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Alterations in the Posterior Oblique Chain Muscle Activity among Individuals with Sacroiliac Joint Dysfunction

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Abstract: Alteration in the posterior oblique chain (POC) muscle activity is one of the abnormal biomechanical patterns among patients with low back pain. However an understanding on the alteration of the POC muscles in sacroiliac joint dysfunction (SJD) is not known. Therefore, the main aim of this study was to investigate the changes in the amplitude of muscle contraction of POC among patients with SJD. A total of 40 participants (20 with SJD and 20 healthy participants as matched controls) were recruited in this study. The amplitude of muscle contraction of the POC which includes biceps femoris (BF), gluteus maximus (GM), contralateral lattissimusdorsi (LD) and contralateral upper trapezius (UT) were measured using a multi-channeled surface electromyography during a prone hip extension task. The amplitude of muscle contraction of POC was compared between ipsilateral and contralateral side among participants with SJD and as well as with healthy participants. Parametric and non-parametric statistics were used to analyze the data. The results showed significant higher amplitude of muscle contraction for BF (p=0.001) when compared between two sides among SJD participants and also when compared with healthy controls. Although there is a trend of higher amplitude of muscle contraction in other POC muscles, the differences in the contraction were not statistically significant. In conclusion, only BF in the POC showed higher amplitude of the muscle contraction during prone hip extension task which might be an alteration in POC and a compensatory mechanism among participants with SJD.

Key words: Sacroiliac Joint Dysfunction · Posterior Oblique Chain · Electromyography · Prone Hip Extension · Muscle Amplitude

INTRODUCTION

Low back pain is a very common problem with roughly 60% to 90% of people encounters it at some time in life with an annual incidence of approximately 5% [1]. Among several factors causing low back pain, sacroiliac joint is one of the major cause for low back pain [2,3]. Evidence suggests that sacroiliac joint dysfunction (SJD) as the primary source for low back pain among 22.5% of patients [4,5]. The term SJD refers to 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 [6]. The SJD is also referred to an altered position of the sacroiliac joint surfaces created by repetitive stresses which is maintained by compressive and elastic forces of the ligaments and the muscles crossing the sacroiliac joint [7].

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It is also a biomechanical condition where the joint is not stable and it is biomechanically not effective in transmitting load to lower limbs [4].

The sacroiliac joint constantly undergoes large shearing forces and the joint needs to be adequately stability to withstand these shearing forces. The local muscles system of pelvis and global muscles system along with osteoarticular ligamentous structures provide the stability to the sacroiliac joint with an effective central neural control system [8,9]. The local muscles system includes transverses abdominis and multifidus which acttogetherto compress the sacroiliac joint [10,11]. The global muscles systemwhich are responsible for the stability of the sacroiliac joints include longitudinal, lateral, anterior oblique and posterior oblique slings [12,13]. Of particular importance among the global muscles system, posterior oblique chain (POC) muscle system is crucial as it contributes to the functional stability of the sacroiliac joint. The POC is a myofascial muscular sling that runs from GM towards the lumbopelvic region ascends up into the deep lamina of the posterior thoracolumbar fascia, crosses the mid body segment and attach to the contralateral LD [12-14]. The muscles of the posterior oblique such as GM and LD acts as a functionally coupled unit along with thoracolumbar fascia to provide dynamic lumbopelvic stability [15,16].

Prone hip extension (PHE) task is a common movement used in clinical practice to evaluate and treat lumbopelvic dysfunction [17]. Previous studies suggested that the POC muscles are actively engaged during the PHE task and provides active dynamic stability to the sacroiliac joint [15,18]. Furthermore, the pattern of activation of POC muscles during PHE is proposed to represent the muscle recruitment pattern of hip extension during gait [18]. During PHE task, any altered muscle amplitude and muscle activation timing is suggested to cause altered movement patterns with occurrence of anterior pelvic tilt which could result in lumbopelvic symptoms [19]. Any such deficient and altered movement patterns is suggested to play a major role in development of musculoskeletal dysfunctions in lumbopelvic region [20].Therefore any understanding on the role of the muscles that protect and stabilize the lumbopelvic region is important for designing therapeutic exercises to prevent and treat lumbopelvic dysfunction [21].

