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Impairment of static upright posture in subjects with undifferentiated arthritis in sacroiliac joint in conjunction with elevation of streptococcal serology

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Abstract. *Background and objectives:* Our latest work has demonstrated a strong correlation between the anti-streptolysin O (ASO) titer and the sacroiliac (SI) joint scintigraphy in subjects with undifferentiated arthritis [Journal of Rheumatology **34** (2007), 1746–1752]. Of a significant percentage in those subjects with sacroiliac disorder reported suffering from postural abnormality. The purpose of this study was to determine whether there was an abnormality of upright postural sway in those subjects.
Methods: All subjects who have been examined for ASO titer levels and SI joint scintigraphy were divided into two groups according to the reference level of ASO titer in our central laboratory, and were subjected to ten sway tests to assess static postural sway when they were standing upright. The comparisons of the sway parameters were analyzed by using two sample t-test for continuous variables and repeated-measures analysis of variance (ANOVA) for the degree effect and interaction effect (sloped degree $\times$ group) in varying stressful conditions (eyes open vs closed, plantar flexion or dorsiflexion of feet).
Results: In a total of 84 subjects, mean age was 23 years (range 18.0–36.4). Compared with the low ASO (ASO titer $\leqslant$116 IU/mL) group, the two sample t-test showed that high ASO (ASO titer $>$116 IU/mL) group had 2.76-, 4.46- and 4.59-fold in sway area, 1.32-, 1.50- and 1.61-fold in sway velocity, and 2.02-, 1.97- and 1.70-fold in sway intensity, over the study period at 0°, 10°, and 20° in conditions of eyes open and plantar flexion. The values of sway velocity/intensity obtained with eyes open and plantarflexion/dorsiflexion had lower intensity values when compared with those obtained in closed eyes and plantar flexion/dorsiflexion in high ASO group, but not the same as in low ASO group. Repeated-measures ANOVA showed that the sloped degree only affected the sway area in condition of eyes closed and dorsiflexion ($P = 0.016$), and affected the velocity/intensity in all conditions tested (all $P < 0.0001$). In consideration of interaction effect, the sloped degree showed significant difference in sway area in conditions of eyes open and plantar flexion/dorsiflexion ($P = 0.03$ and $P = 0.0113$), in sway velocity in most conditions tested ($P < 0.05$), and in sway intensity in condition of eyes open and dorsiflexion only ($P = 0.0004$).
Conclusion: Subjects with high level of streptococcal serology demonstrated increased sway on all postural control measures as compared to those with low serology. Proprioceptive deficits in the SI joint might contribute to the postural impairment measured in this study.

Keywords: Undifferentiated arthritis, anti-streptolysin O, sacroiliac joint, posture, sway

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1. Introduction

A condition of arthritis that cannot be classified as having a well-defined arthropathy using current classification criteria are labeled as "undifferentiated arthritis" (UA) or "unclassified arthritis," which term manifests the heterogeneity of those arthritides [18,46]. A previous clinical survey in UA has demonstrated a mean age of 41 $\pm$ 15 years in affected population, as well as varying ratios of joint involvement, with 14% for monarthritis, 18% for polyarthritis, and 68% for oligoarthritis [20].

There are many pathogens in the pathogenesis of UA or inflammatory rheumatic disorders of unknown cause; such as mycoplasmas [34], bacteria [45], or virus [35,36]. Of the role of bacteria, Visser et al. [44] used tests of the antistreptolysin-O (ASO) and anti-DNase B to evaluate the diagnostic value of streptococcal serology in discriminating post-streptococcal reactive arthritis and arthritis with other causes in 366 early arthritis patients. Upon positive serological results, they demonstrated the probability of having post-streptococcal reactive arthritis increasing from 2% to 9%. Our latest article also demonstrated a significant correlation between the ASO titer and the sacroiliac (SI) joint scintigraphy in subjects with UA [7], which imply that a reactive process possibly derived from antecedent bacterial infection affecting the SI joint. The most important issue in the article is the involvement of the SI joint in our subjects with high ASO titer [7], rather than the elbow, wrist, hip, knee and ankle joints [4,15, 16,23–25,31,39]. To our knowledge, there are limited articles discussing the relationship between UA and SI joint in the lumbopelvis, except one, which discussed the patients of early UA with persistent oligoarthritis and persistent polyarthritis [18].

