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Evaluation of shoulder proprioception joint position sense in patient with impengement syndrome

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ABSTRACT

Objective: This study was to investigate proprioception joint position sense in subject with shoulder impingement. **Subjects:** Shoulder proprioception joint position sense (JPS) was measured in 40 subjects who were assigned to two groups: group A, healthy subjects (n = 20); and group B, subjects who had shoulder impingement (n = 20). **Method:** Joint position sense was measured by a Biodex system 3 pro Isokinetic dynamometer through determining angular displacement error of active angle-repositioning of shoulder external rotation. **Results:** The results revealed that, there was significant differences ($p < 0.05$) in proprioception JPS between the healthy subjects and affected shoulders of subjects with impingement syndrome and between affected and unaffected shoulder in group B. No significant differences was found in shoulder proprioception JPS between healthy subjects and unaffected shoulders of subjects with impingement syndrome ($p > 0.05$). **Conclusion:** This study imply that shoulder proprioception JPS in active repositioning of shoulder external rotation was affected in impingement syndrome.

Key words: *Shoulder impingement syndrome; Joint proprioception; Isokinetic.*

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INTRODUCTION:

Shoulder joint provides a functional link between upper limb and trunk. It has wide range of motion and is minimally constrained by articular anatomy. Stability of shoulder is provided mostly through the combined effect of static and dynamic soft-tissue factors [1]. The biomechanical function of the rotator cuff is to maximize contraction of rotator cuff and long head of biceps which dynamically stabilize the joint, especially in the midrange of motion where the ligaments are lax [2]. Furthermore, a coordinated, synergistic contraction of the rotator cuff and biceps may protect the ligamentus structures from injury [3].

Shoulder pain is a common musculoskeletal problem affecting approximately 16-20% of population [4, 5]. Moreover, one-fifth of all disability payments for musculoskeletal problems are for patients with shoulder disorders [6]. The most frequent cause of shoulder pain is subacromial impingement syndrome (SIS), accounting for 40% of shoulder disorders [7]. Several factors causing SIS include rotator cuff muscle weakness, muscle imbalance, capsular laxity or tightness, dysfunctional glenohumeral and scapulothoracic kinematics, degeneration and inflammation of the tendons or bursa [8, 9, 10]. The basic symptoms of impingement syndrome are pain, progressive limitation of active mobility of shoulder and a growing feeling of instability of shoulder joint (defined as a fear of subluxation). The reasons of these complaints may be the changes taking place inside muscles that are important for the proper functioning of the shoulder girdle caused by mechanical injury or by adaptive or compensatory changes occurring as a result of the impingement syndrome [10].

Proprioception is defined as the cumulative neural input to the central nervous system from specialized nerve endings called mechanoreceptors that located in the joint, capsules, ligaments, muscles, tendons, and skin [11, 12] and encompasses the sensations of joint motion and joint position [13]. Intact joint position sense is necessary for normal muscle coordination and timing. The traditional view is that sensations of joint position originated in the joint capsule [14]. However, a recent viewpoint suggests that muscle receptors also play a significant role [15]. Proprioceptive mechanisms appear to play a role in stabilizing the glenohumeral joint and may serve as a means for interplay between the static stabilizers and the dynamic muscle restraints [16]. If muscle coordination is impaired as a result of deficient proprioception, symptomatic shoulder instability can occur [17].

Previous studies examined proprioception of the shoulder in normal and pathological condition for normal and athletic individual and found proprioceptive deficits existed within individuals who had sustained anterior shoulder dislocations [3, 18, 19]. Another studies reported similar results when comparing shoulder proprioception of normal, unstable, and surgically repaired shoulders [19, 20]. Studies concluded that shoulder proprioception in active repositioning of external rotation was affected specially muscle mechanoreceptors in the presence of muscle fatigue. Since mechanoreceptors are responsible for proprioceptive feedback and causing active mechanism of protective joint restraint and joint position sense [21]. It is feasible to believe that, when these structures are injured, proprioceptive feedback is affected, and thereby, neuromuscular control and shoulder function are affected, with resultant proprioceptive deficits. This, in turn, could lead to reinjury. The contribution of proprioceptive deficits to the vicious cycle of insidious micro trauma involved in impingement syndrome and recurrent instability is unclear. Anderson [22], demonstrated that impairment of shoulder joint position sense in chronic rotator cuff pathology. The degree of proprioceptive impairment was greatest at higher elevations in the setting of increased shoulder impingement and pain, which may serve to perpetuate the pathology. There is little direct evidence to support proprioceptive impairments as either causal or effectual in these individuals. The purpose of this study is to evaluate proprioceptive joint position sense of shoulder in subjects with unilateral impingement syndrome relative to unaffected side and to subjects without impingement syndrome.

