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Original Research Article

Myofascial force transmission in sacroiliac joint dysfunction increases anterior translation of humeral head in contralateral glenohumeral joint

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ABSTRACT

Introduction: Posterior and anterior oblique muscle slings contribute to the force closure mechanisms that provide stability to sacroiliac joint. These global muscle slings consist of myofascial network of fascia, muscles and tendons from global muscles. It links the lumbopelvic region to other joints of musculoskeletal system especially the contralateral glenohumeral joint (GHJ). Any sacroiliac joint dysfunction (SJD) may likely disrupt the force transmission across the oblique slings and it can affect the contralateral GHJ.

Aim: The current study aims to investigate the effects of SJD on the contralateral GHJ.

Material and methods: An experimental study is designed recruiting 20 participants with SJD and 20 healthy participants as matched controls to test the hypothesis that SJD may cause excessive anterior translation of humeral head (ATHH) in contralateral GHJ. Using real time ultrasonography, resting position of humeral head (RPHH), ATHH and posttranslation distance of humeral head (PDHH) are compared between the GHJs among participants with SJD and the matched controls. Paired sample *t*-test and independent sample *t*-test are used to analyze the data.

Results and discussion: The paired sample *t*-test result showed statistically significant increase in ATHH (P = 0.03) and PDHH (P = 0.01) in contralateral GHJs among participants with

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SJD. The independent sample *t*-test showed a significant increase in RPHH ($P = 0.01$) and PDHH ($P = 0.01$) in SJD participants when compared to matched controls.

Conclusion: SJD contributes to excessive ATHH in the contralateral GHJ. This may occur due to altered myofascial force transmission across oblique sling muscles.

1. Introduction

Sacroiliac joint is one of the common cause for low back and pelvic girdle pain.[1–3] Evidence suggests that the sacroiliac joint dysfunction (SJD) as the primary source of low back pain in 22.5% of patients,[4,5] and one of the potential causes of failed back surgery syndrome among patients with previous spine surgery.[6] SJD refers to any altered or impaired functioning of the somatic framework of sacroiliac joint and its related components such as arthrodial, myofascial, ligamentous, given that the articular surfaces are variable in anatomical position from side to side in an individual.[7] SJD is a musculoskeletal condition where the joint is biomechanically incompetent to transmit load in the absence of a demonstrable pathology.[1] As sacroiliac joint serves as the connecting link between the pelvis and the extremities, it was suggested that any functional SJD may cause secondary disorders in the musculoskeletal system.[8]

Many researchers has explored sacroiliac joint from biomechanical perspective for deeper understanding of joint dysfunction and its consequences to musculoskeletal dynamics.[9–11] Poor sensory motor function of the upper cervical segments and dysfunction of atlanto-occipital-axial joints are reported among patients with SJD.[8,12] Furthermore, the sacroiliac joint is acknowledged to influence the load transfer to lower extremities and foot.[13–15] Some other evidence relate to hamstring tightness and flexibility with SJD.[16,17] All of these studies suggest the biomechanical influence of the sacroiliac joint to structures far away from its presence. Very recently, researchers have started to explore the biomechanical and myofascial connection between lumbopelvic region and the contralateral shoulder region.[18,19] As per the principles of tensegrity that governs tension in tendons, muscles and fasciae, it may be possible that SJD may influence the contralateral glenohumeral joint (GHJ) through altered myofascial force transmission.

The anatomical and myofascial connections between the lumbopelvic region and contralateral glenohumeral region postulates for possibility of altered force transmission from SJD to contralateral GHJ.[20–23] The clinical reasoning for the above biomechanical force transmission lies through global muscle slings termed as posterior and anterior oblique muscular slings.[20,21] Posterior oblique sling is a myofascial muscular sling that runs from gluteus maximus toward the lumbopelvic region ascends up into the deep lamina of the posterior thoracolumbar fascia, crosses the mid body segment and attach to the contralateral humerus via lattisimus dorsi.[20,21,24] Similarly, anterior oblique sling includes structures such as pectoralis fascia, pectoralis major, anterior fascia of trunk, internal and external oblique, transverse abdominis ending up with the contralateral pubic bone.[20,22] It is through these muscle slings with myofascial tissues that the force transmission may occur between the lumbopelvic region and contralateral glenohumeral region by intra and inter-myofascial force transmission.[23,25]