In such an important cohort study, Hitchon et al. [18] have demonstrated a relative significant percentage of sacroiliitis occurring in both early UA populations, with 23% in persistent oligoarthritis and 7% in persistent polyarthritis and reported that some patients who remain undifferentiated at followup show persistence of joint inflammation, development of radiographic damage, and disability of function. Unfortunately, they did not have precise descriptions of the functional disability. We believe the posture is important to execute activities of daily living and its abnormality might be a negative factor contributing to trunk instability and imbalance. We reported in the previous study a high percentage of subjects (85.7%, N = 72) having low back pain (LBP), and interestingly, about half of those backache subjects had posture imbalance occurring with prolonged motionless standing or short-term standing with eyes closed [7]. LBP could be traced back with variable duration and intensity in most of the subjects with high ASO titer. None of the articles discussed the sway characteristics of upright posture in subjects with UA, and no discussion regarded a relationship between ASO titers and posture. We hypothesized that an imbalance of the lumbopelvis due to SI joint disorder/sacroiliitis might create a postural abnormality.

The purpose of this study was to determine whether there was a difference in postural sway during upright posture and standing on sloped platform in UA subjects with high ASO titer, when compared with subjects with low ASO titer.

2. Methods

2.1. Subjects

We surveyed a total of 825 subjects who underwent ASO titer testing in our hospital between September 2002 and September 2005. The ASO titer was done at the laboratory in Department of Clinical Pathology, and was determined by the standard tube dilution method plus a Behring nephelometry kit. The reference range of ASO titer in our hospital is defined as normal $\leqslant$ 116 IU/ml in adults. We set exclusion criteria as age younger than 17 or older than 40 years, and history of rheumatoid arthritis (RA), ankylosing spondylitis, spondyloarthropathy, urethritis, psoriasis, regional enteritis, inflammatory bowel disease, major trauma or surgery, metastatic/metabolic/endocrine diseases, peripheral arthritis, and skeletal malformations such as scoliosis and kyphosis. Among 135 selected subjects, we used CT scan or magnetic resonance imaging to exclude subjects who had lumbosacral herniation of intervertebral disc or spondylolysis, as well as any bony lesion or tumor within the pelvis and spine. In addition, all subjects were tested for erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), rheumatoid factor (RF), antinuclear antibody (ANA), and HLA-B27, as well as urinalysis. A positive result in those serum profiles was also one of the exclusion criteria.

We enrolled 88 subjects in the study, who met the selection criteria. All participants completed the SI joint scintigraphic examination, but four of them were excluded due to higher body temperature and signs of infection at the time of enrollment. The measurement for SI joint scintigraphy was determined by way of

the region-of-interest method with image acquisition from a gamma camera in our Department of Nuclear Medicine [7]. Finally, a total of 84 subjects were allocated with average age as 23 years (range 18.0–36.4), and was then divided into two groups per the reference level of ASO titer. In the group of ASO titer $\leqslant$116 IU/ml (38 in total, 32 men and 6 women), 27 had LBP and 11 had none. In the group of ASO titer $>$ 116 IU/ml (46 in total, 36 men and 10 women), there was, except one, a high percentage (97.8%) of subjects (45/46) reporting LBP, who reported that the pain was limited in the para-sagittal line of the sacrum, e.g. the exact site of the SI joint. The duration of LBP ranged from 3 weeks to more than 2 years, which pain behaving with a more gradual onset.

2.2. Study design

This was a prospective, case-control study conducted to evaluate the sway parameters during standing on platforms with different sloped degrees (0°, 10°, and 20°). The protocol for sway platform testing was the same as before [5,6,8]. In brief, subjects were asked to stand motionless on a ground level platform for 60 seconds with bare feet, first with their eyes open and again with their eyes closed. Measurements on sway parameters were taken in this manner on 8 different surface (sloped platforms) conditions; e.g. sway platform test 10° plantar flexion, 10° dorsiflexion, 20° plantar flexion, and 20° dorsiflexion.

2.3. Measurements of postural sway

Sway parameters (area, intensity, and velocity) were measured by using the CATSYS platform system (Danish Product Development, Denmark) to capture and quantify via a set of portable devices recording measurements of neuromotor control. The clinical assessment of sway is the single best predictor of static posture stability, which is eligible for quantitative measurement in many situations, such as LBP, spina bifida occulta, or ethanol exposure [5,6,8,9,28].

