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Original article

Ultrasonographic analysis of dorsal neck muscles thickness changes induced by isometric contraction of shoulder muscles: A comparison between patients with chronic neck pain and healthy controls

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ABSTRACT

Background: Altered pattern of muscle activity is commonly seen with chronic neck pain (CNP). However, limited investigations have been done on dorsal neck muscles' activity pattern while performing upper limb tasks in patients with CNP.
Objectives: To investigate dorsal neck muscles' thickness changes during isometric contraction of shoulder muscles.
Design: Case-control study.
Methods: This study investigated dorsal neck muscles' thickness changes during isometric contraction of shoulder muscles in 20 healthy participants (mean age 27 ± 4.37) and 17 patients with CNP (mean age 29 ± 5.50). Effects of isometric force of shoulder muscles on dorsal neck muscles' thickness changes were also evaluated.
Results: Significant muscle × group interaction was observed for the dorsal neck muscles thickness changes ($p = 0.008$) indicating different pattern of muscle activity in terms of changes in muscle thickness of two groups. Significant main effects of direction was observed ($P = 0.003$), with the abduction had the greatest impact on changing the dorsal neck muscles thickness.
Conclusions: patients with CNP showed altered pattern of muscle thickness changes in comparison to healthy participants. Isometric abduction of shoulder muscles induced the greatest changes of dorsal neck muscles thickness among other force directions.

1. Introduction

Neck pain is considered as a common musculoskeletal problems of office workers which impose socio-economical burden to the society (Alshagga et al., 2013). Neck pain is commonly associated with various sensorimotor deficits (Treleaven, 2008). Weakness of cervical muscles is represented in individuals with chronic neck pain (CNP) (Rezasoltani et al., 2002; Ylinen et al., 2004). Altered muscle activity is also recognized as a common feature in such individuals (Johnston et al., 2008). It is suggested that muscle impairment may be a potential reason for long standing disability, seen in individuals suffering from chronic neck pain (Peolsson et al., 2013). Delayed muscle activity with increased or decreased muscular activation may lead to modification of normal activity pattern (Falla et al., 2004). Therefore, study of faulty movement pattern in individuals with neck pain (Falla et al., 2004; Peolsson et al., 2012) may shed light on this area of research.

Needle and surface EMG are popular techniques for evaluation of the muscle activity (Falla et al., 2003; Falla et al., 2004; Falla et al., 2007). However, the invasive nature of needle EMG (Falla et al., 2007) and the potential cross talk of surface EMG during data collection, reduces their popularity for evaluation of dorsal neck muscles activity (Stokes et al., 2003). Ultrasonography is a non-

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invasive method for evaluation of real-time activity of muscles and a reliable method for assessment of dorsal neck muscles activity both in healthy individuals and patients with CNP (Kristjansson, 2004; Stokes et al., 2005; Kiesel et al., 2007). Therefore, during the last decade, it has been increasingly used in investigating the neck muscle function (Kristjansson, 2004; Cagnie et al., 2009; Rezasoltani et al., 2010, 2012; Rahnama et al., 2013).

Dorsal neck muscles play a critical role in establishing the optimal mechanical support during activities of daily living. Upper extremity tasks are major components of daily activities which impose various loads to the cervical spine (Anderson et al., 2005; Peolsson et al., 2013). Performing upper extremity tasks in different directions may have different loading effects on cervical spine (Takasaki et al., 2009). Literature indicates functional impairment of dorsal neck muscles during movements of upper extremities in patients with CNP (Peolsson et al., 2013). Accordingly, altered muscle activity in patients with CNP may contribute to changes in loading to cervical spine, which may lead to pain in cervical area. This may produce more devastating effects particularly when tasks are done forcefully like many activities of daily livings. The reason of such devastating effect is that each of axioscapular and cervical muscles originate from and terminate to different landmarks causing diverse moment arms and actions. The cervical spine is stabilized by aforementioned muscles during weight bearing activities. Therefore, altered pattern of their activities may cause altered amount of loads imposed to cervical spine. Consequently, it may cause pain in cervical area (Takasaki et al., 2009).

Despite the importance of the integrated activity of dorsal neck muscles in health of cervical spine, the extent which muscle activity changes in individuals with CNP while performing upper extremity tasks, is not well understood. Therefore, the aim in current study is to, firstly, evaluate effects of isometric contraction of arm muscles in different force directions on dorsal neck muscles' thickness in patients with CNP and healthy participants and, secondly, to compare the effect of each force direction on dorsal neck muscles' thickness in such individuals. Based on the previous literature (Takasaki et al., 2009; Peolsson et al., 2013), it is hypothesized that: 1) compared to healthy individuals, patients with chronic neck pain show greater changes in dorsal neck muscles' thickness during isometric contractions of shoulder muscles and 2) dorsal neck muscles' thickness changes in each movement direction.

