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ORIGINAL ARTICLE

Sacroiliac joint pain increases repositioning error during active straight leg-raising

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Abstract

Purpose This study aimed to compare the repositioning error (RE) of patients with unilateral sacroiliac joint pain (SIJP) to that of patients with low back pain (LBP) and a healthy control (HC) group. Differences between the symptomatic and asymptomatic sides were also investigated.

Methods Sixty-six patients with SIJP, LBP, and HC were included in this study. An active straight leg-raising repositioning test (ASLR-Rt) was performed. ASLR was performed three times each on the left and right sides, targeting a set base angle. RE was calculated as the difference between the base angle and the participant's attempt to adjust the target angle. RE was expressed as constant error (CE) and absolute error (AE).

Results The CE of the SIJP group (median [interquartile range]) (6.9 [4.6−10.4]) was significantly higher than that in the LBP group (3.2 [1.3−7.1]) and the HC group (2.7 [0.3−4.6]) ($P=0.009$, $d=0.91$, $P<0.001$, $d=1.30$). The AE of the SIJP group (7.3[5.0−10.4]) was also significantly higher than that in the LBP (3.7[2.8−7.1]) and HC groups (3.0[1.9−4.2]) ($P=0.003$, $d=1.04$; $P=0.001$, $d=1.57$). Comparing the symptomatic and asymptomatic sides in the SIJP group, the symptomatic side (8.0[6.0−10.6]) was significantly higher than the asymptomatic side (5.7[3.6−8.1]) in terms of CE ($P=0.05$, $d=0.51$).

Conclusion Patients with SIJP increased RE during ASLR, which may be related to impaired proprioception and decreased motor control.

Keywords Sacroiliac joint disease · Proprioception · Joint position sense · Active straight leg-raising

Abbreviations

LBP	Low back pain
SIJP	Sacroiliac joint pain
SIJ	Sacroiliac joint
JPS	Joint position sense
NSCLBP	Nonspecific chronic low back pain
RE	Repositioning error
HC	Healthy control
ODI	Oswestry Disability Index
RMDQ	Roland Morris disability questionnaire
ASLR	Active straight leg-raising
ASLR-Rt	The active straight leg-raising repositioning test
CE	Constant error
AE	Absolute error

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Introduction

The relationship between low back pain (LBP) and proprioception remains controversial. The prevalence of sacroiliac joint pain (SIJP) in patients with LBP is estimated to be 10−38% [1]. Approximately 80% of SIJP involves the posterior sacroiliac ligament and 20% involves the joint space [2]. The sacroiliac joint (SIJ), which plays an important role in load transfer between the lower limb and trunk, is covered by strong ligaments, as well as nerve fibers and mechanoreceptors [3, 4]. Hogervorst et al. speculated that SIJ stability may be "fine-tuned" by neuromuscular mechanisms influenced by the pacini bodies in the ligaments around the SIJ [5]. Conversely, when these proprioceptive senses are impaired, motor control may not be adequate and excessive stress may be placed on the surrounding ligaments, causing pain. Therefore, it is important to investigate the relationship between SIJP and proprioception.

Many studies have evaluated proprioception in patients with LBP, but no studies have evaluated proprioception in patients with SIJP. Proprioception was evaluated by measuring joint position sense (JPS). Trunk proprioception is reduced in patients with LBP. A systematic review comparing JPS between patients with LBP and healthy controls concluded that patients with LBP have significantly reduced lumbar proprioception compared to that in controls SPS:refid::bib6[6]. Sheeran et al. [7] classified nonspecific chronic LBP (NSCLBP) into subgroups of auto-extension and flexion patterns and compared patients with lumbar JPS with a healthy group. Patients with NSCLBP, regardless of subgroup classification, showed significantly larger errors than the healthy group, and subgroup differences in the direction of the errors were detected. O'Sullivan et al. [8] evaluated lumbar JPS in patients with NCLBP showing a flexion pattern and found a significantly greater repositioning error (RE) in the NCLBP group. Symptomatic and asymptomatic sides are considered for knee joint diseases. A systematic review of patients with anterior cruciate ligament injuries concluded that knee joints with anterior cruciate ligament injuries may have more impaired intrinsic knee proprioception than uninjured knees or controls [9]. RE values are characterized by subgroup and condition and may vary on the symptomatic or non-symptomatic side in unilaterally affected cases. This study aimed to compare the RE of patients with unilateral SIJP to patients with LBP and a healthy control (HC) group. The differences between the symptomatic and asymptomatic sides were also examined.

