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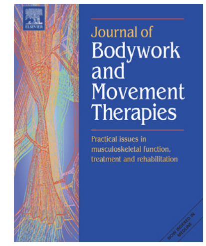

CROSS SECTIONAL MUSCLE PHYSIOLOGY STUDY

The effects of isometric contraction of shoulder muscles on cervical multifidus muscle dimensions in healthy office workers

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Summary It is argued that cervical multifidus muscles (CMM) are responsible for providing neck stability. However, whether they are actually activated during the tasks performed by the upper extremities to the neck is still unknown. Therefore, the aim of this study was to examine the effects of isometric contraction of shoulder muscles on the dimensions of CMM. Twenty three healthy males voluntarily participated in this study. Ultrasonography imaging of CMM was conducted at rest and at 25%, 50%, 75%, and 100% of maximal voluntary contraction of shoulder muscles in 6 directions of shoulder movements. Anterior—posterior dimension (APD), lateral dimension (LD), shape ratio and multiplied linear dimension (MLD) of cervical multifidus were measured. The APD of CMM was increased while LD and shape ratio were decreased by shoulder muscles contraction ($P < 0.01$).

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Introduction

Neck pain is considered as one of the most prevalent problems of modern society (Fernández-de-las-Peñas et al., 2011) causing both disability and functional impairment in office workers (Leijon et al., 2004). It has been reported that more than 34% of people have experienced some kind of neck pain during their lives (Straker et al., 2011).

Several biomechanical and physiological changes have been recorded in patients suffering from neck pain, including reduced strength of deep and superficial neck muscles (Elliott et al., 2008; Falla et al., 2004; Ylinen et al., 2004; O'Leary et al., 2011). Deep cervical muscles are accountable for head and neck stability in both static and dynamic postures (Falla et al., 2007). This muscular stability plays an essential role in preventing strains and injuries to neck structures (Wilke et al., 1995). The Cervical multifidus muscle (CMM) is regarded as a deep neck extensor muscle providing such stability (Wilke et al., 1995). Physiological changes in the CMM has previously been reported in patients with neck pain (Fernández-De-Las-Peñas et al., 2008), in addition to a disturbance to the stability of the cervical spine as a result of CMM weakness. Physical exercises are well recognized in remedying instability and muscular weakness (Kay et al., 2005). However, none of the recommended exercises specifically activates CMM, and at present, we have too little information on these various movements activating CMM effectively. Such movements are designed to prevent muscular weakness, while assisting with the strengthening of these.

It is assumed that the function of CMM is very similar to that of the lumbar multifidus muscle (LMM). Both muscles have a unique feed-forward role in providing intersegmental stability (Anderson et al., 2005; Ward et al., 2009). LMM activity has been reported during the movements of both lower and upper extremities documented before and after an arm flexion task (Moseley et al., 2002), in addition Danneels et al. have shown that the LMM cross-sectional area (CSA) increases by resistance exercises of the lower extremities (Danneels et al., 2001). Therefore, the expectation is that CMM is activated by movements causing lumbar multifidus muscle activation in tasks performed by the upper extremities, if CMM is functionally considered equal to LMM.

To study the functions of the cervical muscle, various methods such as electromyography (EMG), muscle functional magnetic resonance imaging (mfMRI) and ultrasonography have been used, among which ultrasonography is non-invasive and highly comparable to MRI. It has been also shown to be a feasible and reliable method to evaluate the dorsal neck muscles dimensions during muscular contraction (Javanshir et al., 2011; Kiesel et al., 2007; Rezasoltani et al., 2002). The high reliability of CMM ultrasonography has been reported at the level of C4 in the resting position (Kristjansson, 2004). In a more recent study, it was revealed that the CMM thickness increased during different levels of isometric cervical extension (Lee et al., 2007).

While considering the function of CMM, this study was implemented with the objective of examining the effects of isometric contraction of shoulder muscles on the dimensions of cervical multifidus muscle as measured by ultrasonography.

Methods

Participants

A total of 23 healthy male office workers (right handed; mean age: 24 $\pm$ 4 years) voluntarily participated in this cross sectional study. Participants were excluded if they had any history of neck pain in the last year, cervical trauma, or history of spinal surgery. The procedure was explained to the participants prior to the study and informed consents were obtained from those who agreed to participate. The study was approved by the Research Ethics Board of the Faculty of Rehabilitation, Shahid Beheshti University of Medical Sciences.

Procedure

Real time ultrasound imaging was conducted by an ultrasound system (Accuvix V20 prestige, Samsung Medison, Korea) with an 8 MHz and 4.5 cm linear array transducer. A ZEMIC load cell model H3-C3-100 Kg-3B, was calibrated and used to record the isometric strength of shoulder muscles. A custom-designed software (SonoSynch) was used to pick up all load cell data and ultrasound images in a synchronized way with a sampling rate of 20/sec. In other words, at each second, twenty load cell data, including produced forces by the participant and twenty identical images of CMM were simultaneously picked up and stored. This enabled the examiner to have all force levels from 0 to 100% MVC and their identical images at the time of data analysis. A custom made chair was used with an armrest at the dominant (right) side of the subject to measure the strength of shoulder muscles. The load cell was set at a U-shaped groove and placed on the armrest, to enable it move through and record forces in 6 movement directions of the shoulder joint (flexion, extension, abduction, adduction, external rotation and internal rotation). For instance, when the load cell was in the most frontal part of the outer shaft of the U device, just beside the distal part of the forearm of the participants, they exerted their force against it in the external rotation direction.

Participants were asked to sit relaxed on the chair while keeping their heads and necks in a neutral position, resting their left hand on their thighs and their right hand on the armrest (Fig. 1). Two belts, namely thorax and pelvic belts were used to secure the participants in the chair. The thorax belt was at scapular spine level and the pelvic belt was fastened at the level of iliac crest (Rezasoltani et al., 2010). Instructions were given for the arm to be pushed against the load cell gradually in desired directions to reach their maximal voluntary contraction (MVC) in 10 s. The examiner was unaware of the amount of force exerted by the participants. Three repetitions with 60 s intervals were performed in each direction. If the difference among the repetitions was more than 10%, an applicant was asked to perform the forth trial. Each of the