2. Methods

2.1. Participants

A convenience sample of seventeen individuals with non-specific CNP and 20 comparable healthy controls in terms of age, height and weight were participated in this study. All participants were right handed males. Patients with CNP had pain with intensity of minimum 3 on Visual Analog Scale (VAS) for at least 3 months prior to the current study. The controls were pain free at the time of the participation while they did not report any history of neck pain. Participants were not included if they had any history of traumatic injury to the spine, any inflammatory diseases, or any congenital deformity. Participants were excluded if they reported any pain or discomfort during performing the procedure. Additionally, those patients who suffer from pain radiated to arms were excluded. Subjects were recruited among bank officers who returned a questionnaire comprising inclusion/exclusion criteria. The information about the study procedure was given to all participants. After acceptance, written consents were obtained. The study procedure was approved by Ethics Board of Physiotherapy Research Center, Shahid Beheshti University of Medical Sciences.

2.2. Study design

This is a case control study in which the thickness of five dorsal neck muscles was measured at rest, 50% and 100% maximum voluntary contractions (MVC) of shoulder muscles in six directions of movements by a diagnostic Ultrassound (US) device (please add in participants with CNP and matched controls in terms of age, weight, height and body mass index (BMI)).

2.3. Experimental procedure

Participants were instructed to sit relax on a custom made chair, put their right forearms on the arm rest, and keep their heads and neck in neutral position. They were secured to the chair by 2 thoracic and pelvic belts. A ZEMIC load cell model H3-C3-100 Kg-3B was placed on a U-shaped groove, located on the armrest. The groove was designed to let the examiner move the load cell to different locations in order to record isometric contraction of shoulder muscles in 6 different movement directions of the shoulder joint (Fig. 1). The six directions of shoulder movements include; flexion, extension, external rotation, internal rotation, adduction and abduction.

The whole protocol was explained to participants in order to familiarize them with the procedure. They were asked to perform 3 trials of isometric contraction of shoulder muscles in 3 random directions prior to the experimental procedure.

In order to record the isometric strength of shoulder muscles subjects were instructed to push their forearms against the load cell and gradually reach their MVC within 10 s while no kind of feedback were given. Each trial was repeated 3 times with 60 s intervals. Then, to prevent fatigue, they were given a 2-min rest, before performing the isometric contraction of arm muscles in another random direction. The new direction is selected among 6 available ones based on standard uniform random number distribution. The maximum amount of three trials of recorded force by loadcell was recognized as participants' MVC for each direction (Rezasoltani et al., 2010; Rahnama et al., 2015). Then 50% of the chosen MVC were identified by a custom made software for further analyses.

Ultrasound imaging of dorsal neck muscles were carried out by an ultrasound device (Accuvix V20 prestige, Samsung Medison,

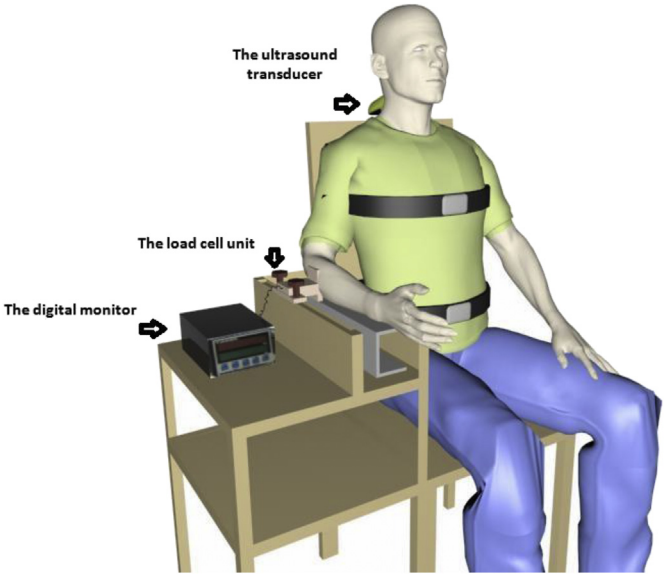

Fig. 1. Experimental setup. Participants were tested in sitting position while their elbow and forearm were rested over the chair's arm rest.