METHODS

A convenience purpose sample of 40 male and female subjects with age between 30 and 45 years were assigned into two groups. Group A, control group (CG): 20 normal volunteer subjects from stuff, employer and post graduate students of Faculty of Physical Therapy, Cairo University. Group B, study group (SG): 20 patients with shoulder impingement syndrome were selected from outpatient clinic of physical therapy department of orthopedic, Faculty of Physical Therapy, Cairo University.

Subjects in control group were matched for age, sex, and limb dominance. They had normal shoulders without history of shoulder injury, surgery, or medical problems that might influence the proprioceptive characteristics of the shoulder. Any subject had regularly participation in overhand sports or undertook more than 3 hours of overhead activities per week was excluded from the study.

The diagnosis of impingement was made initially by the referring physician and was confirmed by CT or MRI. Patients were eligible in group B if they had at least 3 of the following 5 criteria [23, 24, 25]: 1.Positive Neer sign: reproduction of pain when the examiner passively flexes the humerus to end range with overpressure, 2.Positive Hawekins sign: reproduction of pain when the shoulder is passively placed in 90˚ of forward flexion and internally rotated to end range, 3.Positive Jobe sign: reproduction of pain and lack of force production with isometric elevation in the scapular plane in internal rotation (empty can), 4.Pain with apprehension: reproduction of pain when an anteriorly directed force is applied to the proximal humerus in the position of 90˚ of abduction and 90˚of external rotation, 5.Positive relocation test: reduction in pain after a positive apprehension test when a posteriorly directed force is applied to the proximal humerus in the position of 90˚.

Patients were excluded from SG if they had any of the following criteria [23, 24, 25]: 1.Current symptoms related to cervical spine, 2.Positive tests for shoulder instability: a)Sulcus sign: A positive sulcus sign is an excessive downward movement of the humeral head away from the acromion when an inferior pull is placed on the humerus while the arm is in a dependent position. b) History of shoulder dislocation, 3.Acromioclavicular pain: with the arm flexed to approximately 90 degrees, pain is reproduced by passively adducting and internally rotating the humerus across the chest to approximate the acromioclavicular joint, 4.Frozen shoulder as a complication of rotator cuff impingement syndrome, 5.Any other pathology of shoulder as degenerative arthritis.

The study was explained to all subjects who met the criteria, and they were asked to read and sign the informed consent agreement approved by the department and faculty institutional review boards.

Prior to initiating the study, a sample of 20 subjects per group was selected to provide 80% power to detect differences of 2° of acuity between the 2 groups of interest [26]. SDs of 3.5° and 2.0° were applied on the basis of other research investigating human proprioception among persons shoulder disorders and control subjects, respectively [7, 27].

Instrumentation

Isokinetic: Biodex system 3 pro Isokinetic dynamometer (Biodex Medical INC., Shirley, New York, USA), was used to measure the proprioceptive accuracy of the shoulder joint. The reliability and validity of the biodex system 3 pro Isokinetic dynamometer had been favorably demonstrated in several studies [28, 29].

Calibration of the Biodex System 3 was done by associated researcher of the lab every month by using reference weight, under the supervision of Manufacture Company.

Procedure

All tests of this study were conducted at the Isokinetic lab at the Cairo University by a single examiner. Subjects performed the active angle-repositioning test (AAR) on the biodex system 3 pro Isokinetic dynamometers. This test measures proprioceptive feedback using active repositioning of joint position. It was reported that active joint position assessment stimulates both joint and muscle mechanoreceptors and is a more functional assessment of afferent pathways [30]. The sensibility level of shoulder proprioception was measured by determining the repositioning error of active shoulder external rotation. The validity and reliability of this method in the assessment of shoulder proprioception had been demonstrated by Dover and Powers [31].

