Manual Therapy 19 (2014) 32–36

Contents lists available at SciVerse ScienceDirect

Manual Therapy

journal homepage: www.elsevier.com/math

Original article

# Does posture of the cervical spine influence dorsal neck muscle activity when lifting?

Anneli Peolsson [a,b,*], Eivind Marstein [a], Timothy McNamara [a], Damien Nolan [a], Espen Sjaaberg [a], Michael Peolsson [c], Gwendolen Jull [a], Shaun O'Leary [a,d]

[a] NHMRC CCRE (Spinal Pain, Injury and Health), The University of Queensland, St Lucia, Brisbane, QLD 4072, Australia
[b] Department of Medical and Health Sciences, Division of Physiotherapy, Faculty of Health Sciences, Linköping University, Linköping, Sweden
[c] Computational Life Science Cluster and Department of Chemistry, Umeå University, Umeå, Sweden
[d] Physiotherapy Department, Royal Brisbane and Women's Hospital, Queensland Health, QLD, Australia

ARTICLE INFO

*Article history:*
Received 15 November 2012
Received in revised form
6 June 2013
Accepted 13 June 2013

*Keywords:*
Cervical posture
Ultrasound
Lifting
Neck muscle

ABSTRACT

Previous studies have shown that postural orientations of the neck, such as flexed or forward head postures, are associated with heightened activity of the dorsal neck muscles. While these studies describe the impact of variations in neck posture alone, there is scant literature regarding the effect of neck posture on muscle activity when combined with upper limb activities such as lifting. The purpose of this study was to evaluate the effect of three different neck postures on the activity of the different layers of the dorsal neck muscles during a lifting task. Ultrasound measurements of dorsal neck muscle deformation were compared over two time points (rest, during lift) during a lifting task performed in three different neck postural conditions (neutral, flexed and forward head posture) in 21 healthy subjects. Data were analysed by post-process speckle tracking analysis. Results demonstrated significantly greater muscle deformation induced by flexed and forward head postures, compared to the neutral posture, for all dorsal neck muscles at rest ($p < 0.05$). Significant condition by time interactions associated with the lift was observed for four out of the five dorsal muscles ($p < 0.02$). These findings demonstrate that posture of the cervical spine influenced the level of muscle deformation not only at rest, but also when lifting. The findings of the study suggest that neck posture should be considered during the evaluation or design of lifting activities as it may contribute to excessive demands on dorsal neck muscles with potential detrimental consequences.



## 1. Introduction

Neck pain is often associated with occupations that involve lifting (Ariens et al., 2000). This is possible by virtue of the shared muscle attachments between the scapula and axial skeleton, such as upper trapezius and levator scapulae which attach to the head and cervical spine respectively (Moore et al., 2009). Subsequently, loads imposed on the scapula during lifting are transferred to the head and neck. If these loads are excessive or poorly attenuated, they may have the potential to initiate injury or strain pain-sensitive cervical structures (Behrsin and Maguire, 1986). This may be a risk if lifting tasks are performed in the presence of impaired neuromuscular function of the cervical spine or shoulder girdle (Falla et al., 2004, O'Leary et al., 2007; Wegner et al., 2010; Zakharova-Luneva et al., 2012). This proposed mechanism of lifting-induced neck pain is credible considering the reliance of the cervical vertebral column on cervical muscles for physical support (Panjabi et al., 1998).

Another factor often associated with occupational neck pain is cervical posture (Eltayeb et al., 2009). Studies have shown that some postural orientations of the cervical spine, such as forward head posture (FHP), result in heightened gravitational load to some cervical motion segments (Harms-Ringdahl et al., 1986), as well as increased extensor muscle activity (Edmondston et al., 2011). Although these studies suggest a potential association between cervical posture and detrimental strain on the neck, a direct cause–effect relationship between these factors has not been established (Szeto et al., 2002). Additionally, while these studies describe the impact of variations in neck posture alone (Harms-Ringdahl et al., 1986), there is scant literature regarding the effect of neck

* Corresponding author. NHMRC CCRE (Spinal Pain, Injury and Health), The University of Queensland, St Lucia, Brisbane, QLD 4072, Australia. Tel.: +61 7 33652209; fax: +61 7 33652775.
*E-mail addresses:* a.peolsson@uq.edu.au, Anneli.Peolsson@liu.se (A. Peolsson).

1356-689X/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.math.2013.06.003

posture on muscle activity when combined with upper limb activities such as lifting (Nimbarte et al., 2010).

The purpose of this study was to evaluate the effect of three different neck postures on the activity of the different layers of the dorsal neck muscles during a lifting task. Specifically, we utilised an ultrasound measurement application called speckle tracking analysis (Peolsson et al., 2012) to quantify the deformation (changes of longitudinal length of the muscle indicative of muscle activity) of multiple dorsal neck muscle layers during a lifting task in different neck postures. We hypothesised that neck posture will significantly alter the dorsal neck muscle activity during lifting. It is anticipated that the findings of this study will have relevance to understanding the potential for postural-based neck injury in occupational settings.

## 2. Methods

### 2.1. Participants

Twenty-one healthy subjects from a university population volunteered to participate in the study (male $n = 7$, female $n = 14$, mean age 26 years (SD 6.5)). Participants were all right hand dominant with no recent or previous history of a neck disorder requiring medical intervention, and absent signs of physical dysfunction in a clinical examination of the neck. Participants were excluded from the study if they reported any current shoulder disorders.

