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The Supraspinatus and the Deltoid – Not just two arm elevators

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ABSTRACT

Background: The debate on the clinical and functional role of the Supraspinatus in relation to the Deltoid necessitates experimental assessment of their contributions to arm elevation. Our goal was to evaluate the responses of both muscles to increased elevation moment loading.
Methods: Twenty-three healthy volunteers applied 30 N elevation forces at the proximal and distal humerus, resulting in small and large glenohumeral elevation moment tasks. The responses of the Deltoid and Supraspinatus were recorded with surface and fine-wire electromyography, quantified by ($EMG_{distal} - EMG_{proximal}$), and normalized by the summed activations ($EMG_{distal} + EMG_{proximal}$) to R_{Muscle} ratios.
Results: Deltoid activity increased with large elevation moment loading (R_{DE} = .11, 95%-CI [.06–.16]). Surprisingly, there was no significant average increase in Supraspinatus activation (R_{SSp} = .06, 95%-CI [−.08 to .20]) and its response was significantly more variable (Levene's test, F = 11.7, p < .001). There was an inverse association between the responses (β = −1.02, 95%-CI [−2.37 to .32]), indicating a potential complementary function of the Supraspinatus to the Deltoid.
Conclusion: The Deltoid contributes to the glenohumeral elevation moment, but the contribution of the Supraspinatus is variable. We

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speculate there is inter-individual or intra-muscular function variability for the Supraspinatus, which may be related to the frequently reported variations in symptoms and treatment outcome of Supraspinatus pathologies.

1. Introduction

The Supraspinatus is a rotator cuff muscle that is frequently affected in shoulder diseases. Supraspinatus tendon tears have a high prevalence and often affect active members of society (Reilly, Macleod, Macfarlane, Windley, & Emery, 2006; Sobel & Winters, 1996). Its consequences are most apparent during active arm abduction and elevation, expressed in pain and loss of arm force ranging from 0% to over 50% (McCabe, Nicholas, Montgomery, Finneran, & McHugh, 2005; Seida et al., 2010). However, 54% of persons over 60 years have asymptomatic Supraspinatus tears, eventual symptoms are often self-limiting and reported treatment results in patients with shoulder pain and Supraspinatus tears vary greatly; (Keener, Steger-May, Stobbs, & Yamaguchi, 2010; Seida et al., 2010; Sher, Uribe, Posada, Murphy, & Zlatkin, 1995; Tempelhof, Rupp, & Seil, 1999). More insight in its function is needed to gain understanding of these clinical variabilities.

The Supraspinatus has been described as important in two aspects. Firstly, the Supraspinatus is active during arm abduction and contributes to glenohumeral elevation moments, although Deltoid has been reported to be the largest contributor (Ackland, Pak, Richardson, & Pandy, 2008; Escamilla, Yamashiro, Paulos, & Andrews, 2009; Gerber, Blumenthal, Curt, & Werner, 2007; Gorelick & Brown, 2007; Howell, Imobersteg, Seger, & Marone, 1986; Kuechle, Newman, Itoi, Morrey, & An, 1997; McCully, Suprak, Kosek, & Karduna, 2007). The Supraspinatus and the Deltoid also seem to have a complementary role during arm elevation: Supraspinatus knock-out studies, by nerve blocking (McCully et al., 2007) or in Supraspinatus tendon tear patients (Steenbrink, Meskers, Nelissen, & de Groot, 2010) showed increased compensatory Deltoid activation of >50% during elevation tasks compared to controls. Secondly, the Supraspinatus has been reported to play a primary role in stabilizing the glenohumeral (GH) joint. The Supraspinatus, as other rotator cuff muscles, can press the humeral head against the concave glenoid, with its compressive muscle line of action and relatively small muscle moment arm (Hess, 2000; Kelly, Backus, Warren, & Williams, 2002; Kronberg, Nemeth, & Brostrom, 1990; Lippitt & Matsen, 1993; Ward et al., 2006; Wattanaprakornkul, Cathers, Halaki, & Ginn, 2011; Wuelker, Korell, & Thren, 1998). Symptomatic Supraspinatus tears in combination with consequent increased (compensatory) Deltoid activation have been related to humerus cranialization (or superior migration of the humeral head) during arm elevation (Steenbrink, de Groot, Veeger, van der Helm, & Rozing, 2009) underlining a complementary role of the Supraspinatus in glenohumeral stabilization.

To get a clearer view of on the potential role of the Supraspinatus as an elevation moment generator, we determined the response of the Supraspinatus to changes in elevation moment loading in healthy subjects, while keeping the force component constant. We compared this with the response of the Deltoid, using a similar set-up as applied by Steenbrink et al. (2010) for studying Deltoid function in cuff tear patients and healthy controls. We hypothesized that an increase in moment loading of isometric elevation tasks with a constant force magnitude, would lead to an increase in activation of both the Deltoid and the Supraspinatus, assuming that both muscles act as elevation moment generators.

2. Methods

Subjects isometrically exerted 30 N arm elevation forces alternately at the proximal and distal humerus, with the arm fully supported in a splint. This resulted in isometric tasks with a small and large moment arm of external glenohumeral loading, respectively. Task force magnitude and direction were controlled for, similar to a previous experiment with the same set-up (Steenbrink et al., 2010).