Participants and methods

We hypothesized that the RE of patients with SIJP would be significantly greater than that in the LBP and HC groups. Furthermore, the difference between the symptomatic and asymptomatic sides of the patients with unilateral SIJP would be significantly greater on the symptomatic side.

Participants

This was a cross sectional, observational study. Sixty-six patients with SIJP, LBP, and HC were included. The sample size was calculated using a power analysis program (G*Power version 3.1.9.2; Franz Faul, Germany). A sample size of 66 (22 cases per group) was determined for an effect size of $f = 0.4$, $\alpha = 0.05$, and power $= 0.8$ [10]. The inclusion criteria for the SIJP group were (1) patients, aged 16–70 years, who complained of lumbar buttock pain, (2) a history of at least 3 months, (3) one-point sign to the posterior superior iliac spine [2], and (4) at least 70% pain relief by block injection of local anesthetic into the SIJ. The LBP group included patients who visited an orthopedic surgeon and (1) complained of pain in the area between the lowermost rib and the gluteal fold [11], (2) reported a history of the disease for at least 3 months, and (3) experienced no lower extremity symptoms or neurological signs. In both groups, the exclusion criteria were severe deformity of the pelvic girdle, pregnancy, and where a single orthopedic surgeon made the diagnosis. None of the present subjects had hip pain. Hip disease was ruled out when diagnosing the patient as having hip disease. All SIJPs and LBPs were assessed for pain (Numerical Rating Scale: NRS) and functional disability (Oswestry Disability Index [ODI]) [12], and completed the Roland Morris disability questionnaire (RMDQ) [13]. HC was defined as (1) no history of orthopedic or surgical procedures that involved the lower extremities and trunk within at least one year, (2) no back pain at the time of the experiment, and (3) not pregnant. Informed consent was obtained from each participant. This study was conducted according to the Declaration of Helsinki after obtaining approval from the ethical review committee (approval number: 2021–029).

Methods

The active straight leg-raising repositioning test (ASLR-Rt) was performed on all participants according to previous studies [14, 15] (Fig. 1). For the ASLR-Rt, the participants had their eyes closed and were placed in a supine position.

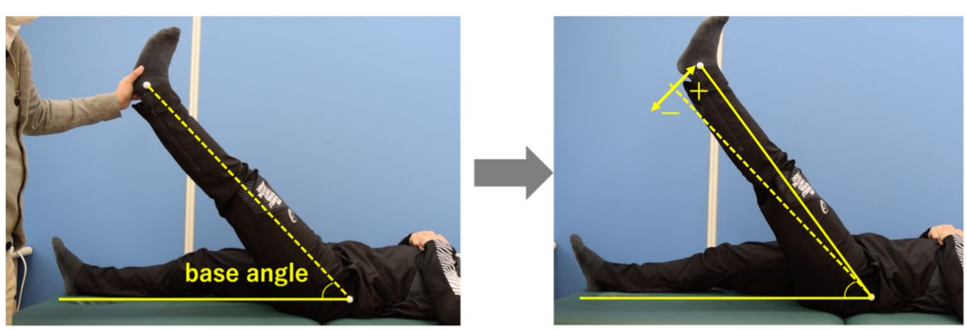

Fig. 1 Active straight leg-raising repositioning test (ASLR-Rt)

The ASLR angle was defined as the angle between the floor and the line connecting the lateral malleolus and greater trochanter during active straight leg-raising (ASLR). The examiner measured the angel using a goniometer with the participant's lower extremity passively raised at 45°. The participants held the lower limb in a raised position and memorized the position of the lower limb. ASLR was performed three times each on the left and right sides, targeting the base angle. The order of the left and right sides was randomized. The target angle and three ASLR were photographed using a digital camera (Nikon D5300, Tokyo, Japan) placed 2 m from the participant at a height of 30 cm, and the angles were measured. Measurements were made using ImageJ software (U.S. National Institutes of Health, Bethesda, Maryland, USA). The target angle and the ASLR-Rt angle were measured for a total of three trials. A single examiner performed all the analyses.

