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RESEARCH REPORT

Pattern of changes in local and global muscle thickness among individuals with sacroiliac joint dysfunction

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KEYWORDS
local muscle;
global muscle;
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thickness

Abstract *Background:* Altered motor patterns of the local muscle system (LS) and global muscle system (GS) is reported among low back pain patients. However, the pattern of changes in the LS and GS among individuals with sacroiliac joint dysfunction (SJD) is not clear.
Objective: This study aimed to investigate the changes in the resting muscle thickness of LS and GS in SJD.
Methods: A total of 40 individuals (20 participants with SJD and 20 healthy participants as matched controls) participated in this study. The resting thickness of the LS and GS such as rectus abdominis (RA), external oblique (EO), internal oblique (IO), transverses abdominis (TrA), and lumbar multifidus (LM) was measured using real time ultrasonography and the data were compared between the ipsilateral side and contralateral side among participants with SJD as well as healthy participants. Parametric and nonparametric statistics were used to analyze the data as appropriate.
Results: The results showed that EO and IO were significantly reduced among SJD participants when compared with the contralateral side. Similarly, EO and LM were significantly reduced among the SJD group when compared with the controls.

Conflicts of interest: All authors have no conflicts of interest to declare.

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Conclusion: The findings of the study supported a trend of reduced size in the resting thickness of the LS and GS in SJD.

Introduction

The stability of the pelvis is governed by the optimal functioning of the lumbopelvic region. The sacroiliac joint is surrounded by many muscles that act to compress the joint which enhances the pelvic stability during a variety of functional tasks [1—4]. Two important muscle systems are operational in the sacroiliac joint to create and maintain the optimum function and stability of the joint through a biomechanical concept called force closure [1,3,5]. Therefore, an efficient force closure system as dictated by the local and global muscle system is important to maintain the stability of the region [6]. The local muscle system refers to the deep intrinsic transversely oriented abdominal muscles such as transverses abdominis and multifidus [2,7,8]. The global muscle system related to lumbopelvic stability refers to the larger, longitudinally oriented superficial abdominal muscles such as rectus abdominis, internal oblique, and external oblique [2,9]. Thus an optimal contractile effect of the local and global muscle system works continuously to maintain the function and stability of the sacroiliac joint.

Pelvic girdle pain is reported to occur due to excessive as well as insufficient motor activation of the lumbopelvic and surrounding muscles [10]. Sacroiliac joint dysfunction (SJD) is a subgroup of pelvic girdle disorder where there is any altered or impaired functioning of the somatic framework of sacroiliac joint and its related components such as arthrodial, myofascial, ligamentous, vascular, lymphatic, and neurological, given that the articular surfaces are variable in anatomical shape not only from individual to individual, but from side to side [11]. Furthermore, SJD is also referred to as an altered position of the sacroiliac joint surfaces, which is created by repetitive stresses and is maintained by compressive and elastic forces of the ligaments and muscles [12]. In the dysfunctional state, the sacroiliac joint is reported to have altered biomechanical features, neural compression, and muscle spasms [13]. In other words, the biomechanics of the sacroiliac joint will be altered and compromised with regard to its function of load transference and motor control.

Any information on the changes on the motor control of these global and local muscles among individuals with SJD still remains unclear. A prior understanding on the normal functions of the local and global muscle system towards sacroiliac joint stability is prerequisite among clinicians to interpret and differentiate the changes in motor control that may occur in sacroiliac joint dysfunction. In normal sacroiliac joints, transverses abdominis (TrA) and middle part of internal oblique (IO) act to compress the sacrum between the ilia and maintain the stability of the sacroiliac joint [2]. Furthermore, preactivation of TrA, IO, lumbar multifidus (LM) and gluteus maximus (GM) is reported to induce posterior rotation of the innominate of illium relative to the sacrum and stabilize the sacroiliac joint [4]. The lumbar multifidus acts as a stabilizer of the lumbosacral region as it sends fibre over the sacrum to unite with sacrotuberous ligaments and stiffens the sacroiliac joint [14]. However, it is not clear what happens to the above said functions of the muscles among individuals with SJD.