Several past studies have investigated the muscle recruitment pattern of POC muscles during PHE and reported altered movement pattern among patients with low back pain [21,22]. However the changes in the motor pattern of POC muscles in SJD are not adequately studied. As SJD remains one of the main causes for low back pain, any knowledge on the motor pattern of POC system may be of therapeutic significance to the clinicians. Therefore, the main aim of this study is to investigate upon the changes in the amplitude of the muscle contraction of the POC in SJD. The primary objective of this study is to compare the amplitude of the muscle contraction of POC system between ipsilateral and contralateral sides among participants with SJD. The secondary objective is to compare the amplitude of POC contraction between participants with SJD and healthy subjects as matched controls.

MATERIALS AND METHODS

Subject: A total of 40 participants (n=20, participants with sacroiliac joint dysfunction and n=20, matched controls) participated in this study. All the participants were recruited based on pre-defined selection criteria. The participants with SJD were recruited from an outpatient physiotherapy department and in-patient wards from a University teaching hospital. The participants with sacroiliac joint dysfunction were recruited through a battery of clinical tests that include Gillet test, standing flexion test, prone knee flexion test, supine long sitting test and palpation of posterior iliac spine asymmetry on sitting. The participants were diagnosed with sacroiliac joint dysfunction if they showed positive response to at least four of five clinical tests [23-25]. The healthy participants were recruited as matched controls from the hospital staffs 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 BMI. Any patients who reported back pain over the past one year, who had any history of spinal surgeries, history of any musculoskeletal symptoms on the lower limbs over the past one 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 the University teaching hospital.

Instrumentation: The amplitude of muscle contraction of the POC muscles (GM, BF, LD and UT) were measured using a multi channeled surface electromyography (EMG) system (ME6000 Mega System Products with Megawin PC-software, VIA technologies, United Kingdom). Before the placement of the electrodes, the skin were prepared by shaving the hair, abraded with a fine sand paper and cleansed with the alcohol. After the preparation of the skin, self adhesive disposable Ag/AgCl disc electrodes with an electrical contact surface of 2 mm^2 were placed parallel on the muscles with an inter electrode spacing distance of 2.5 cm. The electrodes and leads were secured with adhesive tapes to prevent any further excessive movements during testing. The electrodes were placed on the muscles as per the recommended protocol [26]. The electrodes on the BF were placed at half the distance between the ischial tuberosity and lateral epicondyle of tibia. For GM, the electrode was placed at half the distance on the line drawn between sacral vertebra and greater trochanter. For LD, the electrodes were placed 4 cm below the inferior angle of eth scapula and half the distance between the spine and lateral edge of the torso. For UT, the electrodes were placed approximately at half distance on the line drawn between the seventh cervical vertebra and acromion. Normalization of the EMG data was performed using maximum isometric voluntary contraction (MVIC). Prior to the normalization trials, the subjects were instructed about the normalization movements for individual muscles for familiarization. The normalization was carried out for each of the muscles as recommended by the Kendall manual muscle testing procedures [27]. For normalization, a three seconds reference contraction data were recorded while the participants performed three trials of MVIC with a rest period of two minutes between each repetition. The average of the three recordings was calculated and all the EMG data were expressed as percentages of MVIC (%MVIC).

Procedure: The protocol for the prone hip extension task (PHE) was adopted from a previous study [18]. All of the participants were instructed about the prone hip extension task. The EMG measurements were made with the subjects in the prone position having their arms to the side of their body and while performing the PHE task on their dominant leg. The participants were instructed to lift the leg slowly until the lower edge of the patella is raised 15 cm from the table without bending the knee. The leg lift in the prone hip extension task was standardized for all the participants by setting a ruler above the lower leg which stopped the participants from lifting their leg more than 15 cm. For the participants with SJD, the same procedure was then repeated to the opposite leg. A total of three repetitions of prone hip extension task with a holding time of five seconds were performed with a rest period of two minutes between each trial. The averages of the three trials were measured as amplitude of the muscle contraction of the POC. All the raw signals collected were amplified and sampled at 1,000 Hz. The signal was filtered using digital filters with a high and low pass filter between 5 Hz-400 Hz and the final signal was expressed in root mean square using the software.

