Adductor co-contraction during abduction: a friend or foe

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GENERAL INTRODUCTION

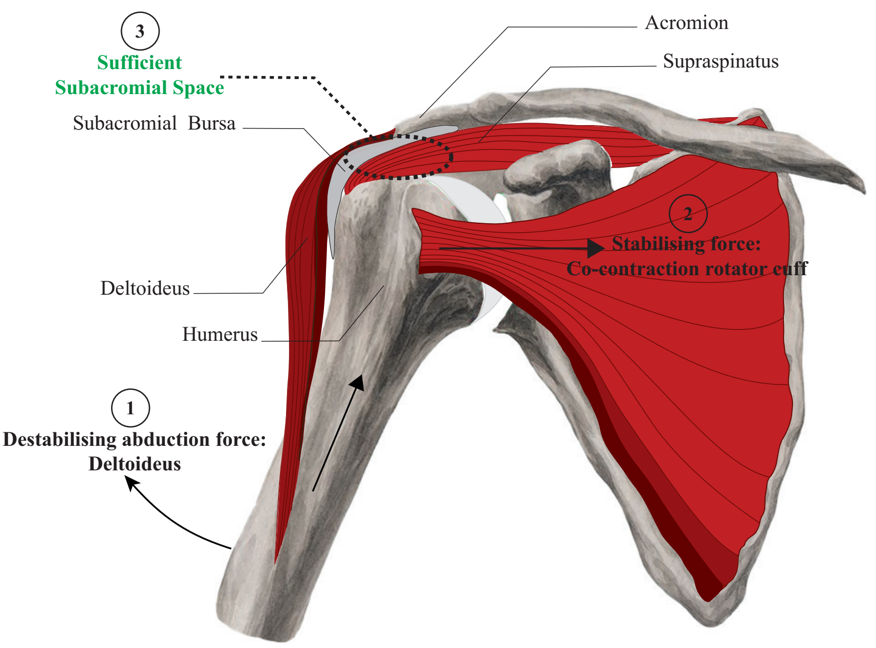
The first publication on subacromial pain dates from 1934[1]. In an ongoing search on the aetiology of this common pain disorder, more than four thousand articles have been published. From the 1970's until 2010 the condition was viewed as a consequence of "impingement" of the rotator cuff tendons and other subacromial tissues by the coracoacromial arch[1]. This turned out to be an overly simplistic representation of the problem, resulting in high recurrence rates after subacromial decompression procedures[2]. Subsequently, the condition has been described by a myriad of names to point at different proposed causes, until in 2014 clinicians concluded that given the lack of knowledge on the aetiology, calling it a pain syndrome is more appropriate[3]. Since then, the term "Subacromial Pain Syndrome (SAPS)" has increasingly been adopted to describe this clinical entity[3].

SAPS is characterised by pain in the subacromial region, that worsens during or subsequent to abduction of the arm[4,5]. Patients may experience (antalgic) loss of arm function and trouble sleeping[4,5]. With prevalence rates ranging between 15% and 22%, SAPS has far-reaching consequences for an individual's ability to perform daily activities, quality of life and health-care consumption[6]. Multiple treatment approaches are available, however up to 40% of patients report persisting complaints after treatment and the clinical course is disappointing in terms of resuming daily activities[7-10]. Hence, here is a need for improvement of therapeutic strategies in SAPS, and to achieve this, a more evidence-based hypothesis on the cause of pain and discriminating factors has to be constructed. In the maze of potential causes for subacromial pain proposed in literature so far, a few things seem to be certain, and have formed the base for this thesis:

1. **There is a relative discrepancy between the volume of subacromial tissues and the volume of the subacromial space.** In patients with SAPS, the subacromial tissues are inflamed with consequent swelling, but there is only limited space for expansion[4,11]. Furthermore, dynamic narrowing of the subacromial space during motion occurs, further narrowing the space[12,13].
2. **In the aetiology of SAPS, factors associated with ageing play a role.** The incidence of SAPS follows a specific age pattern; it develops from midlife onwards showing that age-related factors play a role in the pathogenesis[14-18].
3. **Coping and adaptation determine whether patients develop symptoms or not.** Starting between the age of 30 and 40, asymptomatic degenerative changes in the shoulder become common[14,19]. Most of the individuals remain asymptomatic while a minority develops SAPS, suggesting that coping and adaptation are of vital importance[4,19].