Although the changes in the local and global muscle system are studied extensively among patients with low back pain, studies on the motor control of these muscles among patients with SJD are lacking. Therefore, the main aim of this study was to investigate the change in the muscle thickness of local and global muscles in SJD. The primary objective of this study was to compare the resting thickness of the local and global muscle system (RA, IO, EO, TrA, and LM) between symptomatic and asymptomatic sides among participants with SJD. The secondary objective was to compare the local and global muscles resting thickness between participants with SJD and healthy individuals as matched controls. Clinically, any alterations such as weakness or wasting of local or global muscles may alter the stability of the joint during some functional and locomotive tasks leading to musculoskeletal pathogenesis [15]. Thus, it was hypothesized in this study that the participants with SJD may have reduced resting thickness of the local and global muscles. The findings of the study may help clinicians to frame an appropriate exercise program to address local and global muscle system among patients with lumbopelvic disorders.

Materials and methods

Participant characteristics

This study recruited a total of 40 participants ($n = 20$, participants with SJD and $n = 20$, matched controls). All the participants were recruited based on predefined selection criteria. The participants with SJD were recruited from an outpatient physiotherapy department from a university teaching hospital. The inclusion criteria for SJD participants were that they should test positive for the battery of clinical tests. The participants with SJD were recruited through a battery of clinical tests namely Gillet test, standing flexion test, prone knee flexion test, supine long sitting test, and palpation of posterior iliac spine asymmetry on sitting [16,17]. The participants were diagnosed with SJD if they showed positive responses to at least four of five clinical tests [16—18]. The healthy participants were recruited as controls from the hospital staff and primary care givers who accompanied the patients to the hospital. The healthy participants were matched as controls in terms of age, weight, height, and body mass index

(BMI). Any patients who reported back pain over the past year, who had any history of spinal surgeries, history of any musculoskeletal symptoms on the lower limbs over the past year, and obese participants were excluded. Informed written consent was obtained from all the study participants after explaining the study procedure. The study was ethically approved by the Research Ethics Committee of Universiti Kebangsaan Malaysia Medical Centre.

Procedures

The resting muscle thickness of the deep abdominal muscles and LM was measured through real time ultrasonography using Philips HD11 system ultrasound scanner (Philips Electronics, Eindhoven, The Netherlands). The resting thickness of TrA, IO, and external oblique (EO) was measured using 7-MHz linear array transducer whereas a 7.5-MHz linear array transducer was used to investigate the resting thickness of rectus abdominis (RA) [19]. For the measurement of resting thickness of LM, a 5-MHz convex transducer was used for optimum penetration and resolution [20]. The measurement of resting thickness of the TrA, IO, and EO using ultrasonography was followed as per a previously established protocol [21]. The reliability of the study protocol was tested previously and hence, it was used in this study to measure the resting thickness of the muscles. All the ultrasound measurements were performed by a qualified musculoskeletal radiologist with more than 10 years of experience.

All the participants were positioned on a plinth in crook lying with a pillow under their head and their knees. The transducer was placed in a transverse plane just superior to the right iliac crest along the auxiliary line [21]. The localization of the transducer was standardized by maintaining the hyperechoic interface between the transverses abdominis and thoracolumbar fascia at the far left of the image. The angle of the transducer was adjusted to optimize the visualization of the muscle boundaries. Hypoechoic pixels prior to the fascial layers were used to define the boundaries of the muscle [21]. After the initial placement of the transducers, surface markings on the skin were made using markers in order to standardize the same location of the transducer during data collection. Thus, care was taken to ensure the placement of the transducer at the same location during data collection [21].

The total resting muscle thickness was defined as the distance between the superior border of the external oblique and the deep border of the transverses abdominis. The thickness of the transverses abdominis, internal and external oblique was defined as the distance between the superior border and inferior border of each muscle [21]. For rectus abdominis, the ultrasound transducer was placed 2—3 cm above the umbilicus and 2—3 cm from the midline [19].

The resting thickness of the LM was measured as per another established protocol [20]. The participant was set prone with the forehead resting just above the breathing hole in the plinth, the head in the midline, and the arms supported on the armrests of the plinth. Lumbar lordosis was eliminated using towels and pillow under hips. The convex transducer was first placed longitudinally and midline over the L3 to L5 level. Then, it was rotated 90° to orientate transversely in midline so that the spinous processes and laminae could be seen [20]. It was then moved on laterally to each side at L4 to image the right and left multifidus. The echogenic vertebral lamina was used consistently as a landmark to identify the deep border of LM [22]. The LM muscle was visualized on the image as bordered superiorly by the thoracolumbar fascia and the medial border by the acoustic shadow from the tip of the spinous process at the L4 vertebral level. The lateral border was formed by the fascia surrounding the multifidus and separating it from the longissimus component of the lumbar erector spinae muscle [22]. All of the muscle thickness measurements on the control participants were performed only on the dominant side. Each of the measurements was repeated three times and the mean was used to calculate the resting thickness [19]. Prior to data collection, the intrarater reliability of the ultrasound measurements were established which showed good to excellent reliability for LM [Intraclass correlation coefficient (ICC) 0.75], transversus abdominis (TA) (ICC 0.85), EO (ICC 0.88), RA (ICC 0.94), and IO (ICC 0.97) respectively.