The definitions of the sway parameters followed those of researchers [5,6,8,9,28]. The sway area is defined as the area of the smallest polygon that includes the whole trajectory of the force center. Sway velocity is calculated by dividing the total length of the trajectory (in millimeters) of the center of pressure by the recording period (in seconds). Sway intensity is defined as the root mean square of acceleration, and is determined by analyzing the trajectory using the fast Fourier transformation method. Sway area, velocity and intensity have been known to be able to reflect the function of postural sway [5,6,8,9,28,30,32,37,42].

All subjects provided written informed consents, and the study was approved by the human ethics committee of the local medical center. The research carried out with human subjects was in compliance with the Helsinki Declaration.

2.4. Statistical analyses

We recorded the data using an Excel spreadsheet running on a personal computer. Statistical analyses were performed using SAS software (version 9.13; Carry, NC, USA). Descriptive statistics including means and standard deviations (SDs) were presented for variables of continuous type. The comparisons of these characteristics were analyzed using two sample t-test for continuous variables to ensure the comparability between two groups. The repeated-measures analysis of variance (ANOVA) analyzed the degree effect and interaction effect (sloped degree $\times$ group) in varying stressful conditions (eyes open vs closed, plantar flexion or dorsiflexion of feet). A P value of 0.05 or less was deemed to indicate a statistically significant difference.

3. Results

Based on the statistical analysis by two sample t-test, the sloped degree showed significant effects on all sway parameters (sway area, velocity, and intensity) under all the position conditions tested between high ASO (ASO titer $>$116 IU/mL) and low ASO (ASO titer $\leqslant$116 IU/mL) groups (Tables 1–4). After we analyzed the continuous variables by using repeated-measures ANOVA adjusted for either degree effect only or interaction effect, we found that sway parameters were associated with the comparatives in group, degree, eyes (open vs. closed), and flexion (plantar flexion vs. dorsiflexion) (Tables 1–4).

3.1. Sway area

In general, varying degrees had significant effects on sway areas between the two subject groups. Compared with the low ASO group, the two sample t-test showed that high ASO group had 2.76-, 4.46- and 4.59-fold higher values over the study period at 0°, 10°, and 20° in conditions of eyes open and plantar flexion (Table 1). Those comparatives were similar with those obtained

Table 1
Comparison of sway parameters between subjects groups at sway platform test $0^\circ \sim 20^\circ$ in position with eyes open and plantar flexion

	High ASO (N = 46)	Low ASO (N = 38)	P value[a]
Sway Area			
0°	318.18 ± 257.88	115.43 ± 11.15	< 0.0001
10°	413.28 ± 350.63	92.57 ± 13.14	< 0.0001
20°	380.00 ± 280.18	82.71 ± 7.16	< 0.0001
	P value[b] (sloped degree): 0.3491		
	P value[b] (sloped degree $\times$ group): 0.0300		
Sway Velocity			
0°	9.45 ± 4.02	7.14 ± 0.82	0.0009
10°	9.70 ± 3.51	6.45 ± 0.34	< 0.0001
20°	12.00 ± 6.39	7.47 ± 0.80	< 0.0001
	P value[b] (sloped degree): 0.0002		
	P value[b] (sloped degree $\times$ group): 0.0655		
Sway Intensity			
0°	4.30 ± 2.36	2.13 ± 0.47	< 0.0001
10°	5.42 ± 2.86	2.75 ± 0.19	< 0.0001
20°	5.11 ± 2.31	3.00 ± 0.44	< 0.0001
	P value[b] (sloped degree): $<$0.0001		
	P value[b] (sloped degree $\times$ group): 0.1897		

High ASO titer group: ASOT $>$116 IU/mL.
Low ASO titer group: ASOT $<$116 IU/mL.
[a]: Two sample t-test.
[b]: Repeated-Measures ANOVA.
$*P < 0.05 =$ statistically significant.