This thesis

A characteristic finding in patients with SAPS is exacerbation of pain during active abduction[4,5]. Open MRI and roentgenographic studies have shown that this may be the result of insufficient humeral head depression during abduction, with cranialisation of the humerus towards the acromion[4,5,12,13]. We theorise that patients with SAPS could benefit from mechanical unloading of subacromial tissues by active contribution of humeral head depressors. In both research and clinical practice, there has been a focus on the rotator cuff, while the arm adductors, specifically the teres major, may contribute strongly to depression of the humerus during abduction as well[20-24]. Since adductor co-contraction has so far predominantly been interpreted as a finding specific for shoulder injury, we have put one question central in this thesis, to evoke a shift in thinking[25]:



Young healthy shoulder
Adequate humeral depression during abduction by rotator cuff co-contraction

Figure 1 | Simplified representation of selected glenohumeral forces. *Destabilising cranial force generated by deltoideus during abduction, counteracted by medial directed force of rotator cuff.*

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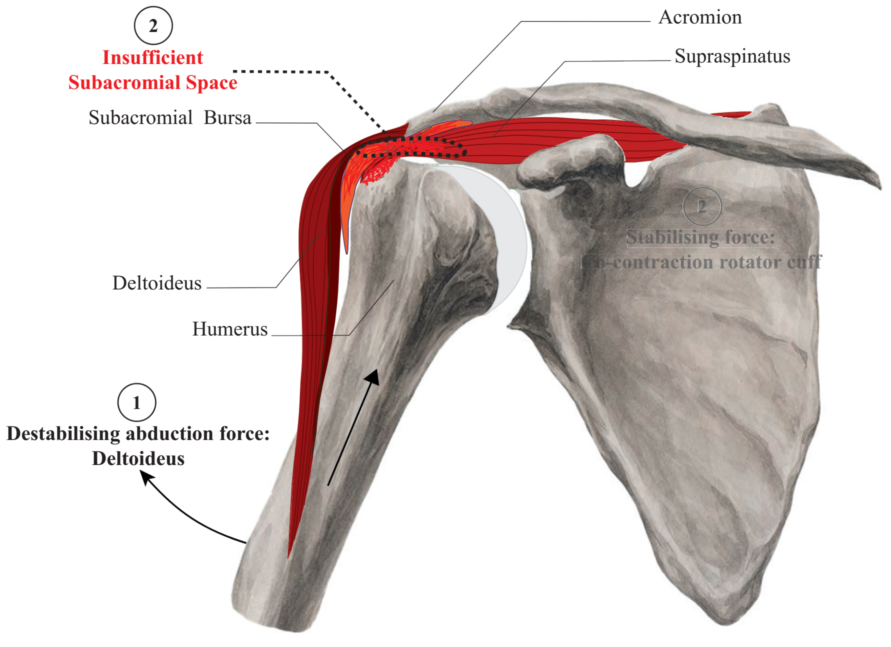
Background

In the young and healthy shoulder, cranially directed forces during abduction are counteracted by co-contraction of the rotator cuff muscles, predominantly the subscapularis and infraspinatus[21,22]. In this way, it is prevented that the humerus moves cranially towards the acromion, thus entrapping subacromial tissues (**Figure 1**). During ageing however, shoulder tissues are subject to marked degeneration, which particularly concerns the rotator cuff muscles[14,16,26-31]. This may have two consequences. First, due to reduced contribution of the upper parts of the rotator cuff to the abduction movement, the deltoid has to compensate, which results in a more cranially, instead of mediocranially directed force. Second, reduced stabilising force by the rotator cuff may jeopardise counteraction of cranial deltoid forces. These changes both could lead to cranialisation of the humerus and painful compression of subacromial tissues, which is depicted in **Figure 2**.



Painful irritation of subacromial tissues during abduction
Insufficient humeral depression, e.g. due to rotator cuff degeneration

Figure 2 | Simplified representation of selected glenohumeral forces. *Destabilising cranial force generated by deltoideus during abduction, not sufficiently counteracted by rotator cuff, leading to painful irritation of subacromial tissues.*

The arm adductors, as mentioned earlier, exert a medio-caudally directed force on the humerus and are capable of counteracting cranial deltoid forces during abduction[21,22]. Previous studies have shown that arm adductors, specifically the latissimus dorsi, teres major, and, to a lesser extent, the pectoralis major, may significantly contribute to humeral head depression during abduction[21,22]. We theorised that in the ageing shoulder, due to rotator cuff degeneration, increasing co-contraction of the arm adductors may be necessary for mechanical unloading of subacromial tissues during abduction (**Figure 3**)[14,16,27-31].

