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Original Research Article

Is there any coexistence of sacroiliac joints dysfunction with dysfunctions of the occipito-atlanto-axial complex? Part I: The sensorimotor function

*Tomasz Adamczewski**, *Adrianna Grabowska*, *Jolanta Kujawa*

Department of Medical Rehabilitation, Medical University of Łódź, The Dr Z. Radliński Provincial Centre of Orthopaedics and Locomotor System Rehabilitation in Łódź, Poland

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ABSTRACT

Introduction: Suboccipital muscles and ligaments of the cervicocephalic joints (CCJ) embody a large number of proprioceptors. There exists a possible correlation between the sacroiliac joints (SIJ) dysfunction with the suboccipital muscles atrophy leading to headaches and body imbalance. This can be caused by the sensorimotor dysfunction of cervical segments due to their functional connections with the SIJ.

Aim: The aim of this study was to investigate the coexistence of SIJ dysfunction and the sensorimotor dysfunction of the CCJ.

Materials and methods: A double-blind test of CCJ and SIJ by Kaltenborn and Evjenth was conducted involving 80 patients experiencing low back pain, 40 of whom were diagnosed with SIJ dysfunction. Functional tests of the cervical spine were performed with Sensoneck. StatGraphics Centurion XV was employed to obtain the statistical analysis of the data.

Results and discussion: There was a tendency towards reduced strength of the C_2 muscles and a statistically significant instability of the C_1 segment in the study group. Exteroceptive sensation was not disturbed. Sensorimotor function of the CCJ differed in the number of errors made by patients with SIJ dysfunction, especially concerning complex head movements. The intragroup analysis indicated that more errors were made by those having the left SIJ dysfunction.

Conclusions: 1. In patients with SIJ dysfunction the tendency towards asymmetrical muscle strength was observed for the C_2 segment. 2. Exteroceptive sensation in the upper cervical dermatomes was not distorted by the influence of SIJ dysfunctions. 3. The sensorimotor function of the upper cervical motor segments was significantly worse for the population of patients with SIJ dysfunction, especially on the left side. 4. Sensoneck is a useful tool for an objective assessment of a manual therapy employed in the dysfunction concerning the occipito-atlanto-axial region.

*Correspondence to: Department of Medical Rehabilitation, Medical University of Łódź, The Dr Z. Radliński Provincial Centre of Orthopaedics and Locomotor System Rehabilitation, Drewnowska 75, 91-002 Łódź, Poland. Tel.: +48 42 253 71 77, +48 42 253 71 42, +48 505 941 857; fax: +48 42 654 01 19.
E-mail address: tomasz-adamczewski@o2.pl (T. Adamczewski).

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1. Introduction

The suboccipital region plays an important role in the sensorimotor function of the human body because the suboccipital muscles and ligaments of the cervicocephalic joints (CCJ) embody a large number of proprioceptors.[11,12,15,18,21,25] Their proper functioning conditions the horizontal positioning of the head. Other reasons for a connection between distant parts of the musculoskeletal system are tensegrity principles that govern tension distribution in tendons, muscles, fasciae and ligaments.[14,23,24,25]

Some scientists suggest that this correlation between functional disorders of the sacroiliac joints (SIJ) and suboccipital muscles atrophy can lead to chronic headaches and body imbalance in a standing position.[3,6,15,19,22] This could be caused by a sensorimotor dysfunction of the CCJ, due to their biomechanical and functional connections with the SIJ.[10,14]

The sensorimotor function of the deep neck structures is another problem of contemporary diagnostic processes in medical rehabilitation and physiotherapy.[7,9,19,20] The most often used methods are subjective.[19]

Although it is obvious that compensatory mechanisms exist in the musculoskeletal system, in particular in the vertebral column and pelvis, their function and biomechanical basis are still underestimated and provoke more questions than answers.[2,10]

2. Aim

The aim of this study is to investigate whether there is any correlation between the SIJ and CCJ sensorimotor dysfunction. Moreover, the study was expected to discover whether the side of SIJ dysfunction determines the side of sensorimotor CCJ dysfunction.

3. Materials and methods

3.1. *Patients*

This study was carried out in the Department of Medical Rehabilitation at the Medical University of Łódź, Poland, involving 80 patients referred to hospital because of low back pain. All subjects signed an informed consent form approved by the University Committee for Bioethics in Medical Research before participating in the study.

