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Electromyographic analysis of rotator cuff muscles in patients with rotator cuff tendinopathy: A systematic review

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ABSTRACT

The shoulder is inherently an unstable joint which heavily relies on the neuromuscular activation of the rotator cuff (RC) complex for stability during movement. Currently, there is no consensus regarding how the activity of RC muscles is affected among individuals with a RC tendinopathy (RCTe). This study reviewed the evidence of studies comparing the electromyographic (EMG) activity of any RC muscle of shoulders with a symptomatic RCTe to asymptomatic shoulders. Eight databases were searched. Data from 343 participants (201 symptomatic and 209 asymptomatic shoulders) were analyzed from 10 out of 402 included studies. Strong evidence for the infraspinatus and supraspinatus during isometric contractions and limited evidence for the supraspinatus and infraspinatus during isokinetic contractions suggest that the muscular activity is not altered among individuals with a RCTe during these types of contraction. Very limited evidence indicates reduced muscle activity for the infraspinatus and subscapularis in the presence of a RCTe during isotonic contractions, and no alterations for the supraspinatus or teres minor were identified. Lastly, conflicting to moderate evidence suggests alterations in RC muscle activity during unrestrained movements and swimming. These findings indicate that EMG deficits associated with a RCTe can best be appreciated during unrestrained movements.

1. Introduction

Shoulder disorders are very common (point prevalence ranging from seven to 66.7%) (Luime et al., 2004) and are associated with substantial functional limitations that tend to increase with age. Rotator cuff tendinopathy (RCTe) is the most common source of shoulder pain (Alqunaee et al., 2012) and represents an estimated 66 to 85% of all shoulder cases (Tekavec et al., 2012). RCTe is an umbrella term, which encompasses several diagnoses related to various tendon signs and symptoms (e.g. tendinosis/ tendinitis, supraspinatus tendinopathy / tendinosis / tendinitis, subacromial impingement, subacromial bursitis) (Hanratty et al., 2012; Desmeules et al., 2015), combining pain and impaired function (Factor and Dale, 2014).

While there is no consensus regarding etiological mechanisms (de Witte et al., 2011; Lopes et al., 2015), several factors have been suggested to explain the persistence of symptoms and functional limitations in individuals with an RCTe. Among these factors, a lack of coordination (Wadsworth and Bullock-Saxton, 1997; Hess et al., 2005; Clisby et al., 2008) and neuromuscular balance (Bertoft, 1999; de Witte et al., 2011) between the RC muscles, which includes the supraspinatus (SS), infraspinatus (IS), subscapularis (SB), and teres minor (TM), has been identified. Proper RC musculature activation is crucial for shoulder stability control, as it increases glenohumeral joint stiffness, thereby maintaining a stabilizing congruency between the humeral head and the glenoid fossa. In addition, RC muscles are activated together with other scapulothoracic and scapulohumeral muscles to properly align the humeral head with respect to the glenoid fossa, thereby preventing the impingement of the subacromial structures during arm elevation that would otherwise result from superior migration of the humeral head (Sharkey and Marder, 1995).

Changes in muscle activation patterns of the RC muscles could explain, in part, the dynamic narrowing of the subacromial space and the alterations in upper limb kinematics that have been observed in individuals with RCTe during arm elevation (Ludewig and Cook, 2000; Roy et al., 2008; Savoie et al., 2015). In fact, the neuromuscular deficits of RC muscles have been targeted by

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several investigations evaluating the effects of rehabilitation intervention for RCTe (Brox et al., 1997; Muth et al., 2012; Røe et al., 2000; Savoie et al., 2015; Tate et al., 2010). Examination of RC muscular activity is, therefore, essential for a thorough evaluation of shoulder neuromuscular control. A recent systematic review on EMG activity of the shoulder complex (Chester et al., 2010) concluded that individuals with an RCTe may present with altered EMG activity; however, this review was inconclusive due to inconsistencies during data retrieval, and inclusion of studies only evaluating scapulothoracic and middle deltoid muscles (evidence related to the EMG activity of RC muscles was not included). To our knowledge, there are currently no published systematic reviews compiling evidence of RC muscles activity in patients with an RCTe. Thus, the aim of this study was to review systematically the evidence concerning the EMG activity of RC muscles in individuals with RCTe. Presentation of this systematic review follows the recommendations outlined by PRISMA.

2. Methods

2.1. Identification and selection of studies

Bibliographical searches were performed in eight databases (Medline/PubMed, Science Direct, Scopus, EMBASE, ISI Web of Science, PSYCInfo, CINAHL and Scielo) from their inception to August 2016 addressing three concepts (outcomes, patients/symptoms, and anatomical site/muscles) with the following search strategy: (EMG OR electromyograph* OR "musc* activity") AND (tendinopathy* OR impingement OR "subacromial pain") AND (infraspinatus OR supraspinatus OR "teres minor" OR subscapularis OR "rotator cuff muscles"). This strategy was adapted for each database using the appropriate truncation and medical subject heading (MeSH) (see Appendix A for an example of a search strategy). Reference lists of the retrieved studies were also searched to identify additional relevant publications. Published studies written in English, Spanish, French or Portuguese were included. After removal of duplicates, two reviewers (FCLO, JSR) independently screened the study titles and abstracts using a blinded standardized protocol. The selection criteria for the full-text review were: (a) reporting on the EMG activity of any RC muscles, (b) including individuals with RCTe, and (c) comparing impaired shoulder to unimpaired (painful to pain-free shoulders in the same individuals or individuals with a painful shoulder to asymptomatic individuals). Thereafter, the same two reviewers scrutinized the full-text of all potentially eligible studies, independently, to decide on their inclusion. Disagreements concerning study eligibility were resolved by consensus. If no consensus was reached, a third reviewer made the final decision (LJB).

