaterally extended to the left – superior shear	0
Unilaterally extended to the right – superior shear	0
Bilaterally flexed	0
Bilaterally extended	0
Total	21

Table 3 – Subgroups of the iliosacral dysfunctions of SIJ.

Dysfunction	Number of patients
Anteriorly rotated	12
Posteriorly rotated	6
Upslip–superior shear	1
Downslip–inferior shear	0
Outflare	0
Inflare	0
Total	19

Table 4 – Types of the C_0–C_1 segment dysfunctions in the study group (G1) and in the control group (G2).

Type of dysfunction	G1		G2	
	Left side	Right side	Left side	Right side
Lack of mobility	3	1	1	0
Severely restricted mobility	5	3	4	2
Slightly restricted mobility	14	14	10	15
Hypermobility	0	0	0	0

Gliding dysfunction in the C_0–C_1 segment was significant between the groups ($p=0.0038$), but there was no statistical difference concerning gliding in the C_1–C_2 segment. Although the occurrence of gliding dysfunction was similar to the dysfunctional segmental mobility, the differences in gliding mobility were significant between the left and the right sides in the G2 group and on the right side between the study group and the control group. Moreover, dysfunctional gliding on the left in the C_1–C_2 segment correlated with a dysfunction of the right SIJ ($p=0.0489$, $\phi=-0.58$). Detailed results are presented in Tables 6 and 7.

4.2. *Muscle function in the upper cervical segments*

There was no difference concerning strength of the indicatory muscles for the tested upper cervical segments between the study group and the control group.

4.3. *CCJ stability*

There were no differences in stability concerning the C_0–C_1 and C_1–C_2 motion segments in both groups.

Table 5 – Mobility on each side in the C_0–C_1 segment in the study group (G1) and in the control group (G2).

	G1 left side	G1 right side	G2 left side	G2 right side
G1 left side	–	0.0402*	0.4832	–
G1 right side	0.0402*	–	–	0.4236
G2 left side	0.4832	–	–	0.3731
G2 right side	–	0.4236	0.3731	–

Comments: * Significant values.

Table 6 – Gliding dysfunction in the C_0–C_1 segment in the study group (G1) and in the control group (G2).

Gliding in C_0–C_1	G1		G2	
	Left side	Right side	Left side	Right side
Normal	0	0	0	8
Abnormal	40	40	40	32

Table 7 – Gliding on each side in the C_0–C_1 segment in the study group (G1) and in the control group (G2).

	G1 left side	G1 right side	G2 left side	G2 right side
G1 left side	–	1	1	–
G1 right side	1	–	–	0.0392*
G2 left side	1	–	–	0.0392*
G2 right side	–	0.0392[a]	0.0392[a]	–

Comments: * Significant values.

Table 8 – Stability of the C_1 segment in the study group (G1) and in the control group (G2).

Stability	G1		G2	
	Left side	Right side	Left side	Right side
Abnormal	2	16	9	10
Normal	22		21	

The only finding of statistical significance is the prevalence of abnormal stability on the right side of the C_1–C_2 motion segment in the study group ($p = 0.003$). However, the side of SIJ dysfunction did not correlate with the side of abnormal cervical segments stability. Detailed results of the C_1–C_2 motion segment stability are shown in Table 8.

5. Discussion

In our opinion, the prevalence of dysfunctions in the cervicocephalic region in patients both with and without SIJ dysfunctions can be caused by other mechanisms than those described by many authors.[7,8,13,19,20,22,24] If the pelvis were the primary source of CCJ malfunctioning, or even joints in extremities, on the one hand their occurrence would be typical of those with SIJ dysfunctions and, on the other hand, manual therapy applied to the pelvic joints would be highly beneficial for the recuperation of the dysfunctional joints of the vertebral column. There are no further possibilities of compensation of CCJ dysfunctions as these joints are the last link in the kinematic chain of the vertebral column.