The examiner measured using a goniometer and passively raised the participant's lower extremity at 45°. The participants held the lower limb in a raised position and memorized the position of the lower limb. The ASLR was performed three times, targeting the base angle.

RE was calculated as the difference between the base angle and the participant's attempt to adjust the target angle. RE was expressed as constant error (CE) and absolute error (AE). CE was shown as a positive value when it was above the target value and a negative value when it was below the target value [16]. AE was defined as the difference from the target value in absolute value [17]. In all cases, the average values of CE and AE were calculated from the three trials. The NRS indicated the intensity of pain felt during the week and was measured as a score between 0 and 10. The ODI was calculated by dividing the total score by the full score of 50 points and subtracting the total score for the items for which no response was received. The RMDQ was calculated using a maximum score of 24.

Statistics

Statistical analyses were performed using SPSS version 28.0 (IBM Corporation, Tokyo, Japan). Normality and equal variances of the data were checked using the Shapiro–Wilk and Levene tests, respectively. The Kruskal−Wallis test was used to compare age between the groups. The Mann−Whitney U test was used to compare the NRS, ODI, and RMDQ scores between the SIJP and LBP groups. The Kruskal−Wallis test and Mann−Whitney U test were used to compare the CE and AE between the groups, and the Bonferroni method was used for post-tests. Welch's t test was used for the CE and AE comparisons between the symptomatic and asymptomatic sides in the SIJ group. Cohen's d was expressed as an effect size for each group and for comparisons between the symptomatic and asymptomatic sides, with values ranging from 0.20 to 0.49, 0.50, 0.79, and >0.80 for small, medium, and large sides, respectively. The relationships between CE, AE, and the NRS, ODI, and RMDQ indices in the SIJP group were evaluated using Pearson's correlation coefficient (r) and Spearman's product rate correlation coefficient (rs), depending on the normality of the data distribution. In both cases, $\alpha = 0.05$.

Results

The SIJP group included 8 males and 14 females, with a mean age of 37.7 ± 16.2 years (mean ± SD), The LBP group included 10 males and 12 females, with a mean age of 39.9 ± 16.1 years. The HC group included 9 males and 13 females, with a mean age of 39.8 ± 13.8 years (Table 1). There was no difference in age between the three groups. The degree of functional disability also did not differ between the SIJP and LBP groups.

The CE of the SIJP group (median [interquartile range]) (6.9 [4.6−10.4]) was significantly higher than that in the LBP group (3.2 [1.3−7.1]) and HC groups (2.7 [0.3−4.6]) ($P = 0.009$, $d = 0.91$, $P < 0.001$, $d = 1.30$) (Fig. 2). The AE of the SIJP group (7.3[5.0−10.4]) was also significantly higher than that in the LBP group (3.7[2.8−7.1]) and the HC group (3.0[1.9−4.2]) ($P = 0.003$, $d = 1.04$; $P = 0.001$, $d = 1.57$) (Fig. 2). Comparing the symptomatic and asymptomatic sides of the SIJP group, the CE of the symptomatic side (8.0[6.0−10.6]) was significantly higher than that in the asymptomatic side (5.7[3.6−8.1])($P = 0.05$, $d = 0.51$) (Fig. 3). The correlation coefficients between CE and AE and NRS, ODI, and RMDQ scores were weak or moderately negative (Table 2).

Table 1 Characteristics and clinical profiles of patients with sacroiliac joint pain, patients with low back pain, and healthy controls

	SIJP	LBP	HC	*P* value
Age	37.7 ± 16.2	39.9 ± 16.1	39.8 ± 13.8	0.859
Gender (male/female)	8/14	10/12	9/13	
NRS (/10)	6.2 ± 1.8	5.9 ± 1.7	–	0.228
ODI (/100%)	27.0 ± 15.5	24.9 ± 9.8	–	0.646
RMDQ (/24)	8.9 ± 5.3	7.5 ± 3.7	–	0.258

SIJP sacroiliac joint pain, *LBP* low back pain, *HC* healthy controls, *NRS* numerical rating scale, *ODI* Oswestry disability index, and *RMDQ* Roland Morris disability questionnaire

