Cervical Extensor Load Sharing Strategy in Cervical Axial Rotation; A Shear Wave Elastography Study

Constantin M. Heinemann[1], Zachary J. Domire[1]
[1]Performance Optimization Lab, East Carolina University, Greenville, NC, USA
Email: heinemannc22@students.ecu.edu

Summary

This study used shear wave elastography to measure cervical extensor and SCM forces in rotated head postures. Results showed muscle-specific force changes, with splenius capitis increasing due to stretch, multifidus due to activation, and SCM showing the largest increase, consistent with its role in head rotation.

Introduction

The human muscular system's redundancy allows any movement to be achieved by multiple muscle combinations, creating near-infinite possibilities for load sharing. Cervical extensor muscle function is understudied due to limitations in traditional muscle activity measures [1]. As such cervical load sharing strategies are solved by static optimization or computer modeling, which are challenging to validate, often rely on large muscles, and lack physiological con-contraction. Shear wave elastography has shown the ability to differentiate cervical extensor shear modulus. Muscle shear modulus increases with muscle activation and stretch and correlates very well with active and passive muscle force [2,3,4].

This study aimed to quantify muscle forces produced by the cervical extensors and SCM in low and high axial rotation head postures. We hypothesized that muscle forces would be altered in a muscle-specific manner by the different head postures.

Methods

20 participants (9f 11m, 24.5+/-3) completed this study. SWE images were taken of the cervical extensor muscles in several positions; unloaded, seated neutral, low axial rotation, and high axial rotation. Probe position began 2cm lateral to the C4 spinous process and was adjusted to align with the fiber direction of the muscle being imaged. B mode ultrasound images were taken transverse to the muscle fiber direction to measure cross-sectional area.

If the shear modulus is measured at rest and muscle length is accounted for, then with isometric muscle contraction at that length, any increase in shear wave speed can be attributed to muscle stress. With cross-sectional area, muscle force can be calculated from stress.

Results and Discussion

Significant effects of muscle and muscle x position interaction were found. There were non-significant changes in the individual cervical extensor muscle forces between low and high axial rotation; only splenius capitis changed force significantly. SCM force increased significantly from low to high axial rotation.

Cervical extensor muscles created differing amounts of force in the axial rotation postures and were impacted differently by an increase in axial rotation angle. Splenius capitis and multifidus were the most impacted by cervical axial rotation, owing to more angled fibers allowing a greater horizontal force component than other CE. Multifidus contributes to contralateral rotation and splenius capitis ipsilateral rotation [5,6]. Increases in multifidus force are from activation while increases in splenius capitis force are a result of stretch. The biggest change was seen in the SCM which increased its force output significantly to reach high axial rotation; this matches the literature as SCM is established as the largest head rotator [7]. These findings show traditional modeling approaches of the neck muscles may not be accurate as cost functions typically select larger muscles or muscles with more advantageous moment arms; whereas we showed that the small deep neck muscle multifidus accounted for a large share of force in cervical rotation.

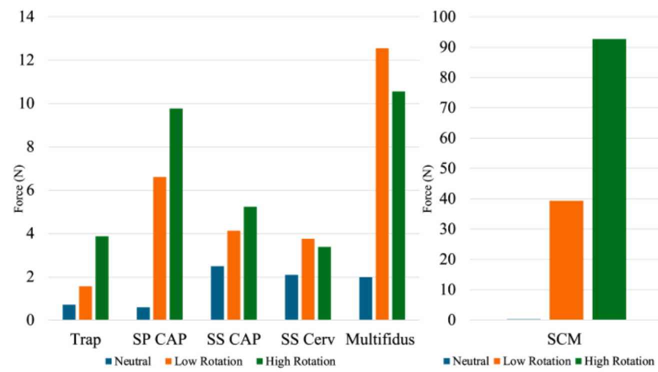

Figure 1: Cervical extensor and sternocleidomastoid muscle forces in neutral and low and high degrees of axial rotation.

Conclusions

This study demonstrates that cervical muscle forces vary based on head posture. These findings contribute to understanding cervical muscle function and can inform biomechanical modeling and movement strategies.

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