The posterior and anterior oblique muscle slings can be seen as two elastic cables. In GHJ, the neutral position of the humeral head is maintained as long as the net passive elastic moment generated by both of these two muscle slings equals to zero. When the contractile force generated by the muscles of posterior oblique sling muscles is impaired as it may happen in SJD, then the net moment of force generation from anterior myofascial sling may increase which may cause excessive anterior translation of humeral head (ATHH) in the GHJ. Thus the current study proposes a medical hypothesis that there will be excessive ATHH in the contralateral glenohumeral when compared with the ipsilateral joint among participants with SJD and as well as matched controls. The findings of the study may assist the clinicians toward understanding the biomechanical effects of SJD on the musculoskeletal dynamics of the shoulder joint.

2. Aim

The first objective was to compare the amount of ATHH between ipsilateral and contralateral GHJ among subjects with SJD. The second objective was to compare the ATHH in GHJ between participants with SJD and matched controls.

3. Material and methods

3.1. *Subjects*

A total of 40 participants (20 participants with SJD and 20 matched controls) participated in this experimental study. All the subjects with SJD were recruited from outpatient physiotherapy department at a University tertiary hospital using a convenient sampling method. A battery of clinical tests which includes Gillet test, standing flexion test, prone knee flexion test, supine long sitting test and palpation of posterior iliac spine asymmetry on sitting were conducted to diagnose SJD.[24,26,27] All of the clinical tests were conducted by one senior musculoskeletal therapist. The diagnosis was made if a subject showed positive response to at least four of five clinical tests.[24,26,27] The healthy participants were recruited as matched controls from the hospital staffs and primary care givers. The healthy participants were matched in terms of age, weight, height and BMI. All the participants had full range of shoulder movements without any musculoskeletal complaints in the shoulder joints. Any participants with shoulder pathology, presence of pain on shoulder or any shoulder injury over the past 3 months, with any past history of shoulder surgery and those who were involved in repetitive activities for shoulder joint such as over head sports were excluded. The subjects were briefed about the study details and a written informed consent was obtained prior to their participation in the study. A University hospital ethical committee provided ethical approval for this study with ethical code NN-181-2011.

3.2. *Procedure*

A real time ultrasonography (Real-Time ultrasound, model IU22, Philip, Netherlands) by B mode through a linear transducer of 3.5 MHz was used to measure the ATHH based on the established protocol.[28–31] A qualified radiologist performed the US imaging of the shoulder translation from anterior GHJ. Three well defined bony landmarks which include greater tubercle of the humerus, coracoids process of the scapula and anterior superior part of the neck of scapula were identified and captured by the radiologist. In this position, the placement of the transducer on the skin was marked. The resting position of the humeral head (RPHH) was measured by placing the cursor on the coracoid process of scapula, neck of scapula and top of the greater tubercle in the captured image. The distance between neck of scapular and the top of greater tubercle was measured as RPHH (d1). A total of three trials were carried out and the average of the three readings was taken as final measurement.

The second part of the procedure involved the measurement of ATHH. Acromion process and humeral head were palpated and the joint line was identified. After identifying the shoulder line and the best angle for translation, the investigator applied a translator force of 80 N using a push–pull dynamometer to the posterior part of humeral head to passively translate the humeral head anteriorly to the point of end feel. The bony landmarks of shoulder posttranslation of 80 N were measured again by the radiologist using ultrasonography by placing the cursor on the coracoid process of scapula, neck of the scapula and top of the greater tubercle. The distance between the neck of scapula and the top of the greater tubercle after the translator force was measured and recorded as posttranslation distance of humeral head (PDHH) (d2). An average of three measures was taken for final reading of d2. The ATHH was calculated through the difference between distance measured during a passive anterior translation (d2) and at rest (d1). The reliability of the whole procedure was established with intraclass correlation coefficient value of 0.94 with SEMs (0.01 cm) prior to collection of the study data.

3.3. *Statistical analysis*

The data were analyzed using statistical software package (SPSS) for windows version 20.0. The paired sample-*t*-test was used to analyze the difference in ATHH between the ipsilateral and contralateral GHJ among participants with SJD. The difference in ATHH between participants with SJD and matched controls were analyzed using independent sample *t*-test. The level of significance was set at 0.05 for all tests. The Cohen *d* effect size for the observed effect was calculated to estimate the clinical effects of the observed findings.

