Back to TOC

Neck muscle size-strength correlation is gender-dependent

Curran Reddy[1], Yu Zhou[2], Bocheng Wan[2], and Xudong Zhang[1,2,3*]
[1]Department of Biomedical Engineering, [2]Department of Industrial and Systems Engineering,
[3]Department of Mechanical Engineering, Texas A&M University, College Station, TX
Email: *xudongzhang@tamu.edu

Introduction

Head injury risk secondary to unsafe head accelerations is a growing concern for athletic populations as new discoveries of adverse effects from even sub-concussive impacts have been made. In order to investigate the potential effects of neck strength on head-acceleration injury risk, previous efforts have used static strength tests and dynamic impact simulations to identify factors that may have injury-prevention implications. While neck strength and muscle size have been shown to have a protective effect in laboratories, their relationships have shown mixed results when used to predict on-field injury rates, stressing the need for a clearer understanding of the muscle size-strength relationship and how it might vary across different conditions and population groups.

Therefore, the purpose of this study was to elucidate the neck muscle size-strength relationships and explore the effects of gender and neck posture on the relationships.

Methods

Thirty healthy adult subjects (13 males, 17 females) underwent neck strength testing and MR imaging of the neck region. In strength testing, the subjects wore a helmet, were strapped into a seat within a custom-built test frame, and performed maximal voluntary exertions (MVEs) by pressing via a helmet-mounted interface against a tri-axial load cell in three different configurations: A) flexion in a neutral posture, B) flexion in a 40° extended posture, and C) extension in a 40° flexed posture. The analysis of MR images (3T clinical scanner, PD-TSE, 3.0mm slice thickness, no gap) involved manual segmentation in MIMICS 20.0 of the following muscles: sternocleidomastoid (SCM), infrahyoids (IH), anterior scalene (AS), longus capitis and colli (LONGUS), semispinalis cervicis and multifidus (DEEP), splenius capitis and cervicis (SPL), longissimus capitis and cervicis (LONGISS), semispinalis capitis (SSC), levator scapula (LS), and trapezius (TRAP).

The following muscle size measures were defined and calculated for each muscle: anatomical cross-sectional area (ACSA) was defined as the single largest cross-sectional area for a given muscle; muscle volume (MV) was calculated by multiplying the sum of segmented areas from all MRI slices by slice thickness; reconstruction-based cross-sectional area (RCSA) was a novel measure of physiologic cross-sectional area calculated by dividing MV by muscle length (ML)—estimated by re-slicing the 3D point cloud reconstruction of a segmented muscle into 3mm axial sections and finding the length of the cubic polynomial fit to the sections' centroids.

Student's t-tests were used to compare anthropometric, strength, and muscle size measures between genders. Linear regression and ANCOVA were used to analyze muscle size-strength relationships and test for gender differences.

Results and Discussion

Males had significantly greater neck strengths than females in all configurations while there were no statistical differences in age, weight, or BMI between the two genders. Female neck strengths showed significant inter-configuration correlations while male strengths did not. ANCOVA models found total superficial flexor (TSF = SCM+AS+IH) and SCM sizes to have significant correlations with flexion strength in the neutral posture, with no gender difference; for males, the SCM was a strong predictor of neck flexion strength in the neutral posture, while the AS muscle was evidently more involved in the extended posture—none of these however held true for females (Fig. 1). Less strength variability was explained by muscle size alone in females than in males. All muscle size metrics yielded nearly identical strength-size relationship results.

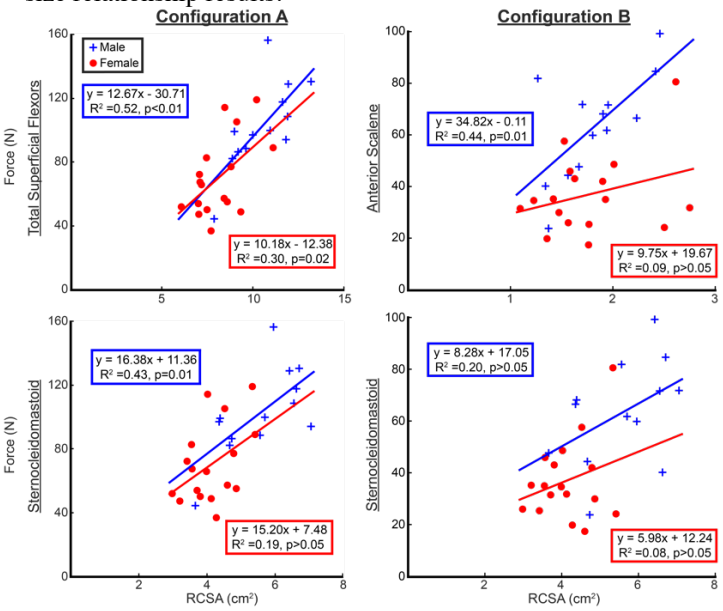

Figure 1: Sample muscle strength-size relationships where statistical significance ($\alpha = 0.05$) was identified for TSF and SCM in config A and for AS but not SCM in config B, for at least one gender.

Significance

Males and females exhibited distinct strength and muscle correlations, highlighting the importance of gender-specific strength data analyses and applications. Such applications may include musculoskeletal modeling, strength prediction for injury prevention, and job design. Muscle strength testing results in the most commonly adopted neutral posture are not good predictors for strengths in deviated neck postures, which may be more relevant to practical or clinical applications. Lastly, there is no readily apparent advantage of one muscle size metric over another when analyzing neck muscle size-strength relationships.

References

1. Bamman MM et al., *Med Sci Sport* 32 (2000): 1307-1313
2. Bruce et al., *Med Sci Sport* 29 (1997): 677-683
3. Holzbaur et al., *J Biomechanics* 40.11 (2007): 2442-2449
4. Schmidt et al., *Am J Sports Med* 42.9 (2014): 2056-2066
5. Tingart et al., *Clin Orth and Rel* 415 (2003): 104-110
6. Vasavada et al., *Spine* 23.4 (1998): 412-422

The Big Book of Abstracts

vASB2020

Virtual 44th Meeting of the
American Society of Biomechanics

vASB2020

Virtual 44th Meeting of the American Society of Biomechanics

August 4-7, 2020

Home of the ASB 2020 Virtual Meeting!

We were excited to host the 2020 Annual Meeting in a virtual format and thank everyone for making it such a successful virtual conference! The abstract book from this year's conference can be downloaded below.

vASB 2020 Abstract Book