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Arm Adductor with arm Abduction in rotator cuff tear patients vs. healthy – Design of a new measuring instrument

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ABSTRACT

The incidence of (a)symptomatic rotator cuff tears is high, but etiologic mechanisms are unclear and treatment outcomes vary. A practical tool providing objective outcome measures and insight into etiology and potential patient subgroups is desirable. Symptomatic cuff tears coincide with humerus cranialization. *Ad*ductor co-activation during active arm *ab*duction has been reported to reduce subacromial narrowing and pain in cuff patients. We present an easy-to-use method to evaluate adductor co-activation. Twenty healthy controls and twenty full-thickness cuff tear patients exerted EMG-recorded isometric arm abduction and adduction tasks. Ab- and adductor EMG's were expressed using the "*Activation Ratio* (AR)" ($-1 \leqslant AR \leqslant 1$), where lower values express more co-activation. Mean control AR's ranged from .7 to .9 with moderate to good test-retest reliability (ICC: .60–.74). Patients showed significantly more *ad*ductor co-activation during *ab*duction, with adductor AR's ranging between .3 (teres major) and .5 (latissimus dorsi). In conclusion, the introduced method discriminates symptomatic cuff tear patients from healthy controls, quantifies adductor co-activation in an interpretable measure, and provides the opportunity to study correlations between muscle activation and humerus cranialization

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in a straightforward manner. It has potential as an objective outcome measure, for distinguishing symptomatic from asymptomatic cuff tears and as a tool for surgical or therapeutic decision-making.

1. Introduction

The incidence of shoulder related complaints in general practice is 22 per 1000 registered patients per year (Sobel & Winters, 1996). Chronic shoulder pathology as a result of rotator cuff (RC) diseases, including subacromial impingement syndrome and RC tears, mainly affects a population in the fifth to seventh decade of life and is a main cause of work-related problems of the locomotor system, with a high socio-economic impact. The etiology of these entities is not clearly understood and, consequently, diagnostic and therapeutic strategies are subject of debate. In this study, a new measure is presented, which is potentially valuable in both research and clinical decision making.

When conservative treatments fail, standard surgical treatment for full-thickness or massive RC tears is RC tendon repair, often in combination with subacromial decompression (Blaine, Freehill, & Bigliani, 2001; Nottage, 2003). Reported results of conservative and surgical treatments vary to a great extent (Seida et al., 2010). Moreover, symptoms are self-limiting in many RC tear patients, and 54% of persons over 60 years have asymptomatic RC tears (Keener, Steger-May, Stobbs, & Yamaguchi, 2010; Sher, Uribe, Posada, Murphy, & Zlatkin, 1995). Consequently, shoulder symptoms are not necessarily the consequence of an observed RC tear. To a further extent, this implies there may be several etiological mechanisms leading to shoulder complaints, related to a diagnosed RC tear in some but not all patients, requiring discrete therapeutic approaches. A practical tool providing objective outcome measures and insight into etiology and potential patient subgroups is desirable.

In the healthy shoulder a perfect compromise is assumed between arm mobility and glenohumeral stability (Veeger & van der Helm, 2007). In both healthy subjects and cuff lesion patients, deltoid activation leads to subacromial narrowing as a consequence of its mostly cranially directed force arm, pulling the humerus upwards (Graichen et al., 1999, 2005; Hinterwimmer et al., 2003). In healthy subjects rotator cuff activity reorients abduction forces in medial direction, with the resultant force falling within the glenoid fossa, ensuring glenohumeral stability (Fig. 1). In symptomatic rotator cuff tear patients, the muscle moment balance around the glenohumeral joint is disturbed which results in a conflict between mobility and stability: (1) there is increased deltoid activation during abduction to compensate for lost rotator cuff abductor forces (McCully, Suprak, Kosek, & Karduna, 2007; Steenbrink, de Groot, Veeger, van der Helm, & Rozing, 2009; Steenbrink et al., 2010b) and (2) there is decreased glenohumeral stability in cuff lesion patients as a consequence of impaired rotator cuff function (Steenbrink et al., 2009). It has been hypothesized that the combination of these mechanisms causes *excessive* cranialization (proximal migration) of the humerus in patients, leading to (painful) impingement of subacromial tissues (Graichen et al., 2005; Keener, Wei, Kim, Steger-May, & Yamaguchi, 2009; Steenbrink et al., 2009). To restore the glenohumeral stability, arm *ad*ductors with more caudally directed moment arms are activated during active arm *ab*duction in patients in order to reduce this subacromial narrowing (Fig. 1). This 'out-of-phase' *ad*ductor activation (co-activation) has been reported in both model simulation studies (Steenbrink et al., 2009) and patient experiments, in particular for the teres major and latissimus dorsi muscles with their medio-caudally directed force vectors (de Groot, van de Sande, Meskers, & Rozing, 2006; Steenbrink et al., 2010b, 2010a; Steenbrink, Meskers, Nelissen, & de Groot, 2010a). The conflicting effect of co-activation of *ad*ductors for reducing subacromial narrowing and pain, is the decrease of net arm *ab*duction torque and an increase of glenohumeral contact force.

Adductor co-activation provides insight into etiological and patient coping mechanisms, but also has potential value as a practical measure for identifying etiological subgroups in patients with shoulder symptoms and RC pathologies, applicable in diagnostics and clinical decision making, in discriminating symptomatic rotator cuff tears, and in objectively assessing treatment effects. However, current methods for assessing arm adductor co-activation are rather laborious to perform, applicable only in experimental environments (de Groot, Rozendaal, Meskers, & Arwert, 2004; de Groot et al., 2006;