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Cervical spine mechanical deficits in patients with shoulder impingement syndrome: A case-control study

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ABSTRACT

The purpose of this case-control study was to investigate whether cervical mechanical deficits differ between patients with shoulder impingement syndrome (SIS) and control subjects. A total of 40 non-athletic males and females participated in this study. They were divided into two groups: group A, including 20 patients with SIS with a mean age of 36 years, and group B, including 20 control subjects with a mean age of 34 years. Each participant was assessed for pain and disability using shoulder pain and disability index (SPADI), active joint angular reproduction (AJAR) at 30º cervical flexion and extension using inclinometer, and craniovertebral angle (CVA) using photography. The results of the study showed that there was a statistically significant positive correlation between AJAR error at 30º cervical flexion and both shoulder pain and disability ($r > 3$, $p = <0.05$), and also a statically significant difference between groups at AJAR error in extension ($t = 3.8$, $p = 0.000$). In conclusion, cervical proprioception deficits showed a significant correlation with shoulder pain and disability in patients with SIS.

KEYWORDS

Shoulder Impingement Syndrome; Craniovertebral Angle; Proprioception.

1. INTRODUCTION

Subacromial impingement syndrome (SIS) is traditionally characterized by a narrowing of the subacromial space that causes encroachment of the subacromial tissues such as the rotator cuff and subacromial bursa (Lewis, Wright & Green, 2005). Forty-four to sixty-five percent of the population with shoulder pain is impingement (Van der Windt, Koes, Boeke, Deville, de Jong & Bouter, 1996). It has high recurrence rate (Rekola, Levoska, Takala & Keinänen-Kiukaanniemi, 1997), and the direct cost of its treatment is $7 billion in US (Meislin, Sperling & Stitik, 2005).

Cervical spine mechanical deficits as impaired posture and proprioception are common, both generally and specifically in SIS, and importantly related to shoulder. Forward head posture (FHP) is an important factor in development of shoulder injuries (Greenfield, Catlin, Coats, Green, McDonald & North, 1995), by decreasing glenohumeral stability as the glenoid fossa becomes more vertical due to serratus anterior weakness (Janda, 1988) and increasing load in the muscles (Sjøgaard, Lundberg & Kadefors, 2000). The incidence ofr forward head posture is 66% among people in age group of 20 to 50 years (Mueller-Klaus, Oatis, Griegel-Morris & Larson, 1992). In addition to that, up to 40% of patients with shoulder pain have cervicothoracic spine dysfunction (Sobel, Kremer, Winters, Arendzen & de Jong, 1996).

2. LITERATURE REVIEW

Cervical alignment is associated with the efficient function of the deep cervical flexors (Falla, O'Leary, Fagan & Jull, 2007), the trapezius and the serratus anterior muscles (Weon, Oh, Cynn, Kim, Kwon & Yi, 2010). Sustained forward flexion of the neck results in excessive loading of the cervical and shoulder girdle muscles (Sjøgaard, Lundberg & Kadefors, 2000). The cervical spine is one of the three key areas of proprioceptive input for the maintenance of posture (McLain, 1994) and preparing for and responding to joint movements for functional stability (Riemann & Lephart, 2002). So, it is hypothesized that altered cervical proprioception will lead to shoulder dysfunction directly by reducing its protective mechanism and indirectly by causing postural abnormality which in turn badly affects the scapular and shoulder mechanics.

Research focusing directly on the effect of various cervical postures on rotator cuff strength is recommended to be conducted to shed further light on the relationship between the cervical spine and shoulder function (Pheasant, 2016).

Joint position sense measures the accuracy of position replication and can be conducted actively or passively in both open and closed kinetic chain positions (Torres, Vasques, Duarte & Cabri, 2010). It can be also assessed using contralateral or ipsilateral matching responses (Bouet & Gahery, 200.).

The Kinovea computer program is a software that is able to measure range of motion (ROM) of the body's joints; a video can be analyzed in slow motion so that the video can be viewed frame by frame. Lines and arrows can be added on the video with the drawing tool (Watson & Trott, 1993). The use of photography, or photogrammetric method, to assess FHP has been reliable and sensitive (Gadotti & Biasotto-Gonzalez, 2010). It is a valid method that correlates well with radiographs (Grimmer-Somers, Milanese & Louw, 2008). Shoulder pain and disability index (SPADI) has shown to be valid and highly responsive in assessing shoulder pain and function (MacDermid, Solomon & Prkachin, 2006). Therefore, it is highly recommended for the use in patients with SIS (Cloke, Lynn, Watson, Steen, Purdy & Williams, 2005).