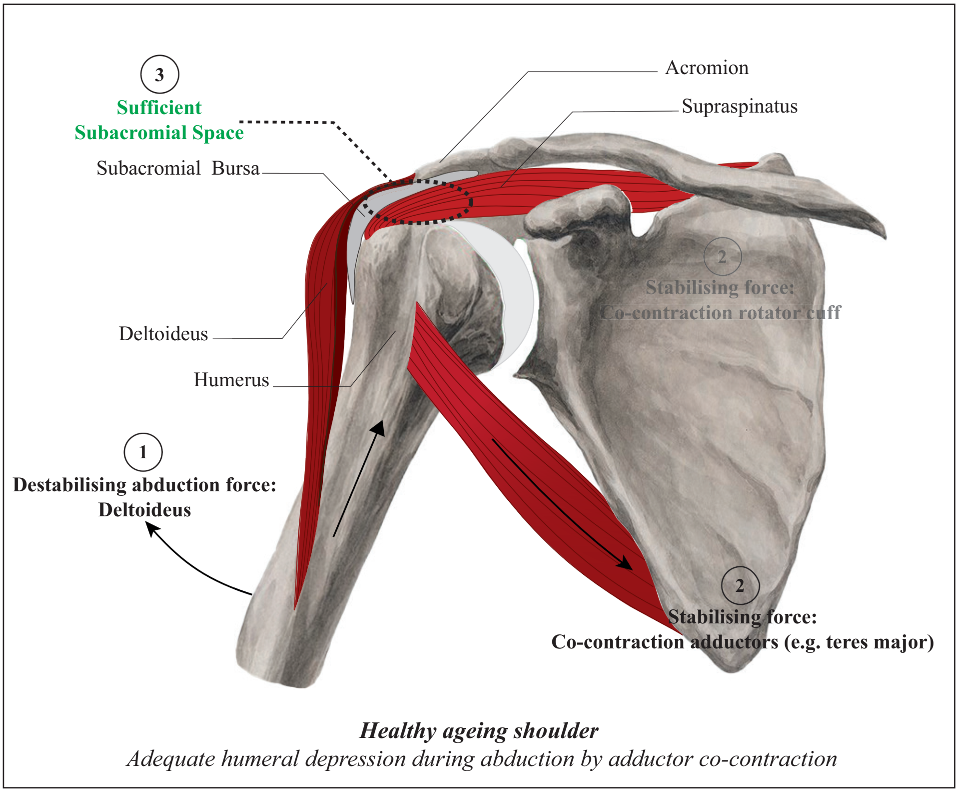


Figure 3 | Simplified representation of selected glenohumeral forces. *Destabilising cranial force generated by deltoideus during abduction, not sufficiently counteracted by rotator cuff, instead counteracted by co-contraction of adductors (e.g., teres major, latissimus dorsi).*

Following this line of reasoning, we explored the role of adductor co-contraction in individuals without shoulder complaints and in patients with SAPS in PART 1 of this thesis. In PART 2, factors that may determine adaptation of adductor activation patterns and perception of pain in SAPS are discussed.

PART I - The role of adductor co-contraction in the asymptomatic and symptomatic ageing shoulder (chapters 1-4).

- Chapter 1. To assess possible changes in adductor co-contraction during ageing, a cross-sectional analysis with electromyography (EMG) on co-contraction of the latissimus dorsi, teres major and pectoralis major was assessed in a wide age range of individuals without shoulder complaints[32].
- Chapter 2. Co-contraction of the latissimus dorsi, teres major and pectoralis major was compared between patients with SAPS and age-matched asymptomatic controls[33].
- Chapter 3. A prospective longitudinal cohort study comparing patients with SAPS at baseline and at 4 years of follow-up, to assess whether an increase of adductor co-contraction is associated with a favourable course of SAPS[23].
- Chapter 4. The effect of subacromial lidocaine infiltration on adductor co-contraction patterns was assessed in patients with SAPS, to evaluate potential causal relationships[34].

PART II - Factors that may determine adaptation of adductor activation patterns and perception of pain in SAPS (chapter 5-8).

The ability to adapt adductor activation patterns may depend on various psychosocial and biomechanical factors, among which is motor complexity[35,36]. This factor is rather new in the field of orthopaedic research and not fully validated yet, but may provide important insight[37-40]. It is proposed to describe the available spectrum of motor solutions for a given task, which should allow for learning through exploration and uniform load distribution across muscles[37-40].

- Chapter 5. Motor complexity of arm elevation trajectories was assessed in 120 asymptomatic shoulder controls between 18 to 70 years[35].
- Chapter 6. Force complexity was compared between 40 patients with SAPS and 30 matched asymptomatic controls[36].
- Chapter 7. A narrative review summarising the evidence of loss of proprioception in SAPS was performed, as proprioception is vital to counteract upward migration of the humerus during abduction and thus may play a role in SAPS[41-45].
- Chapter 8. The association between psychosocial functioning and persistence of complaints 4 years after routine care in patients with SAPS was evaluated[46].

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