Longitudinal Changes in Ventral and Dorsal Neck Muscle Layers During Loading Against Gravity in Healthy Volunteers Using Speckle Tracking

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Abstract

Objective: This study aimed to describe and compare the longitudinal mechanical activity, deformation, and deformation rate of the different layers of dorsal and ventral neck muscles in healthy volunteers during head lifts against gravity.

Methods: The cross-sectional study included 19 healthy volunteers (mean age, 28 years; SD, 7 years). Ultrasound with speckle-tracking analysis was used to investigate longitudinal mechanical activation, deformation, and deformation rate of dorsal and ventral neck muscles in real time during a head lift. Significance levels were set as $P = .025$ or $P = .0125$, depending on the number of comparisons.

Results: The dorsal neck muscles did not significantly differ in deformation ($P > .04$); however, the multifidus had a higher deformation rate than all other dorsal muscles ($P < .003$). The sternocleidomastoid had significantly higher deformation than the longus capitis ($P = .005$) and colli ($P = .001$) but a lower deformation rate than the longus colli ($P = .02$).

Conclusion: The sternocleidomastoid deformed more than the deeper muscles, but it did significantly slower than the longus colli. Among the dorsal muscles, the deepest (the multifidus) had the highest deformation rate. (J Manipulative Physiol Ther 2014;xx:1-7)

Key Indexing Terms: *Neck Muscles; Exercise; Motor Skills; Ultrasonography*

Neck pain is a common problem, with published 1-year prevalence ranging from 34% to 65%[1-4] and the highest values reported in the most recent reports.[2,4] Neck muscles provide up to 80% of cervical spine stability.[5] Compared with healthy subjects, people with neck pain show decreased neck muscle endurance (NME)[6-8] and altered neck muscle activation patterns.[9,10]. In patients with neck disorders, neck-specific exercises are an important part of rehabilitation.[11,12]

Training exercises and clinical tests of NME commonly use loaded and unloaded neck lift exercises against gravity, in prone positions for the extensors and in supine positions for the flexors.[7,8,13-15] Only sparse information is currently available regarding which muscle layers are used in these positions without risk of cross talk.[10,13,16,17] Several studies have analyzed postperformance muscle behavior by examining cross-sectional areas using magnetic resonance imaging[16] and functional magnetic resonance imaging (*f*MRI)[10,13,17], and one has separately analyzed the behavioral functions of the longus capitis and longus colli.[13] One disadvantage of *f*MRI is that exercises cannot be studied in real time during the actual performance. No study has evaluated the different layers of neck muscles used and their mechanical properties in real time during exercise performance. Further investigations are needed to understand which muscles are actually activated and tested in measures of NME, which could be useful for improving rehabilitation protocols.

The purpose of this study was to investigate, describe, and compare the mechanical activity, deformation (percentage of change in longitudinal length), and deformation rate (the speed of the deformation) of the different layers of dorsal and ventral neck muscles during loading against gravity.

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Methods

In the present study, healthy volunteers performed head lifts against gravity, and we used ultrasound imaging with speckle tracking to evaluate longitudinal changes of the neck muscles in real time.

Participants

This cross-sectional study included 19 healthy volunteers (10 women and 9 men; mean age, 28 years; SD, 7 years; range, 21-48 years). Eighteen of the volunteers were right handed and one ambidextrous. Healthy was defined as follows: no present or past neck problems (<10 mm on the visual analog scale[18,19] and <20% on the Neck Disability Index[20]), no neck or head trauma, no rheumatologic or neurologic diseases, no generalized myalgia, and no severe back pain. The mean visual analog scale value for pain intensity was 0.2 mm (SD, 0.5; range, 0-2), mean Neck Disability Index score was 0.7% (SD, 0.8; range, 0-3), and mean physical activity level was 3.9 (SD, 0.2; range, 3-4) out of a maximum score of 4.[15]

All participants provided written informed consent. All procedures were conducted according to the Declaration of Helsinki, and the study was approved by the Ethics Committee at the Faculty of Health Sciences at Linköping University in Sweden.

