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RESEARCH ARTICLE

CORRELATION BETWEEN SCAPULAR MUSCLE ENDURANCE AND CORE MUSCLE ENDURANCE IN SUBJECT WITH CHRONIC SHOULDER PAIN

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ABSTRACT

Background: Scapular muscle endurance and core endurance reportedly may influence shoulder injury risk. Hence, the present study aimed to analyze the difference between healthy subjects and those with chronic shoulder pain with regard to scapular endurance, core endurance and pain level. Additionally to explore the relationship between measures of scapular endurance, core endurance and pain level. **Subjects:** Sixty subject of both sexes with mean age 25.66 ± 2.30 years were participated in this study. They weredivided into two equal groups; the control group and the study group who suffering from chronic sub acromial impingement syndrome (SAIS). **Methods:** Endurance of the serratus anterior and trapezius muscles was assessed using the scapular muscle endurance (SME) test. Modified Sorensen test, trunk flexor endurance test and endurance of lateral core muscles were conducted to assess the core endurance. The pain level was assessed by shoulder pain and disability index (SPADI). **Results:** There were significant declines of the values of Scapular muscle endurance test and all functional core endurance test in experimental group compared by control group. Additionally, Scapular muscle endurance test scores showed a correlation with the modified Sorensen test, trunk flexor endurance test,lateral endurance on affected side and pain level (r = 0.859, p = 0.0001; r = 0.845, p = 0.0001 ; r = 0.824, p = 0.0001 ; r =- 0.668, p =0.0001) respectively. No significant correlation was found between scapular muscle endurance test and lateral endurance test for non-affected side (p >0.05). **Conclusion:** Scapular endurance and core endurance deficiency was found in patient with SAIS. There appears to be a link between the scapular muscle endurance and all core test except non-affected lateral core endurance test.

INTRODUCTION

Shoulder pain (SP) is one of the most common musculoskeletal complaints in the primary care (Mitchell *et al.,* 2005). Shoulder subacromial impingement syndrome (SAIS) is the most common disorder of the shoulder, constituting 74% of cases. The concept of SAIS represents mechanical compression of the rotator cuff, subacromial bursa, and biceps tendon against the anterior undersurface of the acromion and coracoacromial ligament, especially during elevation of the arm (NEER, 1972). The scapula provides a stable base for the muscles of the rotator cuff to exert forces on the glenohumeral joint and allow upper extremity motion. Without this stable base, there will be a breakdown of energy transfer in the kinetic chain, requiring the muscles to compensate (Seroyer *et al.,* 2009). Scapular muscle dysfunction may change normal scapular position and scapular mechanics (Hamberg-van Reenen, 2006). Weakness of the scapular muscles can lead to early fatigue, inadequate scapular stabilization, increased shoulder overload, and functional impairments Thus, fatigue of the shoulder complex muscles is thought to be a neuromuscular change that leads to shoulder pathology (Roy *et al.,* 2011). The core has been described as a box or a double-walled cylinder (power-house) with the abdominals in the front, paraspinals and gluteals in the back, the diaphragm as the roof and the pelvic floor and hip girdle musculature as the bottom. Therefore, the core serves as a muscular corset that works as a unit to stabilize the body and spine (Akuthota and Nadler, 2004). When the system works as it should, the result is proper force distribution and maximum force generation with minimal compressive, translational, or shearing forces at the joints of the kinetic chain (McGill *et al.,* 2003) Core is the anatomic and functional powerhouse of the body. All motions are generated from the core and are translated to the extremities (Kibler *et al.,* 2006). Muscle endurance can be defined as the ability of a group of muscles to execute repeated contractions over a given time that is sufficient enough to cause muscle fatigue**.** Muscular endurance is more influential to spinal stability than muscular strength. Only a small percentage of maximum muscular force is used to stabilize the spine during daily activities (McGill *et al.,* 1999). Research has focused on comparison between normal athletes and athletes with shoulder dysfunction regarding to core endurance assessment (Radwan *et al.,* 2014) and the relation between shoulder dysfunction and core instability in shoulder impingement syndrome (Hazar *et al.,* 2014). However, none of

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the previous studies compared normal subject and subject with chronic shoulder pain (SAIS) concerning core endurance, scapular endurance and pain level. In addition the correlation between scapular endurance, functional core score and pain level has not been determined.

