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Full Length Article

Exercises focusing on rotator cuff and scapular muscles do not improve shoulder joint position sense in healthy subjects

Yin-Liang Lin, Andrew Karduna *

Department of Human Physiology, University of Oregon, 1240 University of Oregon, Eugene, OR, USA

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ABSTRACT

Proprioception is essential for shoulder neuromuscular control and shoulder stability. Exercise of the rotator cuff and scapulothoracic muscles is an important part of shoulder rehabilitation. The purpose of this study was to investigate the effect of rotator cuff and scapulothoracic muscle exercises on shoulder joint position sense. Thirty-six healthy subjects were recruited and randomly assigned into either a control or training group. The subjects in the training group received closed-chain and open-chain exercises focusing on rotator cuff and scapulothoracic muscles for four weeks. Shoulder joint position sense errors in elevation, including the humerothoracic, glenohumeral and scapulothoracic joints, was measured. After four weeks of exercise training, strength increased overall in the training group, which demonstrated the effect of exercise on the muscular system. However, the changes in shoulder joint position sense errors in any individual joint of the subjects in the training group were not different from those of the control subjects. Therefore, exercises specifically targeting individual muscles with low intensity may not be sufficient to improve shoulder joint position sense in healthy subjects. Future work is needed to further investigate which types of exercise are more effective in improving joint position sense, and the mechanisms associated with those changes.

1. Introduction

Proprioception includes afferent inputs of joint position sense (JPS), kinesthesia and sensation of resistance. These afferent inputs originate from muscle spindles and Golgi tendon organs in the musculotendinous structures as well as mechanoreceptors in the joint capsule, ligament and tissue surrounding the joint (Riemann & Lephart, 2002). Proprioception is involved in reflex arcs contributing to joint stabilization (Borsa, Lephart, Kocher, & Lephart, 1994) and automatic movement (Riemann & Lephart, 2002) as well as motor planning and strategy (Riemann & Lephart, 2002).

Proprioception input is essential for the central nervous system to regulate neuromuscular control in order to maintain functional joint stability, especially for the shoulder complex, which relies heavily on muscular contractions for stability. Subjects with shoulder pathologies, such as shoulder impingement syndrome (Anderson & Wee, 2011; Machner et al., 2003), anterior glenohumeral dislocation history (Smith & Brunolli, 1989), and shoulder instability (Lephart, Warner, Borsa, & Fu, 1994) have demonstrated proprioception deficits. It is possible that injured or loose ligaments, capsules, and muscles affect proprioception afferent input. Proprioception deficits may result in impaired neuromuscular control, which could ultimately lead to muscle imbalance and joint instability. The microinjuries resulting from joint instability can aggra-

* Corresponding author at: Department of Human Physiology, University of Oregon, 1240 University of Oregon, Eugene, OR 97403, USA.
E-mail address: karduna@uoregon.edu (A. Karduna).

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vate these proprioception deficits. This vicious cycle may be a factor in the development of chronic shoulder pain and the high recurrent rate of shoulder dislocation (Lephart et al., 1994).

Impaired neuromuscular control in patients with shoulder pathologies can include an abnormal contribution of the rotator cuff and scapulothoracic muscles. Previous studies have reported an increase in electromyography (EMG) of the upper trapezius as well as a decrease in EMG of the rotator cuff, lower trapezius, and serratus anterior (Lin, Hsieh, Cheng, Chen, & Lai, 2011; Ludewig & Cook, 2000; Reddy, Mohr, Pink, & Jobe, 2000). Exercises focusing on strengthen the rotator cuff and scapulothoracic muscles are typically recommended for shoulder rehabilitation and training (Cricchio & Frazer, 2011; Reinold, Escamilla, & Wilk, 2009). In order to restore the balance and coordination between muscles, those exercises are performed with shoulder movements in which the rotator cuff and scapulothoracic muscles show high muscle activity, with lower levels of deltoid, upper trapezius or pectoralis major activity (mainly open-chain exercises, except the exercise for serratus anterior) (Decker, Tokish, Ellis, Torry, & Hawkins, 2003; Ellenbecker & Cools, 2010; Reinold et al., 2004, 2007). Closed-chain exercise, on the other hand, can generate higher muscle activation level of serratus anterior (Decker, Hintermeister, Faber, & Hawkins, 1999) and it has also been suggested that closed-chain exercise can facilitate co-contraction of the rotator cuff and scapulothoracic muscles, which is essential for joint stability (Myers & Oyama, 2009; Ubinger, Prentice, & Guskiewicz, 1999).