Statistical analysis

The sample size for this study was calculated using the G*power program 3.1.0 (G power program Version 3.1, Heinrich-Heine-University Düsseldorf, Germany) for two tailed, paired *t* test. The effect size for the sample size calculation was obtained from a pilot study on sacroiliac joint dysfunction. Based on the data from the pilot study, the estimated sample to obtain a power of minimum 80% at a significant alpha level of 95% required a total sample size of 20 participants. The data were analyzed using SPSS for Windows version 20.0 (IBM Corp., Armonk, NY, USA). To compare the characteristics between participants with SJD and control participants, independent sample *t* test, Mann—Whitney *U* test, or Chi-square test were used to analyze the data, depending on whether the criteria for parametric statistics were met. To test the difference between the ipsilateral and contralateral muscle thickness in the SJD participants, paired sample *t* test was used for normally distributed data and Wicoxon test was used to analyze the data that were not normally distributed. The level of significance was set at 0.05 for all tests.

Results

The mean (SD) of the age, weight, height, and BMI of the participants are shown in Table 1. The results showed that there was a significant difference ($p = 0.031$) in the height of the study participants between the SJD and healthy group. However, the differences in height did not have much influence on the participant characteristics as the overall BMI of the participants between the groups remained not significantly different ($p = 0.524$). The mean (SD) of the resting thickness of the local and global muscle system between the ipsilateral side and contralateral side of dysfunction are shown in the Table 2. The general trend from the results showed that the resting thickness of all the muscles (RA, EO, IO, TrA, and LM) was smaller when compared with the contralateral side among the

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Table 1 Demographic characteristics of the participants

	Participants with SJD	Matched controls	p
Age (y)	35 ± 6.2	35 ± 8.1	0.132
Height (cm)	161 ± 6.7	164 ± 6.3	0.031
Weight (kg)	64 ± 7.2	65 ± 1.9	0.342
Body mass index (kg/m^2)	24 ± 5.1	24 ± 2.2	0.524
Gender			
Male	8	8	0.483
Female	12	12	
Side of SJD			
Right side	18	—	—
Left side	2	—	
Limb dominance			
Right side	18	18	0.381
Left side	2	2	

Data are presented as mean ± SD.
SJD = sacroiliac joint dysfunction.

participants. The results from paired t test showed that the resting thickness for EO ($p = 0.013$) and IO ($p = 0.011$) was significantly smaller. The results from Wilcoxon signed rank test showed that the smaller size of TrA observed was close to the significant level ($p = 0.073$). Although RA ($p = 0.164$) and LM ($p = 0.105$) showed a smaller size, the difference was not significant when compared with the contralateral side muscles. All of the muscles showed a trend of reduced resting thickness among participants with SJD when compared with the healthy matched controls (Table 3). However, the Mann–Whitney U test showed a true significance only for EO ($p = 0.041$) and LM ($p = 0.033$).

Discussion

The current study investigated the changes in the resting thickness of the LS and GS among participants with SJD. The concept of testing the LS and GS could be rationalized by the following evidence [10,23,24]. The distortions of the pelvis as observed in SJD might occur secondary to the changes in pelvis and trunk muscle activity which might lead to directional strain and not positional changes within the sacroiliac joint [10]. Such secondary changes mentioned in the pelvis and trunk muscle activity imply study of the LS and GS of the sacroiliac joint. Secondly, a study conducted using Doppler imaging of vibrations to examine laxity on the sacroiliac joint reported that the voluntary unilateral contractions of relevant muscles of the pelvis resulted in reduced mobility of the sacroiliac joint on the ipsilateral side [23]. Thirdly, adequate compression of the pelvis joint surfaces was suggested as the result of reaction forces acting across the joint through muscle cocontractions and ligament tension [24]. In consideration to the above studies, it may be apparent that the LS and GS that cross the pelvic joint need to be studied for understanding the biomechanical alterations in SJD.

Table 2 Resting thickness of contralateral and ipsilateral muscles in SJD.