The steps of the measurement were explained for each subject. Weight, height and personal data were recorded to the computer. The dynamometer chair rotation was adjusted to zero degree and dynamometer tilting was adjusted to five degree. The limb support was set in place and the shoulder attachment was fixed to the dynamometer, so the fulcrum of the dynamometer was corresponding to the axis of rotation of the patient's shoulder.

Each subject was seated on the chair with his or her shoulder positioned in 90º abduction, 90º elbow flexion, and neutral pronation/ supination. All subjects were blindfolded to eliminate visual clues to arm position. To eliminate auditory clues to the start of arm rotation, subjects wore a set of earphones and listened to ''white noise'' during test. To familiarize themselves with the testing device, subjects were instructed to actively perform three repetitions of shoulder movement ranging from maximal internal rotation to maximal external rotation. Type of test was chosen (active repositioning test with speed 30º / sec) with three repetitions for each test. Range of motion was set (from 0º- 90º) and the anatomical reference angle for shoulder external rotation was set at 75ºusing the control panel. The weight of the tested limb was recorded through the computer for each subject. After this the subject was ready to start test procedures. The subject moved his shoulder and held at the starting angel 0º, by using the hold/ resume (HR) button. The tested limb was allowed to move to reference angle actively by the subject then held for 10 sec as teaching process for the subjects [32]. The limb was allowed to return to the starting angle actively. Then the subject was allowed to return to the reference angle actively and when he feel that he reach the reference angel the apparatus stopped by using H/R button Fig. (1).

Fig. 1: Active angle reposition test

Three trials were recorded. The Angular displacement error was recorded as the error in degrees between the presented angle and the reference angle. The mean of the three trials for each test condition was calculated to determine an average error score that was used in the statistical analysis [32]. Tests were performed in a single session, with the test order of unaffected shoulder followed by the affected shoulder. In the control group, the non dominant shoulder was tested.

Statistical analysis:

The statistical analysis was conducted using the SPSS for Windows computer software system (SPSS, Chicago, Ill.). Independent t-test was used to determine significant mean differences between the normal and affected shoulder or between the affected and unaffected shoulder. The level of significance for all statistical analysis was set at $p < 0.05$.

RESULTS

Demographic characteristics of subjects are represented in Table 1.

Table (1): Demographic characteristics of the all subjects

Items	CG M± SD n= 20		SG M ±SD n= 20		P- value
Age (years)	34.6±6.75		32.6± 2.79		0.53
Weight (Kg)	62.8±7.03		63.5± 8.03		0.35
Height (cm)	163.1±3.63		163.5± 4.71		0.85
Sex	**Male**	**Female**	**Male**	**Female**	
	10	10	11	9	
Duration of illness (months)	-----------------------		13.35 ± 2.97		

M: mean, SD: standard deviation, CG: control group, SG: study group, MD: mean difference

Shoulder position sense was measured by active angle-repositioning test (AAR) and quantified with angular displacement error. The control group achieved a mean angular displacement error value of 4.39° ± 2.56°. While The SG has mean value of angular displacement error for affected side 7.53° ± 3.12°, and 4.55° ± 2.37°for unaffected side.

Unpaired t- test revealed a statistical significant difference between the control group and affected side of SG. While there was no significant difference existed between the control group and unaffected side of SG. Also, unpaired t- test revealed a statistical significant difference in the mean value of angular displacement error between the affected and unaffected side of SG, fig. (2) and table (2).

DISCUSSION

Impingement syndrome is one of the most common shoulder disorders. Proprioception is a critical component of coordinated movement at the shoulder complex, and deficits had been found in pathological shoulders [22]. Previous researches have demonstrated differences in shoulder proprioception between normative and pathologic groups [33, 20], normative and surgically repaired groups [34, 20] and normative and highly trained groups [35]. Recently, Anderson [22] found that adults with chronic rotator cuff pathology had reduced absolute proprioceptive acuity during shoulder elevation, relative to asymptomatic controls.