Data are mean ± SD

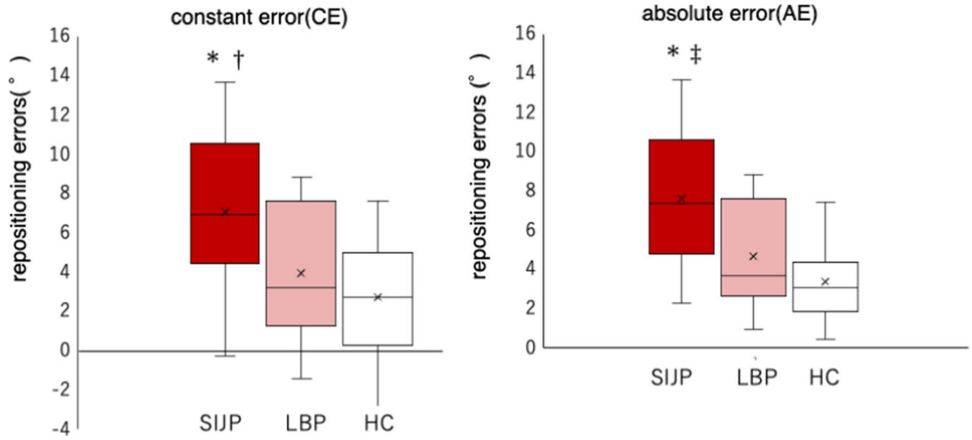

Fig. 2 Repositioning errors for each group. In CE, the SIJP group was significantly higher than the LBP and HC groups ($P=0.009$, $d=0.91$, $P<0.001$, $d=1.30$). In AE, the SIJP group was significantly higher than the LBP and HC groups ($P=0.003$, $d=1.04$, $P=0.001$, $d=1.57$). *SIJP* sacroiliac joint pain, *LBP* low back pain, *HC* healthy controls. *, †, ‡: Statistically significant difference between groups. * vs HC, $P<0.001$, † vs LBP, $P=0.009$, ‡ vs LBP, $P=0.003$

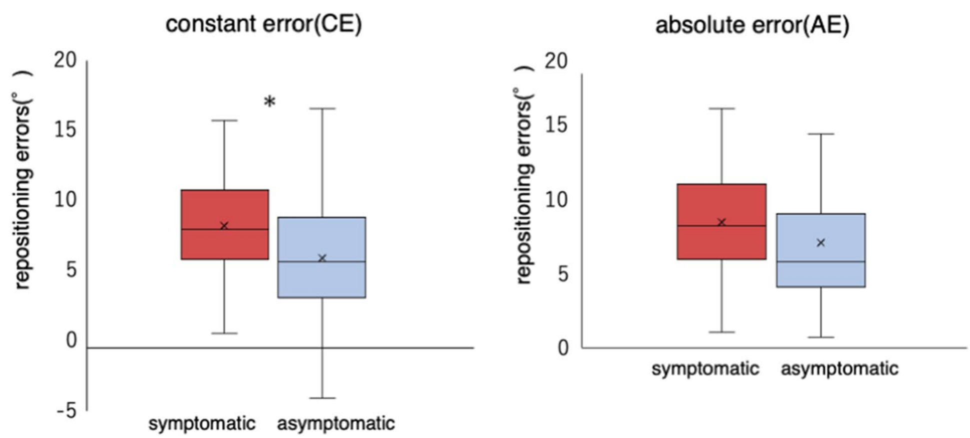

Fig. 3 Differences in repositioning errors for the symptomatic and asymptomatic sides of SIJP. Comparing the symptomatic and asymptomatic sides of the SIJP group, the symptomatic side was higher than the asymptomatic side in CE, a significant difference (*$P=0.049$, $d=0.51$). SIJP: sacroiliac joint pain. ◎: outlier

Table 2 Correlation coefficients between RE and NRS, ODI, and RMDQ scores

	Constant error (CE)		Absolute error (AE)	
	rs	*P*	rs	*P*
NRS	−0.211	0.347	−0.143	0.526
ODI	0.063	0.781	0.089	0.694
RMDQ	−0.408	0.059	−0.371	0.089

RE repositioning error, *NRS* numerical rating scale, *ODI* Oswestry disability index, and *RMDQ* Roland Morris disability questionnaire

Discussion

This study aimed to evaluate proprioception in patients with SIJP. This is the first study to evaluate the JPS in patients with SIJP. Patients with SIJP showed an increased RE during ASLR-Rt compared to patients in the LBP and HC groups. Furthermore, patients with SIJP demonstrated an increased RE on the symptomatic side compared to the asymptomatic side.