Ultrasound Imaging

Anatomical assessments were performed with a 14.0 MHz linear transducer (38-mm footprint) and an Ultrasound Vivid 9 Dimension (GE Healthcare, Horten, Norway) with a high frame rate (78 frames per second) operated in B mode and a 2-dimensional ultrasound imaging system.

Images were recorded of the dorsal cervical muscles—including (from the most superficial to the deepest) the trapezius, splenius, semispinalis capitis, semispinalis cervicis, and multifidus (Fig 1A). We also recorded images of ventral muscles, including the most superficial (sternocleidomastoid and longus capitis) and the deepest (longus colli) (Fig 1B). For the dorsal muscles, an experienced physiotherapist identified the C4 level by palpation and marked the skin with a pen. The transducer was then positioned in a transverse orientation at that level on the right side, identifying the articular process, lamina, and the different layers of the dorsal neck muscles. For the ventral muscles, the transducer was positioned in a transverse orientation at the C4 level at the right side, using the bifurcation of the carotid artery and the thyroid as reference points to ensure imaging of the segmental level of interest. Once the operator was comfortable that the C4 spinal level had been identified, the transducer was rotated 90° to a longitudinal orientation. This provided an optimal image plane for specialized postprocess speckle-tracking analysis using research software based on the stable Farneback mathematical model.[21]

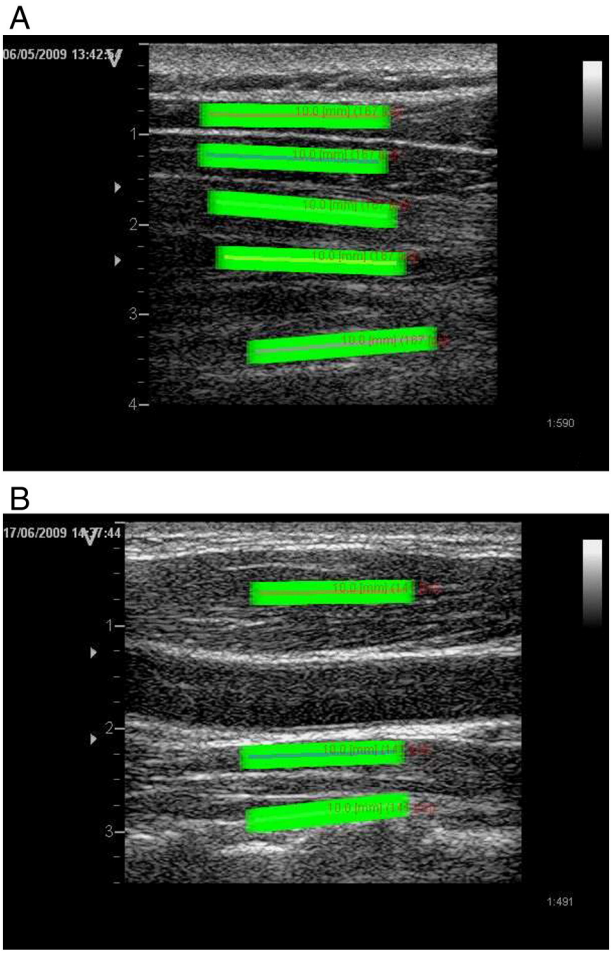

Fig 1. *A, Longitudinal ultrasound projection of the dorsal neck muscles with ROI added on top of the muscle imaging. The following muscles were included (from most superficial to deepest): trapezius, splenius capitis, semispinalis capitis, semispinalis cervicis, and multifidus. B, Longitudinal ultrasound projection of the ventral neck muscles with ROI added on top of the muscle imaging. The following muscles were included (from most superficial to deepest): sternocleidomastoid, longus capitis, and longus colli. (Color version of figure is available online.)*

Speckle-Tracking Analysis

When ultrasound waves hit irregularity in muscle tissues, they are reflected and spread out in different directions. When these sound waves meet each other, a unique acoustic mosaic pattern occurs (like ripples on the water when several stones have been thrown), which is like a fingerprint for that specific muscle. This unique speckle pattern could be analyzed using postprocessing software to automatically identify the moving muscle structure of interest between the fascia during an exercise. Rectangular markers, region of interests (ROIs) (10 × 2 mm) were