4. Results

4.1. *Comparison of variables between contralateral and ipsilateral GHJ in SJD*

The mean (±SD) of the age, weight, height and body mass index of the participants are shown in Table 1. The mean (±SD) of RPHH, ATHH and the posttranslation distance of the humeral head between the ipsilateral and contralateral GHJs are demonstrated in Table 2. The results show that the RPHH, APHH and PDHH shows higher values in GHJ contralateral to the SJD when compared to the ipsilateral GHJ with significant differences in ATHH ($P = 0.03$) and the PDHH ($P = 0.01$). The analysis of the Cohen *d* effect size indicates that the observed effects were moderate to large for APHH ($d = 0.6$) and PDHH ($d = 0.5$), respectively.

4.2. *Comparison of variables between SJD and matched controls*

Table 3 shows the mean (±SD) of RPHH, ATHH and PDHH in GHJs between participants with SJD and matched controls. The results from independent sample *t*-test shows significant differences in RPHH ($P = 0.01$) and PDHH ($P = 0.01$) with a smaller effect size.

5. Discussion

The main aim of this study is to investigate the biomechanical effect of SJD on the contralateral GHJ. The results of the current study supported that there is a significant increase of ATHH in contralateral GHJ when compared to the ipsilateral GHJ in SJD and matched controls. The biomechanical concept of understanding altered myofascial force transmission on the musculoskeletal system in case of SJD is getting a topic of interest very recently among clinicians and researchers.[12,13,18,19] Recent evidences suggest the existence of global link between sacroiliac joint with cervical intervertebral joints, foot and hamstrings through altered muscle coordination patterns and disrupted myofasical force transmissions.[12,13,18] To the best of our knowledge, the current study is the first study which has investigated the global biomechanical effects of SJD in the contra lateral GHJ. In our opinion, an

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

	Participants with SJD	Matched controls	P value
Age, years	35 ± 6.2	35 ± 8.1	0.13
Height, cm	161 ± 6.7	164 ± 6.3	0.03
Weight, kg	64 ± 7.2	65 ± 1.9	0.34
BMI	24 ± 5.1	24 ± 2.2	0.52

Table 2 – Values for humeral head between contralateral and ipsilateral GHJ in SJD (mean ± SD).

Variables	SJD		Mean difference	CI of difference		*P* value	Cohen *d*
	Contralateral GHJ	Ipsilateral GHJ		Lower	Upper		
RPHH, cm	1.29 ± 0.24	1.22 ± 0.23	0.07	0.01	0.15	0.09	0.3
ATHH, cm	0.19 ± 0.10	0.13 ± 0.08	0.06	0.01	0.11	0.03	0.6
PDHH, cm	1.48 ± 0.28	1.35 ± 0.23	0.13	0.03	0.22	0.01	0.5

understanding of the muscle coordination patterns and myofascial force transmission from pelvic structures within and adjacent to sacroiliac joints may assist clinicians for effective management of musculoskeletal disorders.

5.1. *Fascial adaptability and tensegrity*

The explanation for changes in posterior myofascial sling in SJD and the possible impaired myofascial force transmission are discussed below. Human fascia influence musculoskeletal dynamics by transmitting force generated by muscles to surrounding tissues and as well as actively creating a myofascial vector force.[32] Also, fascia can spontaneously adjust its stiffness over a time period and contribute more actively to musculoskeletal dynamics.[32] In sacroiliac joint, the force closure is contributed by fascia and muscles.[15,33,34] Biomechanical analysis shows that myofascial forces have a stabilizing effect on pelvic load transfer.[35] As per the concept of tensegrity, a mechanical load in any part of the body is distributed to the entire skeleton through network of fascia, ligaments and muscles.[36] SJD is a condition where load bearing is compromised and the joint is biomechanically incompetent.[5] A model on myofascial-ligamentous force closure system on pelvis explains that the efficient transfer of load could not be sustained by pelvic structures alone but requires a coordinated function of local and global muscle systems.[15,33,34] However, several studies have indicated impaired and delayed activity of gluteus maximus in lumbopelvic dysfunction leading to instability of sacroiliac joint. Hence, the nature of the force and load in case of SJD may not be equally distributed and likely to be altered. As per the tensegrity concept, any such altered force from sacroiliac joint may influence the musculoskeletal dynamics through the myofascial connection with the contralateral GHJ. Furthermore, any biomechanical alterations in a joint is suggested to cause creep of the connective tissue and ligaments which desensitize the mechanoreceptors and change muscle activation.[37]

