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Neuromuscular control of scapula muscles during a voluntary task in subjects with Subacromial Impingement Syndrome. A case-control study

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ABSTRACT

Imbalance of neuromuscular activity in the scapula stabilizers in subjects with Subacromial Impingement Syndrome (SIS) is described in restricted tasks and specific populations. Our aim was to compare the scapular muscle activity during a voluntary movement task in a general population with and without SIS ($n = 16$, No-SIS = 15).

Surface electromyography was measured from Serratus anterior (SA) and Trapezius during bilateral arm elevation (no-load, 1 kg, 3 kg). Mean relative muscle activity was calculated for SA and the upper (UT) and lower part of trapezius (LWT), in addition to activation ratio and time to activity onset. In spite of a tendency to higher activity among SIS 0.10–0.30 between-group differences were not significant neither in ratio of muscle activation 0.80–0.98 nor time to activity onset 0.53–0.98.

The hypothesized between-group differences in neuromuscular activity of Trapezius and Serratus was not confirmed. The tendency to a higher relative muscle activity in SIS could be due to a pain-related increase in co-activation or a decrease in maximal activation. The negative findings may display the variation in the specific muscle activation patterns depending on the criteria used to define the population of impingement patients, as well as the methodological procedure being used, and the shoulder movement investigated.

1. Introduction

Subacromial impingement Syndrome (SIS) comprising both shoulder pain and disability is one of the most common shoulder disorders registered in primary care (House and Mooradian, 2010; Ostor et al., 2005). The prevalence of SIS is especially high in overhead sports, as well as in overhead work with high demands for dynamic shoulder stability (Belling Sorensen and Jorgensen, 2000; Cools et al., 2003; van Rijn et al., 2010). SIS is characterized by shoulder pain exacerbated with arm elevation or overhead activities which may be due to a compression of subacromial structures, such as rotator cuff muscle tendons (Fu et al., 1991; Neer, 1972), potentially caused by an inappropriate scapulo-humeral movement (Belling Sorensen and Jorgensen, 2000; Page, 2011). During scapular rotation the serratus anterior (SA) works in coordination with the upper (UT), middle (MT) and lower parts (LT) of the trapezius (Inman et al., 1944; Kibler and McMullen, 2003). A close coupling of SA and LT muscles may counterbalance upper trapezius activity, thereby providing a balanced control of scapular orientation and rotation (Inman et al., 1944). Various parameters have been used previously to describe this activity.

Some authors reported a high mean activity in the UT (Chester et al., 2010; Cools et al., 2004, 2007a; Lin et al., 2006; Ludewig and Cook, 2000) and a low mean activity in SA in subjects with SIS as compared to subjects without SIS (No-SIS) during arm motions in low and high loading conditions (Ellenbecker and Cools, 2010; Lin et al., 2006; Ludewig and Cook, 2000). Further, a higher ratio of relative activation of the UT and the LT (Cools et al., 2007a), and a delay in timing of onset of shoulder muscle activation during standardized tasks is reported for the MT, and the LT muscle, in SIS subjects compared to healthy controls (Cools et al., 2003; Moraes et al., 2008; Wadsworth and Bullock-Saxton, 1997). Moreover, longer latencies of muscle activation in the affected shoulder compared to the non-affected shoulder were found for all three parts of the trapezius muscle and the SA muscle (Moraes et al., 2008).

The current clinical treatment guidelines for patients with SIS are therefore based on the described neuromuscular imbalance and thus they include focus on increasing the activity in the lower

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parts of the scapular stabilizing muscles (SA and LT), while decreasing or maintaining the activity of the upper parts of these muscles (UT) (Cools et al., 2008b; Ellenbecker and Cools, 2010).

The neuromuscular imbalance has mostly been reported during restricted movement tasks. These include maximum isokinetic strength tasks, i.e. concentric protraction/retraction (Cools et al., 2004), isokinetic arm abduction and external rotation (Cools et al., 2007c) and sudden arm perturbation (Cools et al., 2003). Few studies have included voluntary movements such as arm elevation (Lin et al., 2006; Moraes et al., 2008) and lifting (Ludewig and Cook, 2000) which more closely reflect activities of daily living. Moreover, the included study populations have often been young male overhead athletes (Cools et al., 2003, 2004, 2007a) or mid-aged overhead workers (Ludewig and Cook, 2000). Other risk factors than overhead activities have been found to increase the risk of developing SIS, such as highly repetitive work and forceful exertion in work, awkward postures, and high psychosocial job demands (Frost and Andersen, 1999; van Rijn et al., 2010). However, imbalance of scapular muscle activation has not been studied in a more general SIS population during a voluntary movement task.

Therefore, the aim was to investigate whether the activity of the Trapezius and Serratus muscles is different during a voluntary arm movement task in a general population with SIS compared to a matched population without SIS. In addition, it was of interest to investigate any correlation between the levels of shoulder pain and muscle activity. The hypothesis was that the SIS group compared to the No-SIS group would have a higher muscle activity in the upper part of trapezius compared to the lower part and SA, as well as higher ratios of activation and delayed timing of the onset of activity in the lower trapezius and SA.