As the pelvis is a closed kinematic chain, any alteration (dysfunctional or therapeutic) in this region influences its three-dimensional position.[3,6,15,16,17,18] Therefore, the rotational dysfunction of the pelvis is described as occurring most often[13] and this was also confirmed by our study. Rotational forces that appear in the pelvic region force rotational adjustments of the adjacent and distant elements of the musculoskeletal system (secondary dislocations). These mechanisms were examined by Ackermann[1] and Ackermann et al.[6,14,15,16,17,18]

Vleeming et al.[22] and Claus et al.[3] raise the issue of the thoracolumbar fascia and back musculature in transmitting tension and load between the pelvis and other elements of the musculoskeletal system. The role of the thoracolumbar fascia is underlined as it is involved in stabilizing the pelvic ring and there, on the fascia, the latissimus dorsi, the erector spinae and the multifidus have their origins. These connections are of the utmost importance in maintaining the balance between a dynamic stabilization and mobility of the lumbar part of the vertebral column.[12,21,23] Vleeming et al.[23] describe the contribution of the thoracolumbar fascia to coordinated movements of upper extremities, back and lower extremities by a transmission of muscular tension in the so-called deep longitudinal kinematic system which is raised by walking tension of the thoracolumbar fascia due to the sacral nutation by the tension of the sacrotuberous ligament, that is an element of the aforementioned kinematic system. The higher the tension of the fascia, the more compressed the SIJ becomes.[7,12] Such a role of the thoracolumbar fascia with respect to so minute movements of the vertebral column justifies an assumption that even subtle biomechanical changes in the SIJ can be transmitted to the suboccipital region according to the principles of tensegrity. A good example of tensegrity is muscular imbalance between the right and left sides of the latissimus dorsi that promotes a skewed position of the head.

Furthermore, Hack et al.[9] point to a functional cohesion between the rectus capitis posterior minor and the dura. The dura is fixed to the axis, thus its dislocations caused by the transmitted dysfunction from the SIJ or by an imbalanced tension of the suboccipital muscles and ligaments can interfere with the central nervous system.

Another hypothesis is that the suboccipital region is a key source of dysfunction in the biomechanical chain of the vertebral column. Therefore, a paramount sensorimotor function of the suboccipital muscles and ligaments of the CCJ with their immense number of proprioceptors must be mentioned.[5,11] Consequently, the coexistence of the altered function of the alar ligaments and the dysfunction of the SIJ supports the thesis of the cooperation of the examined regions in sensorimotor head reactions. Dysfunction transmitted by the kinematic chain of the vertebral joints from the SIJ to the CCJ forces an imbalanced tension in the alar ligaments. The connection between the SIJ dysfunction and the alar ligaments and a lack of connection between the SIJ function and the transverse ligament of the atlas seem to confirm a high contribution of the alar ligaments to stabilize the axis.[2] Improper stabilization of the right-sided alar ligaments and the head rotation, restricted concurrently to the right, stand for the functional coactivation of passive and active structures in the suboccipital region. The aforementioned observation can also result from patients' lateralization in their motion habits. Another idea that supports the hypothesis of lateralization of the motion habits is the significant correlation between the right-sided translatory dysfunction in the C_1–C_2 segment with the left-sided dysfunction of the SIJ. This could be also proof of a biomechanical coadaptation of both regions to the horizontal positioning of the head.

Although the connection between the lumbar-pelvic-iliac region and the suboccipital region is undoubted, there is still insufficient knowledge concerning the connection between the type of SIJ and CCJ dysfunctions. In the conducted study there was no prevalent dysfunction in the SIJ. Also, the specific mechanisms of the discussed connections and their direction remain to be discovered.

6. Conclusions

1. Among SIJ dysfunctions there is no dominant one.
2. The prevalence of the dysfunctions of the upper cervical motion segments is high in that population of patients with low back pain.
3. Higher numbers of dysfunctions of the right CCJ than in the left one in patients with SIJ dysfunction were observed.

Conflict of interest

None declared.

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