Forward head posture positions the scapula in more elevated, protracted, anteriorly tilted (Kebaetse, McClure & Pratt, 1999), and downwardly rotated position (Lewis, Wright & Green, 2005), causing forward shoulder posture, inefficient upper trapezius and rotator cuff (Ludewidg & Reynolds, 2009), mechanical block to elevation of the humerus, and irritation of the subacromial tissues (Sahrmann, 2002). As a result, considerable importance is placed on the assessment and correction of posture in patients with shoulder impingement syndrome (Kibler, 1998).

The mechanical factors external to the tendon which may potentially lead to shoulder impingement syndrome include altered cervical and/or thoracic posture. Evidence based guidelines for the clinical examination of subacromial shoulder impingement recommend including measurement of cervical posture in addition to orthopedic special tests (Hanchard, Cummins & Jeffries, 2004).

Without correct sensorimotor control, there will be increased translation between the humeral head and glenoid, resulting in plastic deformation and laxity of the joint capsule, decreased rotator cuff facilitation and alterations in muscle sequencing and timing (Ogston & Ludewig, 2007).

Several studies have addressed the relation between cervical spine and shoulder joint. Some found a relation (Lewis, Wright & Green, 2005; Greenfield, Catlin, Coats, Green, McDonald & North, 1995; Lewis, Green & Dekel, 2001; Thigpen, Padua, Michener, Guskiewicz, Giuliani & Keener, 2010; Land, Gordon & Watt, 2017; Walker, Salt, Lynch & Littlewood, 2018; Shin, Kim & Kim, 2017), and others not (Pheasant, 2016; Hanchard, Cummins & Jeffries, 2004; Gumina, Carbone, Arceri, Rita, Vestri & Postacchini, 2009; Ahn, Kim, Bendik & Shin, 2015; Zhang, Theologis, Tay & Feeley, 2015; Yong, Lee & Lee, 2016; Katsuura, Bruce, Taylor, Gullota & Kim, 2019).

So this study is conducted to investigate the correlation between cervical mechanical deficits (forward head posture and cervical proprioception), shoulder pain and disability and the difference between patients with SIS and control subjects in terms of cervical mechanical deficits. It is hypothesized that forward head posture and cervical active joint angular reproduction at 30^0 flexion and extension do not correlate with pain and disability in shoulder impingement syndrome patients and that SIS patients do not differ significantly from control subjects in terms of cervical mechanical deficits.

3. METHODS

3.1. Study Design

A case-control study was carried out. Prior to commencing the study, ethical approval was fulfilled from the institutional review board at the Physical Therapy Faculty of Cairo University (NO: P.T.REC/012/002372). It was implemented between June 2019 and December 2019.

3.2. Participants

A convenience sample of forty non-athletic males and females was recruited by announcement at a hospital. The sample was divided into two groups: group A including 20 patients with SIS, and group B including 20 control subjects. Informed consent was taken from each participant after interpreting the research aims and procedures, ensuring their privacy through coding of all their data.

Patients were included in the shoulder impingement group (Group A) if they had at least 3 out of the following 6 criteria (Lukaseiwicz, McClure, Michener, Pratt & Sennett,1999; Lewis, Wright & Green 2005): 1) positive "Neer’s sign"; 2) positive “Hawkins’ sign”; 3) pain on active shoulder elevation in the scapular plane; 4) pain on the C5-C6 dermatome; 5) pain on palpation of the rotator cuff tendons and 6) pain with resisted isometric abduction. Control group had no pain or disability in the shoulder.

Participants were excluded if they complained from any of the following: 1) malignancy; 2) shoulder infection; 3) macro-instability in the shoulder or cervical regions and 4) spinal or upper limb fractures, trauma, surgery.

Sample size calculation was performed using G*POWER (version 3.1) [t-test- difference between two independent groups, α=0.05, power=0.8, effect size = 0.9 from pilot study] and revealed that the appropriate sample size is 40 (20 per group).

3.3. Outcome Measures and Procedures

The procedures were carried out in the outpatient clinics of Cairo University and 23rd of July Egypt Hospitals.

3.3.1 Assessment of shoulder pain and disability

Participants completed the questionnaire of shoulder pain and disability index (SPADI) (Lee, Moon, Lee, Cho, Im, Kim & Min, 2016). They signed at visual analogue scale (VAS) below each question, and scores were calculated using a ruler, with “zero” at right end of VAS and “ten” at the left end of VAS (Pincus, Bergman, Sokka, Roth, Swearingen & Yazici, 2008). Scores were calculated as follows: scores from all questions were added and the mean value was chosen for data analysis.