PATIENTS AND METHOD

The study was conducted on a sample of sixty subject of both sexes who were selected from out clinic of Faculty of Physical therapy, Cairo University between Septembers 2017 and May 2018. They were divided into two groups: Group (A): control group who had no history of shoulder pain and Group (B): experimental group who suffered from chronic shoulder pain. Patients were selected to be enrolled into this study after they had fulfilled the inclusion criteria of the study; patients age between 20-30 years were diagnosed as having SAIS with illness duration more than three months with unilateral affection (dominant side).Subjects were classified as having SAIS if they had at least 3 of the following: a positive Neer impingement test, a positive Hawkins impingement test, pain with active shoulder elevation, pain with palpation of the rotator cuff tendons, pain with isometric resisted abduction, and pain in the C5 or C6 dermatome region (Mcclure *et al.,* 2006). Patients had provided informed consent for participation in the study and for publication of the results. This study was approved by University Ethics Committee for scientific research [No: P.T. REC/012/001675]. All subjects was familiarized with the objectives, equipment and procedures of the study. Exclusion criteria were history of previous shoulder surgery, bony fracture, traumatic congenital deformity, surgery in neck or trunk, Chronic back, cervical pain or musculoskeletal condition affecting the test position

Design of the study

Observational study- Cross sectional design (one shot study).

Instrumentation

Weight and height scale: The standard medical scale (ZT2_200 Health scale, German) was used to measure the weight and height for all subjects before starting the assessment.

Baseline® bubble inclinometer: Baseline® bubble inclinometer (12-1056 USA*)* was used for measurement of back inclination for all participant to maintain the vertical position during soreness test.

Baseline Digital Push-pull Dynamometer 250 lb: Baseline Digital Push-pull Dynamometer 250 lb /120Kg (W54281 USA) was used to measure the scapular endurance during Scapular muscle endurance (SME) test. This dynamometer has two ends one side is push side and another side is pull side. The apparatus is equipped with a display screen showing strength measurement or pull force and lb or kg according to choice (Tedla *et al.,* 2010).

Shoulder Pain and Disability Index (SPADI): Shoulder Pain and Disability Index (SPADI was used to measure the intensity of shoulder pain pre assessment which is valid and reliable (Reddy *et al.,* 2000).

Stop watch: The Stop watch was used to measure the time of endurance of both scapular and core test in second.

Outcome measures

Firstly, data on the subjects' demographic and clinical characteristics was collected including age, weight, height, affected side and pain level. Weight (kg) was measured to the closest 0.1 kg using a standard weight scale. Height was measured to the closest 0.1 cm with the subject standing in an erect position against a vertical scale of a portable stadiometer.

Assessment procedures

1. **Scapular muscle endurance test:** Serratus anterior and trapezius muscle endurance was measured by the SME test, and the results were recorded as seconds. The test was carried out while the subjects were facing the wall in standing position and with their shoulder and elbows were at 90◦ flexion position. There was no contact between the subject s arm and the wall. While both scapula were in neutral position, an appropriate size of stick was placed between the elbows, and a dynamometer (Baseline Digital Push-pull Dynamometer 250 lb-W54281 USA) was placed between their hands. The subject was asked to make a shoulder external rotation until the dynamometer read 1 kg load capacity, and the subject was asked to keep this position. When the subject could not maintain the resistance, dropped the stick, could not maintain the 90◦shoulder flexion, or reported an unbearable pain, the test was terminated (Edmondston *et al.,* 2008).

2. **Modified back extensors test:** Each participant was positioned in prone on a treatment table with the superior borders of the bilateral anterior superior iliac spines at the edge of the table and the upper body hanging off of the table. The lower body of the participant was stabilized on the table by three belts placed over the hips, just below the knees, and just above the ankles. During the modified Biering - Sorensen test, each participant was instructed to extended his/her trunk and maintain the trunk in a horizontal position with the head in a neutral position and both upper limb crossed around chest. Velcro band connected by two vertical poles was placed at the level of the participant's seventh thoracic vertebrae. This Velcro band was used to provide tactile feedback to encourage the participant to maintain his/her body in a horizontal position during the testing. An inclinometer (Baseline® bubble inclinometer (12-1056 USA) was placed over the inter-scapular area to monitor the trunk position. When the participant's trunk deviated more than 10° from the horizontal position, the participant was asked again to extend his/her trunk and keep it in a horizontal position. If a participant could not maintain a horizontal position, the test was ended, and muscles were considered fatigued (Wang-Price *et al.,* 2017).

3. **Flexion endurance test:** Participants were lie supine, with both hips and knees flexed to 90 degrees, trunk inclined at 60 degrees resting on a prefabricated wedge and a strap was placed over the subject's feet to provide support during the test. Participants were cross arms across the chest, placing their hands on opposite shoulders, in a manner comfortable to them.

Participants were instruct to maintain their body position for as long as possible after the wedge was moved back 10 cm. Time was measured from the instant the prefabricated wedge was moved back until the participant visually reestablished contact with the wedge (Reiman *et al.,* 2012).

