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Immediate effects and short-term retention of multi-modal instruction compared to written only on muscle activity during the prone horizontal abduction exercise in individuals with shoulder pain

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ABSTRACT

In rehabilitation, exercise instructions are multi-modal and can include a focus of increasing mean activity of a target muscle and inhibiting aberrant synergistic muscle activity, particularly during shoulder exercises, such as the prone horizontal abduction (PHA). The objective was to compare the immediate effects and short-term retention of multi-modal exercise instruction by a physical therapist written only instruction on normalized mean upper and lower trapezius muscle activity during three phases (concentric/isometric/eccentric) versus of an isotonic PHA exercise between participants with and without shoulder pain. Surface electromyography (EMG) was recorded from fourteen healthy participants and twelve participants with shoulder pain during the PHA exercise under two conditions: (1) written only instructions and (2) multi-modal instruction. Retention of multi-modal instruction on muscle activity was assessed one week later. Results demonstrate 12.8–16.0% increase in lower trapezius muscle activity during the concentric and isometric phases with multi-modal instructions in both groups. Inhibition of the upper trapezius did not occur in either group. Facilitation effects were maintained in short-term follow-up. Findings suggest that regardless of shoulder pain, multi-modal instruction by a physical therapist facilitates greater neuromuscular activity of a targeted muscle compared to written instructions alone and these effects are retained.

1. Introduction

Abnormal scapular kinematics have been characterized by changes in scapular muscle activity (Ludewig and Cook, 2000). Of particular interest are the contributions of the serratus anterior, and the lower and upper trapezius muscles that stabilize the scapula to the thorax and induce scapular upward rotation and posterior tilt during arm elevation (Johnson and Pandyan, 2005; Kronberg et al., 1990). Alterations in muscle activity, such as excessive upper trapezius, decreased lower trapezius, and decreased serratus anterior muscle activity, are associated with various shoulder pathologies (Ludewig and Cook, 2000; Roy et al., 2009) and are theorized to contribute to abnormal shoulder motion. Therefore, exercise programs that not only focus on strengthening the scapular muscles, but also emphasize quality of movement with proper muscle control have been advocated for the treatment of patients with shoulder pain (Cools et al., 2007a,b; Ludewig and Borstad, 2003; Roy et al., 2009). Inhibiting upper trapezius muscle activity and facilitating lower trapezius muscle activity with scapular strengthening exercises is a desired effect in shoulder rehabilitation and injury prevention programs (Cools et al., 2007a,b).

One specific exercise, the prone humeral horizontal abduction (PHA), is a consistent component of evidence-based shoulder rehabilitation and injury prevention programs (Kuhn, 2009; Tate et al., 2010; Wilk et al., 2002). Compared to other frequently prescribed scapular muscle strengthening exercises, the PHA exercise induces the greatest amount of scapular kinematic changes in upward rotation, posterior tilt, and external rotation from resting posture (Oyama et al., 2010) and elicits high middle and lower trapezius muscle activation levels (Moseley et al., 1992; Townsend et al., 1991). These effects are intended to correct impairments associated with shoulder pain. Despite inclusion of the PHA exercise in shoulder injury prevention and rehabilitation programs, the

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technique in which the exercise is performed may impact the scapular muscle activation levels and negate the desired effect (De Mey et al., 2013). For example, if the PHA exercise is performed with poor technique it may elicit excessive upper trapezius activity or low levels of lower trapezius activity, contrary to the desired purpose.

Clinically, rehabilitation specialists provide multiple methods of exercise instruction and feedback to maximize the individual's motor learning, obtain the desired movement pattern and functional outcome. Written exercise instructions typically provide the necessary information to complete an exercise with or without pictures that illustrate the start and end position of the movement. Rehabilitation specialists who treat shoulder injuries, such as physical therapists and athletic trainers, typically provide multi-modal exercise instruction that is a combination of detailed verbal and written instructions, demonstration, tactile cues, and visual and verbal feedback to emphasize the quality of movement and musculature used (Snyder and Leech, 2009). In studies that demonstrate the effectiveness of exercise for the treatment of individuals with shoulder pain, various forms of exercise instruction have been used (Brox et al., 1999, 1993; Ginn and Cohen, 2005; Ginn et al., 1997; Rahme et al., 1998). However, many clinical trials on the efficacy of exercise in patients with shoulder pain lack details regarding the method of instruction and whether or not the exercise program was instructed by a physical therapist or athletic trainer (Ginn and Cohen, 2005; Kuhn, 2009). Providing written instructions for home-directed exercise programs has been advocated as a cost-effective method to achieve similar outcomes to rehabilitation programs supervised by physical therapists (Ginn and Cohen, 2005; Roddey et al., 2002; Werner et al., 2002), or usual care (Geraets et al., 2006). It is unclear what effect multi-modal instruction provided by a rehabilitation specialist versus written exercise instructions alone have on muscle activation in individuals with shoulder pain and whether these effects are sustained in short-term follow up.