3.3.2. Cervical proprioception (active joint angular reproduction at 30^0 flexion and extension)

The subject was instructed to stand with his/her feet shoulder length apart, and sit upright on the chair without leaning over the chair. Bubble inclinometer was fixed with a strap directly above the ear, looking straight ahead. The bubble inclinometer was set at zero and the participants were asked to bend his/her neck at an angle of 30 degrees to hold the pose for 3 seconds. Also, the participants were asked flex and extend the head 3 times the assume the neutral position, then bend his/her neck at an angle of 30 degrees and hold the position for 10 seconds (the participants were asked to remember the point of flexion to repeat). After coming back to the neutral position, the participants were asked to go back to the predetermined position and keep the position for 3 seconds. The flexion angle was measured and recorded. The same procedure was repeated for extension (Land, Gordon & Watt, 2017; Dover, Kaminski, Meister, Powers & Horodyski, 2003).

3.3.3. Forward head posture assessment

Sagittal view photographs were taken for the head, cervical and upper thoracic region. The participanst stand at 90 degrees in a direct line to a camera. The camera distance from each subject was standardized to 2 m. Floor markers were used to standardize the participant position. Markers were attached to the spine using double sided tape and were placed overlying C7 and at the tragus of the ear. They were put on the wall at the level of their eyes. The assessor demonstrated to the participant the postures to be adopted. The subjects were instructed to roll their shoulders forward and back three times and then stand relaxed in their normal posture (Greenfield, Catlin, Coats, Green, McDonald, & North, 1995; Edmondston, Waller, Vallin, Holthe, Noebauer & King, 2011).

Each photo was taken from the right side only (as it not differs between sides in sitting (Youssef, 2016), and entered Kinovea software for the calculation of the angle (Elwardany, El-Sayed & Ali, 2015).

Craniovertebral angle (CVA) is a gross measure of the amount of forward positioning of the head on the trunk. The CVA is the angle, in degrees, of the horizontal line intersecting with a line drawn from the tragus of the ear to the spinous process of C7 (Grimmer-Somers, Milanese & Louw, 2008).

3.4. Data Analysis

Demographic data (means and standard deviations of age, weight, height, and body mass index) were calculated using descriptive statistics. The difference between groups in forward head posture and cervical AJAR at flexion and extension and demographics was calculated using independent t-test. Pearson's correlation coefficient was used to find the correlation between forward head posture and cervical AJAR at flexion and extension, and shoulder pain and disability. The significance level was set at 0.05. The normality test of the data reflected that the data were normally distributed. All statistical analyses were done using SPSS version 20 (IBM Inc., Chicago, IL).

4. RESULTS

4.1. Characteristics of Participants

Table 1 shows the participants' characteristics in both groups. There were no statistically significant differences between groups ($p > 0.05$).

Table 1. Characteristics of participants

Characteristics	**Group A**	**Group B**	**p value**
Age (years), $\bar{X}$ ±SD	36.4(±6.7)	33.8(±5.4)	0.25
Weight (kg), $\bar{X}$ ±SD	74.9(±11.07)	72.7(±17.9)	0.7
Height (cm), $\bar{X}$ ±SD	163(±6)	159(±7.5)	0.13
BMI (kg/m2), $\bar{X}$ ±SD	28.4(±4.6)	28.4(±5.7)	1
Duration of illness (m), $\bar{X}$ ±SD	15(±22)		
Gender (♂%)	10	5	0.55
Dominant arm involved (%)	50		
Shoulder pain (cm, VAS)	28.5(±12.4)		
shoulder disability (cm, VAS)	39(±21)		

$\bar{X}$ (mean); SD (standard deviation); BMI (body mass index); ♂% (male percentage); m (months)

4.2. Differences in posture and proprioception between study groups

Descriptive statistics for craniovertebral angle (CVA), cervical extension joint position sense (JPS), and cervical flexion JPS are shown in Table 2. The differences between Group A and B were non-significant ($p < 0.05$) except for cervical extension joint position sense (JPS), which was statistically significant in both groups ($p = .000$).