Table 2
Comparison of sway parameters between subjects groups at sway platform test $0^\circ \sim 20^\circ$ in position with eyes closed and plantar flexion

	High ASO (N = 46)	Low ASO (N = 38)	P value[a]
Sway Area			
0°	624.08 ± 495.97	116.03 ± 21.26	< 0.0001
10°	671.58 ± 541.22	137.60 ± 19.25	< 0.0001
20°	718.20 ± 594.01	101.83 ± 25.57	< 0.0001
	P value[b] (sloped degree): 0.5634		
	P value[b] (sloped degree $\times$ group): 0.4391		
Sway Velocity			
0°	14.90 ± 6.83	7.60 ± 0.57	< 0.0001
10°	14.33 ± 5.63	9.00 ± 0.62	< 0.0001
20°	17.07 ± 8.97	8.93 ± 0.72	< 0.0001
	P value[b] (sloped degree): 0.0186		
	P value[b] (sloped degree $\times$ group): 0.0097		
Sway Intensity			
0°	6.48 ± 2.71	2.58 ± 0.43	< 0.0001
10°	6.92 ± 2.92	3.70 ± 0.20	< 0.0001
20°	7.67 ± 3.84	3.65 ± 0.40	< 0.0001
	P value[b] (sloped degree): 0.0004		
	P value[b] (sloped degree $\times$ group): 0.1252		

High ASO titer group: ASOT $>$116 IU/mL.
Low ASO titer group: ASOT $<$116 IU/mL.
[a]: Two sample t-test.
[b]: Repeated-Measures ANOVA.
$*P < 0.05 =$ statistically significant.

in conditions of eyes open and dorsiflexion (Table 2), as well as in conditions of eyes closed and plantar flexion/dorsiflexion over the varying degrees (Tables 3, 4). However, repeated-measures ANOVA showed that the degree only affected the sway area in condition of eyes closed and dorsiflexion ($P = 0.016$, Table 4), rather than other conditions else (all $P > 0.05$, Tables 1–3). In consideration of interaction effect, sloped degree would cause different effects on sway area in conditions of eyes open and plantar flexion/dorsiflexion ($P = 0.03$, Table 1; $P = 0.0113$, Table 3), but did not cause significance in conditions of eyes closed and plantar flexion/dorsiflexion ($P > 0.05$, Tables 2, 4).

3.2. Sway velocity

In general, the relationship between sway velocity and subject groups varied with the different degrees, and the statistical analysis showed that the extent of sway velocity significantly increased when subjects stood with the platform sloped at 10° and 20° when compared to neutral standing values in most of the position conditions tested. The sway velocity obtained with open eyes and plantarflexion/dorsiflexion had lower values over the varying degrees (Tables 1, 3), when compared with those obtained with closed eyes and plantar flexion/dorsiflexion in high ASO group (Tables 2, 4), but those were not true as in low ASO group. Compared with the low ASO group, high ASO group had 1.32-, 1.50- and 1.61-fold high in sway velocity over the study period at 0°, 10°, and 20° in conditions of eyes open and plantar flexion (Table 1). Those comparatives were similar with those obtained in conditions of eyes open and dorsiflexion over the varying degrees (Table 3), but higher than those in condition of eyes closed and plantar flexion/dorsiflexion (Tables 2, 4). Repeated measures ANOVA showed that the varying degree would affect the velocity in high ASO or low ASO groups in various conditions tested (all $P < 0.0001$, Tables 1–4). Comparing interaction effect in varying conditions, sloped degrees had significant effects on sway velocity in most conditions tested (all $P < 0.05$, Tables 2–4), but not significant in conditions of eyes open and plantar flexion ($P = 0.0655$, Table 1). The relationship between sway velocity and subject groups varied depending on the degree, and the extent of sway velocity in group difference seems to be obvious when subjects stood at stressful conditions.

3.3. Sway intensity

The values of sway intensity obtained with eyes open had lower intensity values (Tables 1, 3) when compared

Table 3
Comparison of sway parameters between subjects groups at sway platform test 0°∼20° in position with eyes open and dorsiflexion

	High ASO (N = 46)	Low ASO (N = 38)	P value[a]
Sway Area			
0°	318.18 ± 257.88	115.43 ± 11.15	< 0.0001
10°	412.48 ± 327.04	85.23 ± 17.47	< 0.0001
20°	376.70 ± 327.76	90.26 ± 6.00	< 0.0001
	P value[b] (sloped degree): 0.2713		
	P value[b] (sloped degree × group): 0.0113		
Sway Velocity			
0°	9.45 ± 4.02	7.14 ± 0.82	0.0009
10°	9.72 ± 4.46	5.68 ± 0.59	< 0.0001
20°	10.12 ± 4.38	7.23 ± 0.84	0.0002
	P value[b] (sloped degree): < 0.0001		
	P value[b] (sloped degree × group): 0.0017		
Sway Intensity			
0°	4.30 ± 2.36	2.13 ± 0.47	< 0.0001
10°	5.80 ± 2.62	2.63 ± 0.32	< 0.0001
20°	5.00 ± 2.21	3.02 ± 0.36	< 0.0001
	P value[b] (sloped degree): < 0.0001		
	P value[b] (sloped degree × group): 0.0004		