2.2. Assessment of characteristics of studies

2.2.1. Qualitative analysis (critical appraisal)

The *Standard Quality Assessment Criteria for Evaluating Primary Research Papers* (QualSyst), a quality appraisal tool developed by Kmet et al. (2004) was used. It evaluates methodological quality and risk of bias of quantitative and qualitative studies. Items 5, 6 and 7 (random allocation and blinding) were excluded to tailor the QualSyst to the studies included (Table 1).

Two raters (FCLO, ALA) independently evaluated each article using the QualSyst checklist. After each independent evaluation, the pair of raters met to discuss each article. Each specific domain was openly discussed to reach a consensus. A pre-consensus interrater agreement was calculated for the final scores with an intraclass correlation coefficient (ICC). As summary scores were not yet associated with different qualitative categories, the following index was used: "high quality" (HQ) representing scores greater than 80.0%, "good quality" (GQ) for scores between 70% and 80.0%, "moderate quality" (MQ) for scores between 50.0% and 69.9%, and "low quality" (LQ) for scores less than 50.0%.

2.2.2. EMG scale of assessment

A critical appraisal scale for reporting EMG was developed for this study (Appendix B). This scale is based on the *Unit, Terms, and Standard for Reporting EMG Research*, reported by the Ad Hoc Committee of the International Society of Electrophysiological Kinesiology to guide the reporting of EMG research. The scale is composed of 13 items, evaluating the reporting of electrodes type and position, raw signal processing (amplification, filtering,

Table 1
Assessment of methodological quality (critical appraisal) after a consensus between the researchers.

	Item number and corresponding score														Points	FS_{qual} score
	1	2	3	4	5[a]	6[a]	7[a]	8	9	10	11	12	13	14		
Bandholm et al. (2006)	Y	Y	Y	P	n/a	n/a	n/a	Y	P	Y	Y	P	Y	Y	19	0.86
Clisby et al. (2008)	Y	P	Y	Y	n/a	n/a	n/a	Y	P	Y	Y	P	Y	Y	19	0.86
Lopes et al. (2015)	Y	Y	Y	Y	n/a	n/a	n/a	Y	Y	Y	Y	Y	Y	Y	22	1.00
Michaud et al. (1987)	Y	Y	Y	P	n/a	n/a	n/a	P	P	Y	P	P	P	P	15	0.68
Myers et al. (2009)	Y	Y	Y	Y	n/a	n/a	n/a	Y	Y	Y	Y	P	Y	Y	21	0.95
Pink et al. (1993a)	Y	P	P	Y	n/a	n/a	n/a	P	Y	P	P	P	Y	Y	16	0.73
Reddy et al. (2000)	Y	P	P	P	n/a	n/a	n/a	Y	P	P	N	P	P	P	12	0.55
Roy et al. (2008)	Y	P	Y	Y	n/a	n/a	n/a	Y	Y	Y	Y	Y	P	Y	20	0.91
Ruwe et al. (1994)	Y	Y	P	P	n/a	n/a	n/a	Y	P	P	P	P	P	P	14	0.64
Skolimowski et al. (2009)	Y	P	Y	Y	n/a	n/a	n/a	Y	Y	Y	Y	N	N	P	16	0.73

Studies presented in alphabetic order. Y: yes (2 points); P: partial (1 point); N: no (0 points); n/a: not applicable.
Points mean the sum of scores for each item. Score are the points divided by the maximum possible score (22).
FS_{qual} was calculated dividing the total sum (TS) of rates by the maximum possible score (PS).
TS = "*number of yes*" $\times$ 2 points + "*number of partial*".
PS = (22) − "*number of not applicable*" * 2.
(1) Question/objective sufficiently described? (2) Study design evident and appropriate? (3) Method of subject/comparison group selection or source of information/input variables described and appropriate? (4) Subject (and comparison group, if applicable) characteristics sufficiently described? (5) If interventional and random allocation was possible, was it described? (6) If interventional and blinding of investigators was possible, was it reported? (7) If interventional and blinding of subjects was possible, was it reported? (8) Outcome and (if applicable) exposure measure(s) well defined and robust to measurement/misclassification bias? Means of assessment reported? (9) Sample size appropriate? (10) Analytic methods described/justified and appropriate? (11) Some estimate of variance is reported for the main results? (12) Controlled for confounding? (13) Results reported in sufficient detail? (14) Conclusions supported by the results?
Kmet LM, Lee RC, Cook LS. Standard quality assessment criteria for evaluating primary research papers from a variety of fields. Alberta Heritage Foundation for Medical Research; 2004.
[a] Items removed to make the QualSyst tailored for this research.