Although the effects of exercise training on proprioception are not clear, it has been postulated that exercise can enhance proprioception by modulating the sensitivity of muscle spindles or helping subjects pay more attention to joint position (Ashton-Miller, Wojtys, Huston, & Fry-Welch, 2001; Swanik, Lephart, Giannantonio, & Fu, 1997). Most exercises used in previous studies were advanced exercises for athletic training and were categorized into specific types of exercise. The effect of the exercises on shoulder JPS in healthy subjects has been explored with the use of open-chain exercises (Padua, Guskiewicz, Prentice, Schneider, & Shields, 2004; Rogol, Ernst, & Perrin, 1998; Salles et al., 2015), closed-chain exercises (Padua et al., 2004; Rogol et al., 1998), plyometric training (Heiderscheit, McLean, & Davies, 1996; Swanik et al., 2002), and proprioceptive neuromuscular facilitation (Padua et al., 2004). However, the results of exercise training are not consistent, even within the same type of exercises (Heiderscheit et al., 1996; Padua et al., 2004; Rogol et al., 1998; Salles et al., 2015; Swanik et al., 2002).

There are two main limitations in previous studies. First, to our knowledge, only one study used specific exercises targeting the rotator cuff and scapulothoracic muscles with open-chain exercises in a healthy population (Padua et al., 2004). However, in clinical practice, rehabilitation exercises typically contain both open-chain and closed-chain exercises (Cricchio & Frazer, 2011; Reinold et al., 2009). It is still unknown if strengthening exercises for rotator cuff and scapulothoracic muscles have improved the shoulder proprioception. Secondly, previous studies have investigated JPS using the positions of internal and external rotation (Heiderscheit et al., 1996; Padua et al., 2004; Rogol et al., 1998; Salles et al., 2015; Swanik et al., 2002). Although this testing position is easy to perform and is a functional position for overhead athletes, it blocks scapular movement and is not a functional motion for the general population. In addition, scapular JPS has not been investigated in previous exercise training studies.

Therefore, due to the limitations of the exercise and assessment protocols in previous studies, the purpose of the present study was to examine the effects of rotator cuff and scapulothoracic muscle strengthening exercises on shoulder JPS during arm elevation motion in healthy subjects in order to understand the JPS adaptation to exercises. We hypothesized that JPS errors of the humerothoracic (HT), glenohumeral (GH) and scapulothoracic (ST) joints would decrease after rotator cuff and scapulothoracic muscle strengthening exercise training. We also hypothesized that the strength of the rotator cuff and scapulothoracic muscles would increase after the exercise training.

2. Methods

2.1. Subjects

Thirty-six healthy subjects were recruited from the University of Oregon. Subject exclusion criteria for the study were as follows: 1) prior shoulder and cervical surgery; 2) presence of shoulder and neck pain and injuries; 3) history of cervical or shoulder pain or pathology in past 3 years; 4) a concussion within the past 12 months or a history of 3 or more concussions; 5) brain injury and neurological impairment; 6) history of seizures; 7) taking anti-seizure and anti-depressive medication; 8) pacemaker and other magnetic implant; 9) pregnancy and 10) participation in NCAA sports that involves the extensive use of the upper extremity. The study was approved by the Office for Protection of Human Subjects at the University of Oregon and all subjects signed an informed consent form.

2.2. Procedure

Subjects were randomly assigned into either a control or training group during their first visit to the lab. The age, height and weight of subjects in both groups were similar, with no significant between group differences. (Table 1). JPS of the dominant shoulder was assessed at baseline and 4–5 weeks later for both groups. For the control subjects, these were only two visits for JPS assessment. For the subjects in the training group, in addition to the two JPS assessments, there were two visits for exercise intensity evaluation, and 12 visits for exercise training.