2. Materials and methods

2.1. Subjects

A convenience sample of patients and controls, matched on groups by age (20–65 years) and gender, was recruited from physiotherapy clinics and among acquaintances. The population was aimed at matching a general population of SIS-patients, not only working with overhead activities. For the SIS group, the inclusion criteria were at least 30 days with pain/discomfort in the shoulder/neck region within the last year (Juul-Kristensen et al., 2006), but no more than three regions of pain/discomfort in order to exclude generalized musculoskeletal diseases. Furthermore, two or more positive impingement tests based on the Jobe, Neer, Hawkins and Apprehension tests were required (Cools et al., 2008a; Vind et al., 2011). For the healthy control group (No-SIS), the inclusion criteria were less than eight days with pain/discomfort in the shoulder/neck region within the last year, as well as no more than three regions of pain/discomfort elsewhere (Juul-Kristensen et al., 2006), and no positive impingement tests.

Overall exclusion criteria were: history of severe shoulder–neck pathology/trauma, orthopaedic surgery, documented life-threatening diseases, cardiovascular diseases, rheumatoid arthritis, generalized pain, adverse psycho-social conditions or pregnancy, and positive clinical tests for cervical radiculopathy (i.e. Spurling A test, Neck Distraction test, Involved Cervical Rotation test (less than 60°) (Wainner et al., 2003). The inclusion and exclusion criteria were identified by a questionnaire and a detailed interview, validated in previous studies (Andersen et al., 2008; Sandsjo et al., 2006; Sjogaard et al., 2010), as well as a clinical examination of the upper limb and neck performed by a physiotherapist.

A total of 69 subjects volunteered, however, six subjects were excluded during a preliminary telephone interview, based on the overall exclusion criteria. In total, 63 fulfilled the inclusion criteria, 59 accepted to participate in a screenings procedure and of these, 22 subjects were excluded due to the above exclusion criteria or inadequate data collection ($n = 3$), or dropped out due to personal circumstances ($n = 3$). Subjects who, based on the screening procedure, qualified as either a SIS case or a healthy control (No-SIS) ($n = 31$) were invited to participate in the study, comprising 16 subjects with SIS (8 women and 8 men) and 15 No-SIS (8 women and 7 men).

All subjects were informed about the purpose and content of the project and gave informed written consent to participate. The study conformed to the Declaration of Helsinki 2008 (Vollmann and Winau, 1996) and was approved by the Committee on Biomedical Research Ethics for the Region of Southern Denmark, Denmark (Project ID S-20090090). There was no conflict of interest.

2.2. Instrumentation

Bipolar circular surface electromyographical (sEMG) electrodes (10 mm diam, Ambu R Blue Sensor M, Olstykke, Denmark) were placed at the three anatomical subdivisions: UT, MT, and LT of the dominant/involved trapezius muscle and SA during prone lying.

A normal standardized procedure for electrode positions was used (Holtermann et al., 2009, 2010) (Fig. 1). All electrodes were placed in line with the fiber directions with an inter electrode distance of 2 cm (Hermens et al., 2000), with reference electrodes at the acromion and the C7 vertebra.

3. Experimental procedure

Pain intensity was evaluated on a 10 cm Visual Analog Scale (VAS) (Wewers and Lowe, 1990) before and after the tests. Surface electromyography (sEMG) was recorded from Trapezius and SA, (dominant arm of the No-SIS subjects) with a total duration of recording for about 1 h per subject.

For normalization of the EMG signals to maximal voluntary EMG (MVE) all subjects initially performed isometric maximal voluntary contractions (MVIC) for each of the three parts of the trapezius muscle and SA. Resting signal level of sEMG data was collected for 30 s in the resting prone lying position. All maximal contractions of the trapezius and SA were performed bilaterally with bilateral resistance, provided proximal to the elbow joints in an externally rotated shoulder position. Three attempts of 5 s duration with verbally encouragement were performed with 1 min rest in between. For the UT MVE, the subject performed an isometric arm elevation in standing with both arms elevated to 90° in the scapular plane. For

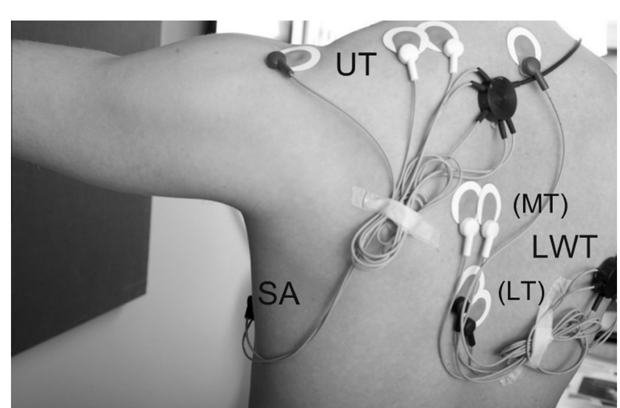

Fig. 1. Electrode placement of SA, UT and LWT.