Thickness	SJD		p
	Ipsilateral muscles	Contralateral muscles	
RA	8.3 ± 0.1	8.7 ± 0.1	0.164[b]
EO	5.2 ± 0.1	5.8 ± 0.1	0.013[a]
IO	6.5 ± 0.1	7.2 ± 0.1	0.011[a]
TrA	3.9 ± 0.1	5.3 ± 0.4	0.073[b]
LM	2.8 ± 0.5	2.9 ± 0.5	0.105[b]

Data are presented as mean ± SD. All the values of thickness are indicated in millimetres except LM which is indicated in centimetres.
EO = external oblique; IO = internal oblique; LM = multifidus; RA = rectus abdominis; SJD = sacroiliac joint dysfunction; TrA = transversus abdominis.
[a] Paired sample t test.
[b] Wilcoxon test.

Table 3 Comparison of resting thickness of muscles between participants with SJD and matched controls.

Thickness	SJD group ipsilateral muscles	Matched controls dominant muscles	p
RA	8.3 ± 0.2	8.8 ± 0.1	0.877[a]
EO	5.2 ± 0.1	6.0 ± 0.1	0.041[b]
IO	6.5 ± 0.2	7.2 ± 0.1	0.156[b]
TrA	3.9 ± 0.1	3.8 ± 0.1	0.769[a]
LM	2.8 ± 0.5	3.1 ± 0.5	0.033[a]

Data are presented as mean ± SD. All the values of thickness are indicated in millimetres except LM which is indicated in centimetres.
EO = external oblique; IO = internal oblique; LM = lumbar multifidus; RA = rectus abdominis; SD = mean; SJD-sacroiliac joint dysfunction; TrA = transversus abdominis.
[a] Independent t test.
[b] Mann–Whitney U test.

In addition, the conceptual model of stability established by Panjabi [5] explains the need to investigate the local and global system in SJD. As per this model, the lumbopelvic stability is maintained by the interaction between the passive, active, and control system [5]. Therefore any excessive stress on the osteoarticular ligamentous passive system as it might be presented in SJD is likely to alter the proprioceptive input from the passive system to the control system. In turn, the resulting altered output from the control system might impair and alter the muscle thickness and contractility of the muscles that cross the sacroiliac joint. Therefore, in the current study, it was hypothesized that the muscle thickness of the LS and GS might be reduced in size due to the altered control system in SJD.

In the current study, all the LS and GS that cross the sacroiliac joint showed a trend of reduced resting thickness of the muscles on the side of SJD when compared with the contralateral joint and as well as against the matched healthy individuals. However, true significance was observed only in the resting muscle thickness of the EO, IO, and TrA on the side of dysfunction when compared with the contralateral side in the sacroiliac joint. In healthy individuals, the significance was observed only in EO and LM. The findings of the study imply that the LS and GS tend to be impaired and altered in SJD. The trend of reduced thickness of the LS and GS is supported by several past studies that also had reported delayed muscle activity of the LS and GS among patients with lumbar and pelvic girdle pain [25–27]. The LS and GS work together to create a rigid cylinder of abdominal cavity thereby protecting the mechanical stress to sacroiliac joint and aids in normal load transfer to the pelvis and lower extremities. The reduced thickness of the muscles might affect the biomechanical property of the joint by altering the mechanical stress and load transfer.

The measurement of the thickness of the LS and GS during rest is one of the limitations of the study. The muscles are not assessed during contraction or during any functional tasks related with sacroiliac joint which might be more appropriate for the functional role of the joint and the muscle system. Nevertheless with SJD reported to cause ~22.5% of back pain, the altered biomechanical changes in the LS and GS may explain the role of SJD as one of the reasons for development of low back pain. Hence, clinicians might consider suggestions of an appropriate exercise program to train the LS and GS muscle system to manage lumbopelvic disorders. Another limitation of the study is that the effect of limb dominance on SJD was not explored in the current study but will be more fully investigated in a future study. Activities such as active straight leg raises were shown to activate and increase the thickness of IO, EO, and TrA muscles [28]. Perhaps, clinicians might use active straight leg raises as a therapeutic movement to strengthen the core stability among individuals with lumbopelvic disorders where LS and GS were compromised.

Conclusion

The reduced resting muscle thickness shows an altered motor pattern of LS and GS among patients with sacroiliac joint dysfunction. Future studies should consider examining the biomechanical effects of altered LS and GS in SJD by looking into functional tasks such as prone hip extension and load transfer during gait.

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