Statistical Analysis: The sample size for this study was calculated using the G*power program 3.1.0 for two tails, paired *t*-test. Based on the data from the pilot study on sacroiliac joint dysfunction, the estimated sample to obtain a power of minimum 80% at a significant alpha level of 95% required a total sample size of 20 subjects. Post-priori analysis also suggested that the recruitment of a total sample size of 20 subjects provided an actual power of 0.819. The data were analyzed using statistical software package (SPSS) for windows version 20.0. Examination of the normality of data using Shapiro-Wilk test showed normal distribution of the variables. The difference in the amplitude of the contraction of the posterior oblique sling muscles between the ipsilateral and contralateral side among participants with SJD was measured using the paired *t*-test for normalized distributed data and Wilcoxon signed rank test for the non normallly distributed data. The difference in the posterior oblique sling muscle amplitude between the participants with SJD and healthy controls were analyzed using independent sample *t*-test for the normalized data and Mann-Whitney U test for the non normalized data. The level of significance was set at 0.05 for all tests.

RESULTS

The mean (SD) of the age, weight, height and body mass index of the participants are shown in Table 1. The mean (SD) of amplitude of muscle contraction of the POC muscles between the ipsilateral side and contralateral side of SJD are shown in the Table 2. The general trend of mean values showed that the POC muscles had recorded higher amplitude of muscle contraction for the BF and GM on the ipsilateral side when compared to the contralateral side among the participants with SJD. However, the higher amplitude of muscle contraction was statistically significant only in BF ($p=0.01$) between the sides. The mean values of the amplitude of contraction of the POC muscles between the participants with SJD and healthy controls were shown in Table 3. The mean values of the amplitude of muscle contraction of POC muscles were generally higher among participants with SJD when compared to the healthy controls. However, the increased amplitude of muscle activity is significant only in BF ($p=0.01$) muscle between the two group of the participants.

Table 1: Demographic characteristics of the participants (mean±SD)

	Participants with SJD	Matched controls	P value
Age (in years)	35.2±6.2	35.9±8.1	0.13
Height (in cm)	161±6.7	164±6.3	0.03
Weight (in kg)	64±7.2	65±1.9	0.34
Body mass index	24±5.1	24±2.2	0.52

Table 2: Values of EMG amplitude of muscle contraction between ipsilateral and contralateral POC among participants with SJD (mean±SD)

	SJD		
Thickness	Ipsilateral muscles	Contralateral muscles	P value
BF	61.59±31.39	50.66±30.12	0.01
GM	26.13±15.78	22.62±17.85	0.31
LD	51.03±25.96	52.81±26.95	0.44
UT	42.84±24.62	43.43±23.09	0.79

SJD-sacroiliac joint dysfunction, BF-biceps femoris, GM-gluteus maximus, LD-latissimusdorsi, UT-upper trapezius. All the values of EMG amplitude is expressed in % MVIC-.-percentage maximum voluntary isometric contraction.

Table 3: Values of EMG amplitude of muscle contraction of POC between participants with SJD and matched controls (mean±SD)

Thickness	SJD Group Ipsilateral muscles	Matched Controls Dominant muscles	P value
BF	61.59±31.39	43.45±17.80	0.01
GM	26.13±15.78	23.11±15.11	0.31
LD	51.03±25.96	48.74±16.72	0.77
UT	42.84±24.62	37.22±19.21	0.90

SJD-sacroiliac joint dysfunction,BF-biceps femoris, GM-gluteus maximus, LD-latissimusdorsi, UT-upper trapezius. All the values of EMG amplitude is expressed in % MVIC.-percentage maximum voluntary isometric contraction

DISCUSSION

This study studied the changes in the amplitude of the muscle contraction of POC muscles system among participants with SJD during a PHE. The findings of the study suggested that the amplitude of the contraction pattern shows different trends of POC muscle activity among participants with SJD and in matched healthy participants. When the muscle activity of the POC has compared with the ipsilateral and contralateral of SJD, only those muscles such as GM and BF that lies with close proximity with the sacroiliac joint showed increase in pattern activity. In contrary, the muscles such as LD and UT that are away from the sacroiliac joint responded with reduced amplitude in POC system. However, when compared with the healthy participants as controls, the trend of POC contraction showed a higher amplitude for the whole chain of muscles among SJD participants. One specific finding from the results showed that the amplitude of muscle contraction of BF was significantly higher when compared between SJD participants and as well as healthy controls. In both the groups, the mean value of amplitude of contraction of BF was higher when compared to the GM which might indicate a weaker GM activity and BF hyper activity.