Several studies demonstrate the contributory role of lumbar fascia toward the lumbopelvic dysfunction. Patients with low back pain have fewer mechanoreceptors in the lumbar fascia with impairment in lumbopelvic proprioception and motor coordination.[15] Furthermore, decreased fascial tonus is also associated with spinal segmental instability and frequently contributes to the onset of low back pain.[38,39] Similarly, loss of fascial tone is suggested to cause sacroiliac pain and lack of force closure of the sacroiliac joint.[40] Therefore in SJD, there may be impaired force transmission in the thoracolumbar fascia which is a part of posterior oblique sling myofascial system. In any conditions of altered myofascial force transmission, the tension generated in a muscle is transmitted to adjacent muscles and to extra articular muscular structures such as ligaments and joint capsules within same segment or other segments and either directly or ultimately bones.[15,41] Eventually, the resultant extra articular myofascial force transmission may results in the extra muscular structures change in length and joint position.[41,42] Thus, the reduced force transmission from the posterior oblique system among participants with SJD may alter the musculoskeletal dynamics of the contralateral shoulder causing excessive ATHH in GHJ which can be discussed through a prestressed two spring model.

5.2. *A prestressed two spring model system*

The musculoskeletal system is a prestressed system regulated by two equally tensed springs or tension cables acting on any joints.[18,43] The two springs correspond to the presence of tension in elastic components such as myofascial structures, tendons and ligaments which works antagonistically to each other.[43] This prestressed tension determines the joint resting position with the net moment torque force from the spring on either side acting on the joint is zero.[18,43] If there is any increase of tension or impairment of tension in any one side of the spring system, i.e. in the elastic components, the net moment acting on the joint varies and eventually displaces the resting position of the joint compromising joint stability and proprioception.[43] As per this principle of prestress spring model, the posterior and anterior oblique myofascial sling may be considered as two antagonistic springs acting on the GHJ. We opine that the contractility and force transmission of the posterior oblique myofascial sling may get impaired when there is a lumbopelvic dysfunction. The reduced force

Table 3 – Mean values for humeral head in GHJs between participants with SJD and matched controls (mean ± SD).

Variables	SJD group	Matched controls	Mean difference	CI of difference		*P* value	Cohen *d*
	Contralateral GHJ	Dominant GHJ		Lower	Upper		
RPHH, cm	1.29 ± 0.24	0.98 ± 0.26	0.21	−0.46	−0.14	0.01	0.2
ATHH, cm	0.19 ± 0.10	0.15 ± 0.26	0.04	−0.09	0.02	0.29	0.1
PDHH, cm	1.48 ± 0.28	1.13 ± 0.23	0.38	−0.37	−0.06	0.01	0.2

transmission may results in reduced tension in the posterior oblique sling system and a compensatory increase in the passive tension in the antagonistic anterior oblique sling system. Thus, the increased force vectors from the anterior oblique myofascial system might cause the excessive ATHH in the GHJ. The application of the prestressed two spring concept is supported by a recent study which investigated force transmission between gluteus maximus and lattisimus dorsi. As per the prestressed spring model, the passive joint position sense of the hip was proved to be displaced by the myofasical force transmission from the contralateral latissimus dorsi. It supports that the excessive ATHH in the GHJ is likely to occur due to altered force transmission across posterior oblique myofascial sling in SJD.

5.3. *Clinical implications*

The clinical implications of this study highlight human fascial system as an interrelated tensile network which explains that a proximal joint dysfunction may alter the musculoskeletal dynamics of a distal joint at a distance which shares myofascial connections. In this case, this study supported the hypothesis that lumbopelvic dysfunction may contribute to the contralateral GHJ dysfunction. Therefore, clinicians may consider evaluating lumbopelvic joint among patients who have recurrent chronic shoulder dysfunctions and vice versa. Future studies may consider putting chronic low back pain into the fascial modeling equation and may look into the implications on the global musculoskeletal system.

6. Conclusions

Excessive ATHH in the contralateral GHJ occurs due to the altered force transmission from the posterior oblique sling muscles among participants with SJD. The findings show evidence that SJD contributes to myofascial force alterations in global muscle slings. Therefore, myofascial force transmission from global muscles system can be considered in management strategies of lumbopelvic and other musculoskeletal dysfunctions.

Conflict of interest

None declared.

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