The purpose of this study was to compare the immediate effects and retention in short-term follow up of exercise instruction (written only vs. physical therapist directed multi-modal) on mean upper and lower trapezius muscle activity during three phases (concentric, isometric, and eccentric) of an isotonic PHA exercise between participants with and without shoulder pain. We hypothesized that: (1) multi-modal instruction by a physical therapist compared to written only instruction will increase normalized mean lower trapezius and decrease normalized mean upper trapezius activity; (2) effects will be greater in the painful group; (3) changes in normalized mean lower and upper trapezius activity will be maintained in short-term follow up one week later. We also explored the additive effects of repeating the therapist directed multi-modal instruction in the follow up session.

2. Methods

2.1. Participants

Twenty-six adults volunteered to participate in this prospective cohort study. Participants were recruited into one of two groups, 12 with shoulder pain (painful group) and 14 healthy participants (healthy group), matched by gender and hand dominance of shoulder tested. There were no statistically significant differences between groups in age, height or weight (Table 1). Participants were excluded if they were unable to perform the PHA shoulder exercise, had adhesive allergies, neurological disorders, or a history of neck or shoulder fracture or surgery. Healthy participants were excluded from the study if they had complaints of shoulder or neck pain within the last six months. Painful participants were included if pain was reproduced during active, passive, or resistive shoulder range of motion. Painful participants were excluded if the shoulder pain was greater than 7/10 on the numeric pain rating scale. Eligible participants read and signed an informed consent approved by the University's Institutional Review Board prior to initiating the study. All participants completed an intake questionnaire and Penn Shoulder Score, a validated self-reported regional disability scale from 0 to 100 points with 100 points representing no pain, high satisfaction, and high self-report of function (Leggin et al., 2006). The painful group reported greater pain, less function and less satisfaction with shoulder function than the healthy group ($p < 0.001$) (Table 2). Using the within session minimal detectable change (MDC) and standard deviation of lower trapezius EMG mean activity obtained from a pilot study (Seitz and Uhl, 2012), we calculated a sample size of $n = 24$ total participants would be needed to detect differences in lower trapezius activity that exceed measurement error with 80% power and $\alpha = 0.05$.

2.2. Electrode placement

Participants attended two sessions one week apart. The testing procedures were the same for each session. The participants' skin was prepared for surface electrode placement, shaved, lightly debrided, and cleaned with alcohol (De Luca, 1997). Bipolar surface electrodes (Blue Sensor; Glen Burnie, MD) were placed parallel to the muscle with a 2-cm inter-electrode distance in standardized locations on the serratus anterior (Ekstrom et al., 2004), and upper (Mclean et al., 2003) and lower portion of the trapezius (Nieminen et al., 1993) (Table 3). A surface ground electrode was placed on the contralateral acromion process. An electrogoniometer (SG110, Biometrics, Ladysmith, VA, USA) was placed on the shoulder across the scapular spine distally to the deltoid. The leads of the EMG channels and electrogoniometer were connected to a portable amplifier (Run Technologies, Mission Viejo, CA). Electrode placement was visually confirmed with resisted contractions of the instrumented muscles while verifying the EMG activity with an oscilloscope. Then, the resting level of the electrical activity of each muscle was recorded for 5 s while the subject stood upright with his or her arms relaxed.

2.3. Prone horizontal abduction exercise instruction

All participants were asked to perform 2 sets of 10 repetitions of the PHA exercise elevating the arm to 100° of abduction. Participants were provided with written only instructions with pictures of a start, middle, and finish position of the PHA exercise (Fig. 1) for the first set of 10 repetitions adapted from the thrower's ten program (Asmi.Org, 2009). The participants were asked to hold an isometric position at the end of the concentric phase for 2 s. Participants held a weight that was 2% of his or her bodyweight, which was modified to provide less resistance than a protocol used in a prior study of active healthy individuals (Table 4) (De Mey et al., 2009). The weight was systematically reduced due to the inability of participants to complete 10 repetitions of the exercise with resistance used the prior published protocol in pilot study. No feedback or other instructions were given. Following the exercise each participant was asked to rate the difficulty of performing the PHA exercise from 6 to 20 using the Borg Rating of Perceived Exertion (RPE) scale with anchors of 6 as "No exertion at all" and 20 as "Maximal exertion" (Borg and Kaijser, 2006; Kang et al., 1998). Participants were then given a five-minute rest period before further testing to minimize fatigue (Merletti et al., 1987; Yates et al., 1987). Prior to the second set, a physical therapist provided participants with specific multi-modal instructions intended to maximize the lower trapezius muscle activity and minimize the upper trapezius muscle activity. The physical therapist positioned