4. **Lateral musculature test feet-elevated side-support test (FESS):** Each participant performed the FESS on the right and left sides (separately), with the test side defined as the side facing the mat. All testing was performed on a table. A dangling pulley system rod was aligned at their iliac crest to provide tactile feedback to the position of maximum hip elevation. Before performing the FESS, the participant's head and shoulders rested on the mat and the feet were elevated on a 15-cm metal step stool with the superior foot placed in front. Participants wore socks, but not shoes, during testing. The stool was padded with a pillow for comfort. Both arms were folded across the chest. Participants were repositioned as necessary to ensure that their torso and hips were neither flexed nor extended. Participants rested in side-lying for 30 seconds to ensure adequate recovery for testing. They then assumed the FESS position and attempted to maintain contact with the reference rod for as long as possible. The test was terminated when contact with the rod was lost for longer than 2 seconds or when the participant lowered to the mat (Greene *et al.,* 2012).

Data collection

For each group, both demographic and clinical characteristics [scapular endurance, functional core endurance and pain level] of patients were collected.

Statistical Analysis

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS™) version 22 for Windows (IBM SPSS, Chicago, IL, USA). Independent t-test was conducted for comparison of physical characteristic between both groups. Multivariate Analysis of Variance test (MANOVA) was used to analyze the difference between healthy subjects and subjects with SAIS. This was followed by an analysis of relationship between the SME test, functional core score and pain level in experimental group measures using the Pearson Product Moment Correlation Coefficient. The level of significance was set at $P \leq 0.05$.

RESULTS

Demographic characteristics of subjects in both groups

Results revealed that there were non-significant differences between the two groups with regard to demographic characteristics where ($P > 0.05$), are shown in Table 1.

Scapular endurance, functional core stability and pain level between the control and experimental groups

Criteria for parametric testing were met and a multivariate analysis of differences was performed to compare the six variables (SME test, modified Sorensen test, flexor endurance test, right and left lateral endurance test FESS and pain level) between healthy subjects (control group n = 30) and subjects with SAIS (experimental group n = 30). MANOVA was significant were P value was (0.0001) for all the variable between the experimental group and the control group. The experimental group had significantly lower SME, core endurance than the control group and higher pain level. Result are presented in Table 2.

Table 1. Demographic characteristics of subjects in all groups

Items	Control group		Experimental group		Comparison		S*
	Mean	± SD	Mean	± SD	t -value	p- value	
Age(yrs)	26.03	2.58	25.30	1.97	1.24	0.221	NS
Weight(kg)	76.90	11.15	74.10	12.43	0.918	0.362	NS
Height(cm)	171.27	10.53	168.60	10.03	1.01	0.319	NS

Data are expressed as mean ± SD; NS= p> 0.05= not significant

Table 2. SME, functional core stability score pain level for both control group and experimental group

Variables	Control Group		Experimental Group		MANOVA		Test
	Mean	± SD	Mean	± SD	F -value	p-value	S*
SME test	75.84	± 22.26	40.50	±14.12	83.185	0.0001	S*
Extensor test	112.48	±34.03	41.60	±17.81	192.526	0.0001	S*
Flexor test	90.42	±29.15	34.33	±15.21	141.614	0.0001	S*
Dominant side test	70.29	±19.34	29.37	±11.69	186.234	0.0001	S*
Non- Dominant side test	73. 65	±20.96	30.83	±11.89	165.510	0.0001	S*
Pain level	0.00	±0.00	41.70	±12.88	304.62	0.0001	S*

*Significant at alpha level <0.05; SD: Standard deviation

Table 3. Correlation analysis between scapular endurance, Modified back extensors test, flexion endurance test, lateral endurance affected side, non-affected side and pain level in experimental group

	r-value	p- value
Modified back extensors	0.859	0.0001*
flexion endurance test	0.845	0.0001*
lateral endurance affected side	0.824	0.0001*
lateral endurance non- affected side	0.256	0.1730
pain level	-0.668	0.0001*

r-value: correlation coefficient*Significant at alpha level <0.05.

Correlation analysis between scapular endurance, functional core stability and pain level in experimental group

Correlation between the scapular muscle endurance test and Sorensen test, trunk flexor endurance, lateral endurance test FESS for both side and pain level was calculated using Pearson Correlation Coefficient. Scapular muscle endurance test score positively correlated with the modified Sorensen test, trunk flexor endurance test, and FESS on affected side and a negative correlation was found between Scapular endurance test and the pain level ($r = 0.859$, $p = 0.0001$; $r = 0.845$, $p = 0.0001$; $r = 0.824$, $p = 0.0001$; $r = -0.668$, $p = 0.0001$) respectively. No significant correlation was found between scapular muscle endurance test scores and the FESS non-affected side ($p > 0.05$). Results are illustrated in Table 3.