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.[4,5] These are as follows: 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, 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 the following elements: testing of indicatory muscles for the C_1 and C_2 segments, testing the ligaments of CCJ by Kaltenborn and Evjenth,[8] assessing exteroceptive sensation and performing a set of functional tasks.

In the sagittal plane, patients flexed and extended their heads to test the rectus capitis posterior major and the rectus capitis posterior minor muscles 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 muscles as indicatory muscles for the C_2 segment. Muscle strength was assessed by a comparison between the left and right head rotations.

Exteroceptive sensation was examined employing palpation and a pin-prick with a disposable needle (25 G) in the C_1 and C_2 dermatomes.

Functional tests were performed with a Sensoneck device (Fig. 1). A patient would sit a definite distance from a board with painted curves, each one representative of the functional movement of the head. Simple movements like extension and flexion, left-side and right-side rotations are described by green curves; whereas the black curves were representative of compound movements: extension to the left, flexion to the right, extension to the right and flexion to the left. These are movements in three-dimensional space, e.g., the extension to the left means the head extension with its left-side rotation and left-side bending. The red figure of eight and the blue oval are to engage all joints of the occipito-atlanto-axial complex, with its muscles in alternate eccentric and concentric contractions during a set of complex movements of the head.[9]

The rectus capitis posterior major and the rectus capitis posterior minor of both sides contract concentrically to extend the head in the CCJ. Although these muscles also participate in flexing the head, their eccentric contractions play only an additional role as stabilizers and inhibitors of the movement. Rotational head movements are more complicated. To make a movement to the right, the right rectus capitis posterior major, the right rectus capitis posterior minor, the right obliquus capitis inferior and the left obliquus

Fig. 1 – Patient examined with Sensoneck.

capitis superior contract concentrically and the left rectus capitis posterior major, the left rectus capitis posterior minor, the left obliquus capitis inferior and the right obliquus capitis superior – eccentrically.

A patient has to follow the curves with a laser pointer placed on the head. The task is to be done as precisely as possible in the shortest possible time. When the patient misses the curve, it is counted as a mistake. Both the mean time for three repetitions for each curve and the average number of errors are measured.

The distance between a patient and the board is established in such a way that it allows for examinations of the movements only in the CCJ.

3.3. *Statistical analysis*

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

Depending on the distribution of the data: normal or different from normal, parametric and nonparametric statistical tests were used.

The χ^2 test was used to analyze muscle strength in the upper cervical motion segments and sensory function in corresponding dermatomes. Results of sensorimotor tests were compared between the study and control groups with Wilcoxon's or Student's *t*-test. The intragroup analysis of sensorimotor tasks results depending on the side of SIJ dysfunction was made using Wilcoxon's test.

4. Results

4.1. *Muscle function in the upper cervical segments*

There was no difference in the strength of indicatory muscles for both tested upper cervical segments between the study group and the control group. The only significant finding was the tendency towards reducing the strength of the right-side muscles of the C_2 segment in the study group.

Table 2 – Stability of the C_1 motion segment in the study group (G1) and the control group (G2).

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

4.2. *Stability of the upper cervical segments*

There were no differences discerned in the stability of the C_0 and C_1 motion segments between both groups.

The only finding of statistical significance is the prevalence of abnormal stability of the right C_1 motion segment in the study group ($p=0.003$). The detailed results of the C_1 motion segment stability examination are presented in Table 2.

4.3. *Sensory findings*

Exteroceptive sensation and pin-prick in the examined areas were of no statistical importance for both groups.

4.4. *Sensorimotor function of the upper cervical motion segments*

Although there was no difference concerning the time of reproducing each functional task between the G1 and G2 groups, the number of errors made by patients with and without the SIJ dysfunction was significant. Patients with the SIJ dysfunctions made more errors, especially concerning

Table 3 – Comparison between the number of errors made by the study group (G1) and the control group (G2) in the functional tasks for the CCJ.

Functional task	Distribution of errors		P-value for comparison G1 and G2
	In G1 group	In G2 group	
Left rotation of the head	NN	NN	0.108
Right rotation of the head	N	NN	0.003*
Head extension	NN	NN	0.046*
Head flexion	NN	NN	0.254
Head extension to the left	N	N	0.013*
Head extension to the right	N	NN	0.049*
Head flexion to the right	N	NN	0.315
Head flexion to the left	N	N	0.222
Figure of eight to the left	N	N	0.009*
Figure of eight to the right	N	N	0.003*
Circle to the left	N	NN	0.0005*
Circle to the right	N	N	0.018*

Comments: N – normal distribution of values, NN – distribution of values different from normal;
* Significant values.