Table 2. Difference between the groups in the craniovertebral angle and position sense

Variables	Group A (n=20)	Group B (n=20)	t value	p value
CVA	33 (10.4)	27.9(9)	1.5	0.14
FLEX	4.9(3.3)	3(2)	1.864	0.07
EXT	5.3(3.3)	2.5(1.4)	3.8	.000*

CVA (Craniovertebral angle); FLEX (Cervical flexion joint position sense); EXT (Cervical extension joint position sense)

4.3. Correlation between cervical proprioception and posture, and shoulder pain and disability

There were no statistically significant correlations between cervical extension (JPS) and CVA with shoulder pain, and between CVA and cervical extension (JPS) with shoulder disability ($p > 0.05$) However, there was a positive significant correlation between cervical flexion (JPS) with shoulder pain ($r = 0.334$, $p = .03$) and disability ($r = 0.3$, $p = 0.05$), as shown in Table 3.

Table 3. Correlation between CVA and position sense with shoulder pain and disability

	r	p value
CVA and shoulder pain	0.11	0.65
Cervical flexion JPS and shoulder pain	0.334	0.03*
Cervical extension JPS and shoulder pain	0.19	0.22
CVA and shoulder disability	-0.08	0.74
Cervical flexion JPS and shoulder disability	0.3	0.05*
Cervical extension JPS and shoulder disability	0.18	0.258

JPS (joint position sense); CVA (craniovertebral angle)

5. DISCUSSION

The general hypothesis of the study stated that there would be significant correlations between cervical mechanical deficits and shoulder pain, disability in patients with unilateral SIS. The results of this study failed to reject this general hypothesis totally, as there were statistically significant differences between groups in cervical extension JPS ($t = 3.8$, $p = 0.000$) and a fair positive significant correlation between cervical flexion and shoulder pain ($r = 0.334$, $p = 0.03$) and disability ($r = 0.3$, $p = 0.5$).

The current study showed that only cervical flexion joint position sense deficits have significant correlation with both shoulder pain and disability, and that only cervical flexion joint position sense deficits significantly differ between shoulder impingement syndrome patients and normal controls. This may suggest that cervical proprioception is important in rehabilitation and prevention of shoulder impingement syndrome, but experimental studies are needed to prove that.

Findings of the present study regarding non-significant difference between groups in CVA, agree with the study by Lewis, Wright & Green (2005) who found that when subjects who were experiencing SIS improved their posture, it was not a significant effect on the intensity of the pain. Furthermore, findings of the present study agree with work of Greenfield, Catlin, Coats, Green, McDonald & North (1995); Thigpen, Padua, Michener, Guskiewicz, Giuliani & Keener (2010) who demonstrated that FHP negatively impact shoulder mechanics independent of shoulder pain (i.e. no relationship between FHP and shoulder pain). These findings mean that improving FHP is not necessarily accompanied by improved shoulder pain as the latter may be the cause of FHP. In addition to that, the current study supports and agrees with the work of Land, Gordon & Watt (2017) who reported that FHP is not an independent predictor of SIS. The current study supports the result of Walker, Salt, Lynch & Littlewood (2018) who found that the role of the cervical spine in shoulder pain remain unclear, also it is on the same line with the study by Shin, Kim & Kim (2017) who found a significant negative correlation between neck pain and shoulder ROM and muscle strength.

Findings of the present study disagree with the work of Pheasant (2016); Ahn, Kim, Bendik & Shin (2015) who reported that strengthening deep neck flexors and correction of FHP resulted in significant decrease in shoulder pain. Our findings disagree with the work of Lewis, Green & Dekel (2001); Hanchard, Cummins & Jeffries (2004) who found that altered cervical posture is an extrinsic factor for subacromial impingement syndrome, also disagree with the work of Katsuura, Bruce, Taylor, Gullota & Kim (2019). In their systematic review that assess the relationship between the shoulder and the spine reported that there is evidence to suggest cervical spine pathology may cause shoulder pain. Alterations in the alignment of the spine change the mechanics of the shoulder and can increase the incidence of shoulder dysfunction. Also, a study by Zhang, Theologis, Tay & Feeley (2015) showed that degenerative cervical spine pathology may pre-dispose a patient to rotator cuff tears. Furthermore, Gumina, Carbone, Arceri, Rita, Vestri & Postacchini (2009) reported that injury to the shoulder can negatively influence neck alignment and Yong, Lee & Lee (2016) found a significant negative correlation between the CV angle and position sense error, as in the present study, groups differ in proprioception but not differ in CV angle.

This study is limited by the small sample size. The majority of the sample were females, so the results cannot be generalized to males. As a conclusion, there is a positive significant correlation between cervical proprioception and both shoulder pain and disability in patients with unilateral SIS. Cervical proprioception training may be important in treatment of shoulder pain and disability.

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All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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