Evidence to support the existence of abnormal shoulder proprioception in patient with impingement syndrome is limited [36, 22]. The purpose of the study was to determine whether impingement syndrome had a significant effect on proprioceptive feedback of the shoulder.

Fig. 2: Mean values of angular displacement error of control group and study group.

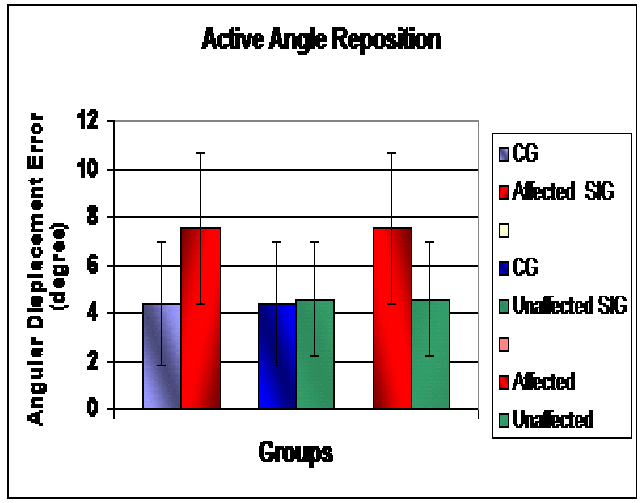

Table 2: Angular displacement error for CG, affected and unaffected side of SG in degrees.

Groups	M ±SD	T	P-value
CG	4.39 ± 2.56		
SG Affected	7.53 ± 3.12		
MD	3.14	3.005	0.005*
CG	4.39 ± 2.56		
SG Unaffected	4.55 ± 2.37		
MD	0.14	0.178	0.86#
SG Affected	7.53 ± 3.12		
SG Unaffected	4.55 ± 2.37		
MD	3.02	2.938	0.006*

M: mean, SD: standard deviation, CG: control group, SG: study group, MD: mean difference

Joint position sense (JPS) is one of the most commonly used measures of proprioception [3]. An intact JPS has been shown to be necessary for normal muscle coordination and timing, and this has been shown to be evident where active muscle forces play a significant role as in glenohumeral joint stability [33]. JPS is usually tested by active limb repositioning after presentation of a reference position [11], which can be conducted actively or passively and in an open or closed chain environment [37].

Reliability coefficients ranging from 0.95 to 0.99 have been reported for JPS [38, 39]. Methods for measuring proprioception include custom-made electromagnetic tracking [40, 37, 30], and Isokinetic dynamometers [3, 41, 12].

The result of this study showed significantly increased angular displacement error scores in unilateral shoulder impingement when compared with unaffected side and with control group. These findings supports the majority of the current literature which shows significant differences in JPS following glenohumeral joint injury [39]. The reason for this dysfunction is not completely understood. A possible reason for dysfunction may be changes in muscle activity that may affect proprioceptive acuity.

This was confirmed by many studies that found changes in the electrical activity of supporting muscle of shoulder due to impingement syndrome. Researchers reported a significantly decreased EMG activity in infraspinatus during 30-90° concentric scaption, middle deltoid during 60-90° concentric scaption and decrease in activity of subscapularis in subjects with SIS compared to healthy controls [42, 43, 44].

On the other hand, Irlenbusch and Gansen [45] found that there was disturbance of muscle fiber distribution in the deltoid and supraspinatus muscles especially in fast twitch fibers even at early stage of impingement syndrome. There is shift in balance between fast twitch fibers and slow twitch fibers. So, there is a primary disturbance of muscular coordination as fast twitch fibers are responsible for rapid reaction and thus the fine motor control of the joint.

Proprioceptive feedback regarding joint position results from mechanical stimulation of the mechanoreceptors present in the articular structures, muscles, and possibly skin. These receptors need to be mechanically deformed or loaded to transmit impulses to the central nervous system [39].