High ASO titer group: ASOT >116 IU/mL.
Low ASO titer group: ASOT <116 IU/mL.
[a]: Two sample t-test.
[b]: Repeated-Measures ANOVA.
*$P < 0.05$ = statistically significant.

Table 4
Comparison of sway parameters between subjects groups at sway platform test 0°∼20° in position with eyes closed and dorsiflexion

	High ASO (N = 46)	Low ASO (N = 38)	P value[a]
Sway Area			
0°	624.08 ± 495.97	116.03 ± 21.26	< 0.0001
10°	683.73 ± 593.17	191.66 ± 19.82	< 0.0001
20°	551.75 ± 521.09	129.29 ± 20.01	< 0.0001
	P value[b] (sloped degree): 0.0160		
	P value[b] (sloped degree × group): 0.4992		
Sway Velocity			
0°	14.90 ± 6.83	7.60 ± 0.57	< 0.0001
10°	13.32 ± 5.65	8.13 ± 0.57	< 0.0001
20°	13.50 ± 6.72	11.59 ± 1.69	0.0087
	P value[b] (sloped degree): < 0.0001		
	P value[b] (sloped degree × group): < 0.0001		
Sway Intensity			
0°	6.48 ± 2.71	2.58 ± 0.43	< 0.0001
10°	7.51 ± 3.74	3.09 ± 0.40	< 0.0001
20°	6.46 ± 3.09	3.03 ± 0.36	< 0.0001
	P value[b] (sloped degree): 0.0170		
	P value[b] (sloped degree × group): 0.0887		

High ASO titer group: ASOT >116 IU/mL.
Low ASO titer group: ASOT <116 IU/mL.
[a]: Two sample t-test.
[b]: Repeated-Measures ANOVA.
*$P < 0.05$ = statistically significant.

with those obtained when eyes closed (Tables 2, 4). Compared with the low ASO group, high ASO group had 2.02-, 1.97- and 1.70-fold higher values of sway intensity over the study period at 0°, 10°, and 20° in conditions of eyes open and plantar flexion (Table 1). Those comparatives were similar with those obtained in conditions of eyes open and dorsiflexion over the varying degrees (Table 3), but higher than those in condition with eyes closed and plantar flexion/dorsiflexion (Tables 2, 4). The relationship between sway intensity and groups was found to vary depending on the sloped angles. In comparison with interaction effect in varying conditions, sloped degree had significant effects on sway intensity only in condition of eyes open and dorsiflexion ($P = 0.0004$, Table 3), but not significant in other conditions (all $P > 0.05$, Tables 1, 2, 4). The relationship between sway intensity and subject groups varied depending on the degree.

4. Discussion

UA has been defined as any inflammatory, nontraumatic arthritis that has the potential for a persistent course, without fulfilling the classification criteria for specific rheumatic disorders, although supporting data from the various associates indicated a considerable proportion of UA patients are actually patients with RA in a very early stage [41]. UA is a frequent clinical presentation with a variable outcome, and the prognosis of patients with UA may vary from self-limited to severe destructive RA. A survey in Austrian Early Arthritis Action with a follow-up of at least one year, 65% out of 182 patients have RA, and approximately 15% of these patients have no established diagnosis and are observed as cases of UA [27]. A previous study demonstrated 117 (54%) as having UA in a total of 217 patients who had inflammatory rheumatic diseases, with follow up over two more years, complete remission revealed in 54%; whereas, 36% fares with partial remission, unchanged activity or progressive disease [20]. A latest large survey conveyed that 40–50% of patients who present with UA experience spontaneous remission, even the risk of developing RA can be predicted [40]. Those facts indicate most patients with UA remaining a good prognosis, although there are insufficient features to permit classification. In general, patients with UA fared better than those meeting criteria for RA or spondyloarthropathy. In a study in performing needle biopsies on the knees of selected patients with UA, 5 of 8 had histological evidence of synovitis, e.g., synovial lining cell hyperplasia, increased vascularity, and lymphocyte infiltrates, with histological changes persisting after resolution of previous early symptoms [29].