DISCUSSION

The present study investigated the difference between healthy subjects and those with chronic shoulder pain with regard to scapular endurance, core endurance and pain level and explored the relationship between measures of scapular endurance, core endurance and pain level. The current study indicated that there was a significant decrease of scapular endurance in experimental group that can be attributed to scapular kinematic alternation and decreased activation of lower serratus anterior muscle that occur at impingement symptoms (Scovazo *et al.,* 1991). Garg and Kapellusch, (Garg and Kapellusch, 2009) have found that fatigue of the shoulder complex muscles is thought to be a neuromuscular change that leads to shoulder pathology. Fatigue of the serratus anterior muscle may be particularly troublesome, as this muscle has been identified as the main contributor to scapulothoracic stability. The current study indicated that there was a significant decrease for all core endurance tests in experimental group compared with control group. This can be attributed to scapulothoracic joint stability provided mainly by the trapezius-serratus anterior coupling, is considered as an important part of providing core stability of the trunk (Mottram, 1997). Horsley stated that the rotator cuff group could have an influence on scapular alignment and therefore core stability, although it does not have direct attachments to the spinal column or rib cage (Horsley, 2005). Bouisset and Zattara (Bouisset and Zattara, 1981) stated that upper extremity motion follows this proximal-to-distal motor program sequence. The task of rapidly reaching forward with the right hand to shoulder level produces a consistent pattern of activation and deactivation of leg and trunk musculature before activation of the anterior deltoid. In the present study, there was significant difference in the result between both groups for pain level this can be attributed to chronic irritation affects the avascular region of the supraspinatus, resulting in tendinitis (Corso, 1995). Smith *et al.* (2006) stated that altered rotator cuff activity may be a precursor to shoulder pain. Disruption to the synergy of the shoulder girdle through scapular dyskinesis, has the potential to affect function and may result in pain. The present study represented a significant positive correlation between scapular endurance and modified back extensor endurance test that can be attributed to the scapular endurance which originate from lumber extension endurance or vice versa. Putnam *et al.* (1993) stated that full arm elevation requires full scapular retraction, which requires spinal extension and hip extension. The large muscles of the hips and trunk thereby help position the thoracic spine to accommodate appropriate scapular motion. Vleeming *et al.* (1995) stated that thoracolumbar fascia provides a link between the lower limb and the upper limb with contraction of the muscular contents. Also, Aruin and Latash (1995) showed early activation of erector spinae muscles prior to upper limb movement. Moreover, results of the present study showed a significant positive correlation between scapular endurance and flexors endurance test this can be attributed to core muscle stabilizers are activated before movement of upper or lower limbs begins; therefore, it might be possible that shoulder pathology is related to core stabilization or core pathology is related to shoulder movement (Hodges *et al.,* 1997). Barati (2013) reported when arm movement is performed, the onset of TrA activity precedes that of deltoid by approximately 30 milliseconds. This order of activation allows for proximal stability and distal mobility. Also, Aruin&Latash identified early activation of rectus abdominis muscles prior to upper limb movement in specific directions (Hodges *et al.,* 1997). The current study revealed that there was a positive significant correlation between scapular endurance and lateral core endurance on the affected side but not on non-affected side that can be attributed to muscle and fascia that connect to several joint segments; therefore, movement and musculoskeletal pathology are never isolated (Page *et al.,* 2010). Hodges and Richardson (Hodges *et al.,* 1997) showed the internal oblique muscle was reported to contract before the deltoid muscle in arm abduction. Moreover, Phil et al. (Page *et al.,* 2010) reported that the abdominal fascia attaches to the external oblique, internal oblique, TrA, pectoralis major, and serratus anterior. Moreover, results of the present study showed a significant negative correlation between scapular endurance and pain level that can be attributed to the alterations in scapular kinematics, muscle activation, muscle fatigue and scapular dyskinesia contribute to shoulder pain. Possibly, decreases scapular endurance predisposes the subject to develop shoulder pain or scapular endurance may be decreased by pain- inhibition mechanisms. Eraslan *et al.* (2013) assessed the effect of scapular muscle endurance on chronic shoulder pain in textile workers, and results suggest the scapular muscle endurance affects chronic shoulder pain and pain intensity. Insufficient endurance of scapular muscles may have an important effect on decreased neuromuscular performance and increased risk of shoulder pain. The limitation of the current study is that unequal proportions of male and female participants and the result may not be applicable to all subject with impingement syndrome (acute impingement, acromioclavicular and sternoclavicular pathology).

Conclusion

Scapular endurance and core endurance deficiency was found in patient with SAIS. There appears to be a link between the scapular muscle endurance, modified Sorensen test, trunk flexor endurance test, (FESS) on affected side and pain level. Therapists should consider incorporating core endurance tests in evaluating the scapular endurance of individuals with SAIS.

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