Proprioception is also impaired in patients with LBP. However, in the present study, the SIJP group had a significantly higher RE than patients in the HC and LBP groups. The SIJ has a ventral articular portion and dorsal ligament portion. It has been reported that the articular capsule and posterior sacroiliac ligament, which make up the SIJ, are rich in intrinsic receptors [3]. Since more than 80% of SIJP pathology originates from the ligamentous region [2], it is likely that the intrinsic receptors are also affected in SIJP. These factors may have contributed to the significantly higher RE observed in the SIJP group. The RE on the symptomatic side was higher than that on the asymptomatic side in the SIJP group. In this study, the ASLR was used to assess the instability and pain induction in SIJP [18]. Instability and pain were evaluated when the lower extremity was raised 20 cm above the floor. Mens et al. [18] reported that patients with pelvic girdle pain (PGP) have an anterior rotation of the iliac crest during ASLR on the symptomatic side but not on the asymptomatic side. The SIJP group showed altered motor control [19]. The proprioception and motor control functions of the symptomatic side were impaired. These may explain the patients' higher RE in the ASLR-Rt.

Information from the muscle spindles is important for joint positioning during locomotion, and information on muscle contraction is also required [20]. Muscle contraction is used to evaluate SIJP [18]. It is used for clinical evaluation from various perspectives. In a study in which ASLR was performed on patients with SIJP and healthy participants, only patients with SIJP reported kinematic changes in the diaphragm and pelvic floor during ASLR [21]. Transversus abdominis muscle activity during ASLR was compared between participants with and without groin pain. The transversus abdominis muscle started to act later than the hip flexors in participants with groin pain [22]. A study investigated pre-activation and auto-contraction in the pelvic girdle and abdominal muscle groups during ASLR in women with persistent PGP versus healthy women [23]. Pre-activation of the pelvic floor muscles occurred during ASLR in 91% of healthy women, but only in 36% of women with PGP. Participants with unilateral chronic PGP were found to use bracing motor control strategies when performing ASLR on the affected side, resulting in increased intra-abdominal pressure and depression of the pelvic floor muscles [24]. As described above, patients with related SIJP have altered trunk muscle activity patterns and motor control during exercise. One of the reasons for the higher RE in the SIJP group may be the changes in motor control of the trunk muscles.

There are several methods for evaluating trunk proprioception, such as anterior–posterior pelvic tilt [17] and anterior–posterior lumbar flexion [16]. However, the ASLR-Rt used in this study can evaluate one side at a time. The ASLR is raised approximately 20 cm from the floor. In the initial stage of leg-raising, the moment to the lower limb is large, and the muscle activity of the rectus femoris and other muscles is also large [25]. However, high muscle activity is not required for assessing proprioception. In many cases, ASLR cannot be performed when the ASLR angle exceeds 60°, owing to the influence of muscle flexibility. From the viewpoint of muscle activity and flexibility, 45° is considered appropriate for evaluating proprioception. Jo et al. evaluated the JPS using a 60° SLR in patients with total hip arthroplasty after a hip fracture or osteoarthritis, and the RE was approximately 6° in both groups [14]. Reddy et al. evaluated repositioning during ASLR on the symptomatic side in patients with unilateral hip osteoarthritis and reported an RE of 3.86° [15]. The RE in this study was 3.2° in the LBP group and 2.7° in the HC group. Both of these RE are considered reasonable.

The ASLR-Rt may be useful in the evaluation of patients with SIJP. Currently, ASLR uses the Likert scale method to assess subjective dyskinesia [18], but this method provides an objective value of RE. Furthermore, improvement in RE may be used to determine treatment efficacy. One possible treatment would be to practice ASLR with the goal of a set angle and provide feedback if the RE is large. This would be one effective exercise to improve motor control in patients with SIJP.

This study has some limitations. The assessment method can only be used in patients who can hold their lower limb in an elevated position. Although ASLR is a hip flexion exercise, the JPS of the hip joint was not evaluated in this study.

Conclusion

Patients with SIJP have a decreased JPS in the ASLR, which may be related to proprioception and decreased motor control.

Acknowledgements None.

Declarations

Conflict of interest None.

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