Table 4 – Comparison between the number of errors made by patients with a left or right SIJ dysfunction in the study group (G1) during functional tasks for the CCJ.

Functional task	Median for the left side	Median for the right side	P-value
Left rotation of the head	1.33	1.00	0.028*
Right rotation of the head	2.00	1.66	0.039*
Head extension	1.66	1.33	0.188
Head flexion	1.33	0.66	0.350
Head extension to the left	4.00	3.66	0.362
Head extension to the right	3.33	3.00	0.447
Head flexion to the right	2.66	2.66	0.817
Head flexion to the left	3.00	2.66	0.473
Figure of eight to the left	8.00	6.33	0.033*
Figure of eight to the right	8.66	6.33	0.015*
Circle to the left	8.66	8.00	0.317
Circle to the right	8.33	9.00	0.462

Comments: * Significant values.

complex movements. A detailed analysis is presented in Table 3.

The intragroup analysis of sensorimotor tasks results depending on the side of the SIJ dysfunction indicated that more errors were made by subjects with the left SIJ dysfunction. Rotational movements or their derivatives were the most problematic. These results are presented in Table 4.

5. Discussion

As the number of mistakes made by patients with SIJ dysfunctions was significantly higher, the conducted study demonstrated that sensorimotor control over the head position was altered in this population. This can be due to the remodeled work of the suboccipital muscles in connection with the malfunctioning SIJ.[10,14] Many authors underline the function of muscles and ligaments in proprioception.[10,11,14,15,18,21,25] Most often patients made errors during a complex multidimensional movement. Thus, the most affected muscles are as follows: the right rectus capitis posterior major, the right rectus capitis posterior minor, the right obliquus capitis inferior, and the left obliquus capitis superior. There are no referential values with respect to time intervals for carrying out each functional task as well as no maximal number of errors that can be counted as a non-dysfunctional work of the suboccipital region,[9,21] although Learman et al.,[10] Lephart et al.[11] and Proske[15] indicate that an appropriate constant proprioceptive impulsation is essential for fluency, precision and duration of the movement. They proved that the ligaments of CCJ react in response to a change of the head position four times faster than the muscles. In our study the alar ligaments in the study group functioned improperly, which implies their crucial role in both the stabilization of the C_1 motion segment and sensorimotor function of this region.

Taking into consideration the reduced strength of the right-sided indicatory muscles for the C_2 segment and an abnormal right stabilization of the C_1 motion segment by the alar ligaments in patients with SIJ dysfunction, it seems that there is a correlation between biomechanical and sensorimotor functions for both regions. Also the side of the malfunctioning SIJ is significant for the side of the dysfunction of the occipito-atlanto-axial complex. The possibility that a reduced mobility, e.g., due to a blocked joint or an inflammatory process, of the CCJ causes a diminished sensorimotor control following improper proprioception is widely discussed.[10,14,16,17] Revel et al.[16,17] and Hallgren et al.[6] point out that the atrophy of the suboccipital muscles that leads to chronic headaches follows the long-term dysfunction of the CCJ. There is also a relationship between muscular atrophy in the suboccipital region and an imbalance of the body in the standing position which is explained by the reduced number of proprioceptors.[1,13]

As there are significant changes in the sensorimotor function of the suboccipital region in patients with SIJ dysfunction, it suggests that the SIJ can be the source of impairment. The 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 significance of a disturbed stabilization of the right-sided alar ligaments and the head rotation restricted more often to the right side stand for the functional co-activation of passive and active structures of the suboccipital region. This could be also proof for a biomechanical coadaptation of both regions to the need of a horizontal positioning of the head.

On the other hand, Lephart et al.[12] state that a structural dysfunction, due to an altered tension of muscles or ligaments, affects proprioceptive afferent impulsation.

To sum up, there is evidence not only for a biomechanical but also for a functional connection between the SIJ and the CCJ. Altered functioning of the pelvis can impact on sensorimotor control over the head.

6. Conclusions

1. In patients with SIJ dysfunctions the tendency towards asymmetrical muscle strength was observed in the C_2 segment.
2. Exteroceptive sensation in the upper cervical dermatomes was not disturbed by SIJ dysfunction.
3. The sensorimotor function of the upper cervical motor segments was significantly worse in the population of patients with SIJ dysfunction, especially on the left side.
4. Sensoneck is a useful tool for an objective assessment of manual therapy applied to dysfunctions of the occipito-atlanto-axial region.

Conflict of interest

None declared.

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