UA of the lumbopelvis has rarely been reported and none of any study about postural sway impairment in UA has been described. This study assessed the clinical postural sway of subjects with UA of the lumbopelvis in conjunction with high ASO titers when standing upright, and evaluated the sway features in these patients. We compared sway parameters in subject groups with high and low ASO titers when they maintained an upright posture in 10 experimental conditions, which were designed to challenge the different roles played by vision (eyes open vs. closed) and proprioception (various platform slope and dorsiflexion vs. plantarflexion). We hypothesized that the higher the ASO titers, the greater the impairment in upright posture. Our results showed that high ASO group had significantly larger sway parameters than the low ASO group during the upright standing tests. Therefore, the postural stability of high ASO group during upright at various slope angles was inferior to that of the low ASO titer group. These results support the hypothesis; therefore, we speculate that SI joint disorder/sacroiliitis in the lumbopelvis due to high ASO titer might create a postural imbalance.

The underlying mechanism of postural imbalance is of concern. Humans maintain a balanced posture by integrating sensory inputs to correct static and dynamic postures as well as to maintain gaze orientation [1]. The maintenance of upright posture is constructed on signals coming from multiple receptors on the trunk muscles and ligaments. When standing on a solid stable support, all of these signals are in concert working simultaneously and coherently, allowing the projection of the center of a suprapedal mass relative to the foot [14]. A previous study has demonstrated a significant proprioceptive deficit in patients with chronic LBP when tested in positions of standing and four-point kneeling [13]. However, a specific structure in the pelvic structures which might be responsible for a loss of postural balance could not be identified. Somatosensory feedback in human is provided mostly by proprioceptive receptors in the lower limbs and trunk [3,22, 38], as well as in the SI joint of the lumbopelvis [19], whereas the feedback system can maintain an upright posture by itself, and plays a dominant role in maintaining an upright posture in healthy subjects standing on a platform with a fixed back support [12]. Ali et al. [2] found that positioning of the torso on the pelvis in both sagittal and coronal planes is an essential element of postural control in both standing and sitting positions.

To our interest, the only difference in pathology between two subject groups (high ASO and low ASO) in our study herein was SI joint disorder by scintigraphy. It seems reasonable to indicate that subjects with high ASO titer would lose more somatosensory ability for controlling upright postural sway. In the present study, all subjects with high ASO titers induced significant changes in sway parameters when they stood in stressful conditions, not on ground level only. The ability to maintain the characteristic upright posture requires good proprioceptive function, especially in the SI joint of lumbopelvis. Upon a postural threat, subjects might increase proprioceptive signals to help compensate, but the SI joint disorders make them fail.

As mentioned above, the only difference between subjects groups is the SI joint disorder. The SI joint disorder has been statistically thought to cause at least 15% of LBP in human, which is more common in the presence of trauma, pregnancy, or in certain athletes [17], and the SI joint biomechanically transmits vertical forces from the spine to the lower extremities and has a role in controlling the lumbopelvic dynamic motion [11]. Changes in loading on the sacroiliac joints may result in altered activation of the stabilizing muscles, and thus play an important regulatory function in stabilization and movement of the upper body during postural changes [19]. Proprioceptive sensors from the SI joint might compensate for the lack of visual feedback when subjects were requested to perform maneuvers with eyes closed or with the alteration of the feet position at a slope. However, SI joint disorder in conjunction with high ASO titer hinders the ability of these proprioceptive sensors. In contrast to the conditions of closed eyes and dorsiflexion, those of open eyes and plantarflexion were associated with significantly lower sway parameters.

Our results might respond to those of Hungerford et al. [21], who studied 14 subjects with SI joint pain in order to determine muscle activation of the supporting leg during hip flexion in standing. They found that the onset of obliquus internus abdominis, multifidus, and gluteus maximus electromyographic (EMG) activity is delayed on the symptomatic side while supporting the leg during hip flexion, rather than the conditions of control subjects, in whom the onset of obliquus internus abdominis and multifidus occurred before initiation of weight transfer. They concluded that an alteration in the strategy for lumbopelvic stabilization may disrupt load transference through the pelvis [21]. We did not examine the EMG activity in the trunk musculature, but the results of sway parameters might indirectly imply that an abnormality happening in the SI joint due to high ASO titer might play a crucial role in a loss of postural control.