Post muscle fatigue or weakness will reduce sensitization of the muscle mechanoreceptors in rotator cuff tendons. This desensitization of rotator cuff may reduce shoulder proprioception more significantly in shoulder external rotation. Dysfunction of mechanoreceptors in external rotation may explain our result that there is a difference in active repositioning in external rotation between control and study group [21].

Shoulder impingement syndrome is characterized by pain that is exacerbated with arm elevation or overhead activities. It was reported that the highest fall of the EMG activity on the diseased side was caused by the reflexory adaptive changes defined as the strategy of avoiding pain [46]. Pain will reduce sensitization of the muscle mechanoreceptors which may reduce shoulder proprioception [47]. This was confirmed by two studies demonstrated changes in the timing or onset of muscle recruitment in the unaffected as well as the painful shoulder, indicating the possibility of a pain for proprioception error [48, 49].

With regard to muscle spindle, it considered the most important peripheral receptor to the sensation of position and movement in humans [50, 51, 52]. Factors which alter muscle spindle sensitivity may therefore affect proprioception [53]. Several animal studies have found evidence for a connection between group III and IV afferent input (associated with muscle pain) and the muscle spindle system [54, 55, 56].

It was proved that the two important factors may interfere with a neuromuscular mechanism are the reduction of rotator cuff muscle strength and loss of precision in coordination. Special attention should be given to training of muscle coordination and proprioception especially at early stage of the impingement syndrome [45].

The results of this study have clinical relevance. The subjects' ability to recognize joint position was hindered in impingement syndrome. The implications from decreased proprioceptive feedback integrated at the CNS, which elicits efferent neuromuscular responses as both spinal reflexes and preprogrammed responses vital to functional stability of the shoulder joint and the neuromuscular responses responsible for joint stability may be hindered, leading to joint instability and eventually joint injury. Clinicians should consider proprioceptive rehabilitation protocols for shoulder impingement even at early stage.

CONCLUSION

This study revealed that shoulder proprioception JPS in active repositioning of shoulder external rotation is significantly altered in impingement syndrome.

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الملخص العربى

تقييم مستقبلات الحس العميق بوضع مفصل الكتف في مرضي متلازمة اصطدام الكتف

هدف البحث: - التحقق من أصابه مستقبلات الحس العميق في المرضي الذين يعانون من متلازمة اصطدام للكتف. **تصميم البحث: -** تقييم مستقبلات الحس العميق باستخدام بيوديكس 3 ايزوكينتك ديناموميتر. **مقاييس النتائج الرئيسية: -** قياس الشعور بوضع المفصل باستخدام بيوديكس 3 ايزوكينتك ديناموميتر من خلال تحديد الخطأ في وضع مفصل الكتف أثناء حركه الدوران الخارجي للكتف . **طريقة البحث: -** قد تم قياس مستقبلات الحس العميق للكتف عن طريق قياس الخطأ في وضع مفصل الكتف في مجموعتين: المجموعة أ، مجموعه سليمة غير مصابه (عددهم = 20)؛ والمجموعة (ب)، المجموعة المصابة بمتلازمة اصطدام الكتف (عددهم = 20). وتم قياس الشعور بوضع المفصل باستخدام بيوديكس 3 ايزوكينتك ديناموميتر من خلال تحديد الخطأ في وضع مفصل الكتف أثناء حركه الدوران الخارجي للكتف. **النتائج: -** أوضحت النتائج أن هناك فروق ذات دلالة إحصائية ($P<0.05$) للإحساس بوضع المفصل بين الأشخاص الأصحاء والكتف المصاب في المرضي الذين يعانون من متلازمة اصطدام للكتف وكذلك بين الكتف المصاب والغير مصاب في المجموعة ب , بينما لم يكن هناك اختلافات ذات دلالة إحصائية ($P>0.05$) للإحساس بوضع المفصل بين الأشخاص الأصحاء والكتف الغير مصاب . **الخلاصة:-** يوجد اصابه لمستقبلات الحس العميق الخاصة بالإحساس بوضع المفصل في المرضي المصابين بمتلازمة اصطدام للكتف.

مفتاح كلمات البحث:- متلازمة اصطدام للكتف ، مستقبلات الحس العميق، بيوديكس 3 ايزوكينتك ديناموميتر.