Unbalanced muscle activity, muscle weakness and poor neuromuscular control in the lumbopelvic region are major factors contributing to lumbopelvic dysfunction [28,29]. Several past studies reported alterations in the motor pattern of POC muscles system which support the findings of the current study among SJD participants [21,22,30,31]. Past studies had also reported increased activity of the POC muscle system among patients with chronic low back pain [21,22]. The increased activity of the POC muscles such as BF, GM and LD was suggested as a compensatory mechanism and additional effort by the body mechanics in order to carry out the functional task such as prone hip extension task and single leg standing tasks [21,22,30,31]. The contraction of the POC musle system was reported to tighten the thoracolumbar fascia in order to provide lumbopelvic stability [16]. Therefore, the higher amplitude of contraction observed in the POC especially in GM and BF might be a compensatory mechanism among participants with SJD to perform the PHE task with a stable pelvis. However, it is important to comment that the higher amplitude of GM and BF noticed is actually an increased activity of the muscle or a muscle guarding phenomenon by the muscles close to the sacroiliac joint.

The possible reasons for the altered amplitude of the POC muscle system among SJD participants may be of importance to the clinicians to design appropriate assessment and treatment strategies. The increased activity of the BF during prone hip extension task might be a compensatory mechanism to stabilize the sacroiliac joint among SJD participants. Past studies had supported a reasoning that shortening of the hamstring length increased the tension in the sacrotuberous ligament and long dorsal ligament thereby contributes to the stability of sacroiliac joint [32,33]. Another theory stated that any increased muscle activities in hamstrings with the attachment of BF with the ischial tuberosity prevents anterior rotation of innominate and induce posterior rotation of innominate which is essential for stability of sacroiliac joint [31]. Hence one might argue that the significant higher amplitude observed in BF during PHE might explain that the BF might be adopting the above explained roles to stabilize the sacroiliac joint during the task. The over activity of the POC system was suggested1 to be a functional adaptation by the muscles to increase stability of the lumbopelvic region [34]. In our opinion, it is equally important to consider the role of local stabilization muscles in sacroiliac joint stability along with the global muscles such as POC muscles. Evidence supports that pre-activation of transverses abdominis, internal oblique and multifidus induce posterior rotation of the innominate of illium relative to the sacrum and stabilize the sacroiliac joint [16]. Furthermore, in case of any local muscle system failure, it was reported that global muscle system would increase significantly to compensate the failure of the deep local muscle system [31]. Hence clinicians may consider all of the above factors when interpreting the role of POC muscle system in the management of lumbopelvic dysfunction.

The study has few limitations. First of all, the pelvic and hip movements are observed visually during the PHE task and there were no pelvic joint kinematics measured or standardized. However, the height of the leg lift during PHE was standardized for the participants by a ruler. Kinematic movements of the pelvis during PHE give more information about the pattern of movement substitutions which is not measured in this study. Although PHE task was suggested to resemble human gait, it is an open kinetic chain movement and it may be certainly different from a closed kinetic activity such as weight bearing position in gait. Hence the study findings may differ when the POC muscle activity to be measured during gait among participants with SJD. In fact, an understanding of the POC muscle system activity is recommended in a closed kinematic task such as gait as it closely resembles the daily functional activity.

CONCLUSION

The higher amplitude of the muscle contraction of BF might be considered as an alteration in POC muscle system during PHE task and it might be a compensatory mechanism among participants with SJD. Although the muscle contraction of other muscles (GM, LD, UT) of posterior oblique muscle system is not significant, the motor pattern shows an higher activity among SJD participants when compared to healthy subjects. Therefore, clinicians may consider assessment and treatment of POC muscle activity among patients with lumbopelvic dysfunction.

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