With respect to the exact mechanism behind sacroiliac joint disorder, a role of proprioceptive impairment has been strongly suggested. Although there have been clinical studies on the diagnosis of SI joint pain, for instance, joint blocks [26] and EMG study, no satisfactory clinical neurophysiological method has been reported. The reason is because the biology of the SI joint is complex, and the joint is relatively heterogeneous considering the forces transmitted across it. What else in the joint is a true synovial joint with an auricular shape and a very limited amount of motion, which is constructed in such a way that they are self-tightening with increasing load due to an extensive network of strong surrounding ligaments.

Whether the joints actually have mechanosensitive units to transmit signals is an interesting issue. Two animal studies regarding somatosensory afferent units in the SI joint would partly answer the question. Sakamoto et al. [33] identified many discrete mechanosensitive units in the cat SI joint and adjacent muscles; of them, 90% are located in the posterior SI ligament and the remaining 10% in the adjacent muscles. Viewing from top to bottom, 55% units were identified in the proximal third of the SI joint. Most of the mechanosensitive units (96.6%) are group III nociceptors units with mechanical thresholds higher than 7 g, and few units (3.4%) may serve as proprioceptor units with thresholds lower than 7 g [33]. Holm et al. [19] demonstrated that irritation of low threshold nerve endings in the porcine SI joint may trigger a reflex activation of the gluteal and paraspinal muscles, where stimulating the ventral site of the joint to induce remarkable responses in both the gluteus maximus and quadratus lumborum muscles, and stimulating the joint capsule to elicit the greatest muscular responses in the multifidus muscle.

Information about human study is very limited. By using histologic and immunohistochemical techniques, Vilensky et al. [43] have demonstrated the presence of myelinated and unmyelinated nerve fibers, as well as paciniform encapsulated and nonpaciniform mechanoreceptors in the posterior ligament of the human SI joint. They speculated that, upon various nerve fibers as well as a broad selection of sensory receptors and mechanoreceptors in the joint, proprioceptive information from the joint can be used to optimize upper body balance. In summary, the human SI joint receives myelinated and unmyelinated axons that presumably conduct pain and proprioceptive impulses derived from mechanoreceptors and free nerve endings in the joint. Those afferent inputs from SI joint mechanoreceptors receptors will contribute to different degrees of muscle activation and may constitute an integral regulatory system [19,43]. A regulatory function for the SI joint in activation of the spinal and gluteal muscles would help control locomotion and body posture, as well as provide stability on the segmental level in the lumbar spine. It is acceptable that injury and/or inflammation would cause perturbations in the proprioceptive function of different receptors and result in increased or prolonged muscle activation by triggering reflex activation of the involved muscle groups, which over time can cause pain [19].

Before any definitive conclusions about the association can be drawn, we must consider the effect of potential confounding variables. It is acknowledged that there are some limitations in this study. First, the number of our subjects is not so large enough. Second, the condition for LBP as a confounder has certainly been met. Third, the potential for the confounding effects of the interaction of SI joint pathology across the groups might exist. Finally, note that the SI joint pathology cannot be verified on purely empirical grounds, which might be a potential confounder of the association between the two groups. Confounders veil the association of real scientific interest, so stratification in statistics is an option for adjusting for confounding. However, it always fails to make meaningful comparisons when too few subjects with any reasonable degree of precision [10], just like in our study that the strata contain too little information to reliably assess the association of main variables.

5. Conclusion

This study addresses the clinical sway characteristics of subjects with high ASO titers with UA of the lumbopelvis when in upright posture. In the present study, we demonstrated that the SI joint disorder in subjects with UA in conjunction with elevation of streptococcal serology is associated with significantly higher sway parameters on upright standing and stressful (sloped platform) conditions. Therefore, subjects with UA of the lumbopelvis are unlikely without abnormal upright posture, particularly in the condition of high streptococcal serology. Our study might indirectly characterize the role of proprioceptive receptor in SI joint for the postural control. This study also provides background data for use in determining future therapeutic exercises strategies for postural abnormality.

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