This study received approval from the Institutional Medical Research Ethics Committee and was conducted in accordance with the declaration of Helsinki. All participants received verbal and written information about the study and signed a consent form.

### 2.2. Measurements

#### 2.2.1. Ultrasound recordings and speckle tracking analysis

Ultrasound measurements of the dorsal cervical muscles were recorded with a 12.0 MHz linear transducer (38 mm footprint) and an Ultrasound Vividi Dimension (GE Healthcare, Horten, Norway) unit utilising a high frame rate (50 frames/s) operated in B-mode and a 2D ultrasound imaging system. Using this method, ultrasound images of muscle contractions were recorded before (at rest) and during the lifting tasks and later analysed as image sequences ("videos") by post-process speckle tracking analysis.

Recordings were made of the dorsal neck muscles, including the Upper Trapezius, Splenius, Semispinalis Capitis and Semispinalis Cervicis, and cervical Multifidus muscles (Fig. 1). All recordings were made at the C4 vertebral level, identified by palpation of the C4 spinous process. The transducer was first positioned in a transverse orientation at the marked C4 level on the right side, so that the underlying muscle layers and bony landmarks were identified. The transducer was then rotated 90°, and orientated longitudinally to the dorsal muscles. This provided the optimal image plane required for the post-process speckle tracking analysis, based on the stable Farneback mathematical model (Peolsson et al., 2012).

#### 2.2.2. Measurement of muscle deformation

Speckle tracking analysis was performed post process using the ultrasound movie sequence of images (AVI format). Ultrasound of muscle results in an interference pattern of acoustic markers referred to as a speckle pattern. In speckle tracking analysis the first frame of the video sequence is viewed and a region of interest frame (ROI; 10 × 2 mm) is positioned over a standardised location within the speckle pattern of each muscle. The ROI tracks its contained unique speckle pattern frame by frame through the movie

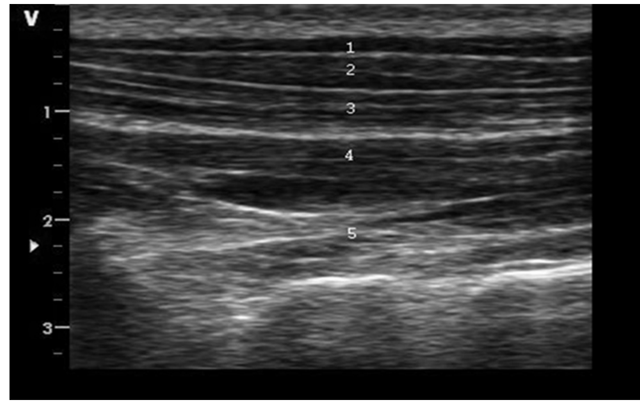


**Fig. 1.** Ultrasound image, dorsal view superficial and deep cervical muscles. 1 = Trapezius, 2 = Splenius, 3 = Semispinalis Capitis, 4 = Semispinalis Cervicis, 5 = Multifidus. Vertical axis in the figure shows the depth of the imaging into the tissues.

sequence. Consequently, as the contained speckle pattern changes length with muscle activity so does the length of the ROI. The change in the ROI length is measured as muscle deformation. The *Muscle Deformation* measure is calculated as the percentage change in the longitudinal median length variation of the ROI compared to that at rest (expressed as % strain). The rate of change in length of the ROI is measured as *Muscle Deformation Rate* which is deformation per time unit (expressed as % strain 1/s).

Tracking of the ROI in the movie sequence is done using a speckle tracking algorithm based on a stable mathematical model (Farneback). This research software tracks the unique speckle pattern contained within each ROI, dependent on at least 80% agreement of the speckle pattern between frames as sufficient for the software to accept that the identical muscle region is being accurately tracked (Peolsson et al., 2010). The calculating algorithm measures deformation of each ROI in each frame sequentially comparing it to its length in the initial resting movie frame.

It was ensured that the ROI representing each muscle was located in a standardised position between participants (midpoint of the muscle belly and orientated longitudinal to the muscle fibres). For each video sequence the optimal position of the ROI was checked by observing the video sequence in slow motion with the ROI's in situ to ensure that they were recognised by the measurement software and that the ROI representing other muscle layers did not cross each other. Once the investigator was satisfied with the location of each ROI the analysis was performed using the software.

The speckle tracking analysis method of measurement has been shown to have excellent test–retest reliability for the measurement of deformation in the cervical muscles (ICC 0.71–0.99) (Peolsson, A., unpublished data). There is also evidence of a positive relationship between the magnitude of muscle deformation (recorded with speckle tracking analysis) and the magnitude of muscle activity using other measurements (force, progressive electrical stimulation) providing justification for the use of the measurements performed in this study (Lopata et al., 2010).

### 2.3. Lifting task

Subjects sat without back support, with their feet flat on the floor, and their spine positioned in a clinically evaluated neutral position. An inclinometer was attached to their head, and was centred over the tragus of the left ear. Participants held a hand weight (2.5 kg for male participants and 1.5 kg for females) with the shoulder in 70° flexion, the elbow extended, and the forearm in