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ORIGINAL RESEARCH

The effect of chronic shoulder pain on maximal force of shoulder abduction

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Summary The aim of this study was to determine if chronic shoulder pain had an effect on arm abduction strength and recruitment strategies of the serratus anterior, middle deltoid, and upper trapezius.

Method: The maximal isometric force at 30° arm abduction and the electromyographic activity of the serratus anterior, middle deltoid, and upper trapezius were recorded for 14 subjects with unilateral chronic shoulder pain and 11 healthy subjects.

Results: Relative to the group without pain, the group with chronic shoulder pain showed no significant difference in maximal force production during isometric arm abduction. The Mann—Whitney tests showed no differences in the activation of the serratus anterior, middle deltoid, and upper trapezius between the two groups.

Discussion and conclusion: Subjects with chronic shoulder pain of mild to moderate intensity showed no difference from healthy subjects in arm abduction maximal strength, and recruitment patterns of serratus anterior, middle deltoid, and upper trapezius.

Introduction

Shoulder pain is one of the most common musculoskeletal complaints encountered in clinical practice and it is usually caused by a small number of relatively common conditions. One of the most common causes of shoulder pain is rotator cuff disease, which can be due, among other things, to subacromial impingement syndrome or rotator cuff tear (Neer, 2005). In cases of rotator cuff injury, the supraspinatus is the muscle most commonly involved. Other common causes of shoulder pain originating within the joint include frozen shoulder, calcific tendonitis, degenerative diseases such as osteoarthritis, shoulder dislocation and instability, and labral tears. Shoulder pain can also

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originate from surrounding areas such as the neck or shoulder girdle muscles (Frost and Robinson, 2006; Kim et al., 2007). Less common causes of shoulder pain are infection, neuralgic amyotrophy and tumour.

In a healthy shoulder there is an upward rotation, posterior tilt and an external rotation of the scapula during arm elevation (Steenbrink et al., 2006; Cools et al., 2007; Phadke et al., 2009). At the same time, the clavicle elevates slightly, retracts, and posteriorly rotates at the sternoclavicular joint. The combination of these movements permits optimal arm abduction and preserves the subacromial space during elevation (Phadke et al., 2009). Many authors agree that this is due to the muscle coordination and synchronised action of force couples of the upper, middle and lower trapezius and the serratus anterior (Cools et al., 2007; Phadke et al., 2009). Alterations to this synchronous motion can disrupt kinematic pattern and have been shown to correlate with shoulder pathologies such as impingement syndrome (Tsai et al., 2003). The usual recruitment patterns of scapular muscles prior to arm elevation is for the upper trapezius to contract first, followed by serratus anterior, middle trapezius and finally lower trapezius (Wadsworth and Bullock-Saxton, 1997; Moraes et al., 2008). The serratus anterior is particularly important as it also causes posterior tilting and external rotation of the scapula. The glenohumeral joint is a shallow ball and socket that is inherently unstable. The rotator cuff muscles (consisting of supraspinatus, infraspinatus, subscapularis, and teres minor muscles) enhance the joint's stability. The subscapularis, infraspinatus and teres minor exert an inferior directed line of action to offset the superior translation component of the deltoid action (David et al., 2000; Dark et al., 2007).

A dysfunctional muscle activation pattern has been described for shoulder abduction: the trapezius has been found to increase activity on the dysfunctional side during arm elevation, whereas serratus anterior activation decreases (Steenbrink et al., 2006; Phadke et al., 2009). This dysfunctional pattern results in increased anterior tilt, internal rotation, and posterior tilt of the scapula during arm abduction (Steenbrink et al., 2006). This pattern reduces the resting length of pectoralis minor which can exacerbate shoulder problems, as the pectoralis minor is an antagonist of scapulothoracic motion (Phadke et al., 2009). Compounding this pattern is reduced rotator cuff activation which reduces humeral head depression and may further contribute to impingement syndrome and shoulder pain (Phadke et al., 2009). It was postulated that this dysfunctional trapezius recruitment pattern was a compensatory mechanism adapted by the body to avoid pain, due to decreased serratus anterior activation during upward rotation of the scapula.

Evidence suggests that the greatest decrease in rotator cuff activity is between 30° and 60° (Myers et al., 2009). A combination of pain and scapular substitution may explain this greatest decrease in the early arcs of motion. The co-activation of subscapularis-infraspinatus and supraspinatus-infraspinatus were found to be higher in subacromial impingement between 90° and 120° when pain was typically present, suggesting that these stabilizing muscles may over-compensate for the excessive humeral head elevation.

Musculoskeletal pain can directly affect muscle recruitment and activity patterns (Cools et al., 2003; Camargo et al., 2010). Although results vary across many studies there appears to be consensus that pain can trigger a series of changes, such as decreased working rhythm, decreased electromyographic activity of the painful muscles, greater postural muscles activity, and a tendency to increased amplitude of arm movements.

Due to the complexity of the shoulder and its dynamic interplay with the scapula several theories have been proposed to explain chronic pain patterns. The pain adaptation model developed by Lund et al. (1991) describes the pathophysiological mechanisms involved in chronic musculoskeletal pain. This model predicts that during muscle pain, activity of the agonist muscle decreases, while activity of the antagonist increases in order to provide active protection of the painful muscle, leading to less powerful and slower movements.

Dysfunctional muscle recruitment and latency patterns of scapulothoracic and glenohumeral mechanics have been associated with chronic shoulder pain (Cools et al., 2003; Steenbrink et al., 2006). The aim of this study was to investigate the effect of chronic shoulder pain on maximal force of shoulder abduction and electromyographic activity of the serratus anterior, middle deltoid, and upper trapezius muscles during shoulder abduction. It was hypothesized that individuals with shoulder pain would demonstrate different activation patterns of the serratus anterior, middle deltoid and upper trapezius compared to healthy controls.

Materials and methods

Electromyographic studies were conducted with surface electrodes placed on the middle deltoid, serratus anterior and upper trapezius in patients with and without chronic shoulder pain. For the purpose of this study chronic shoulder pain was defined as pain in the shoulder girdle area for a minimum of the last 3 months. As our area of interest was the early activation of scapular stabilizers and prime movers, assessments were conducted at 30° of arm abduction.

Subjects

Fourteen subjects (6 females and 8 males, mean age 31.3 ± 9.7 years, range 19–57 years) with unilateral chronic shoulder pain were recruited to participate in this study. The subjects were recruited from advertisements at Southern Cross University Health Clinic. Inclusion criteria were that all subjects had experienced shoulder pain for a minimum of the last 3 months and had at least one positive test out of the following six tests: Painful arc, Empty can test, Neer test, Speed's test, Apley's scratch test, and Hawkins–Kennedy test (Magee, 2013). All shoulder pain group subjects were right arm dominant. The involved side was the dominant side in 7 of the 14 subjects. The pain and disability of the participants were assessed with the Shoulder Pain And Disability Index (SPADI) questionnaire (Breckenridge and McAuley, 2011) (Pain scale 41.43% ± 16.43%, range 20–70%; Disability scale 15.46% ± 14.63%, range .8–46%; Total SPADI score 25.85% ± 14.00%, range 9.2–52%) (Table 1).