

# UPPER LIMB MUSCLE VOLUME CHARACTERIZATION IN OLDER ADULT SUBJECTS

<sup>1,2</sup> Meghan Vidt, <sup>1,2</sup> Melissa Daly, <sup>1,2</sup> Anthony Marsh and <sup>1,2</sup> Katherine Holzbaur

<sup>1</sup>Wake Forest University, Winston-Salem, NC USA

<sup>2</sup>Virginia Tech – Wake Forest University School of Biomedical Engineering and Sciences

email: mvidt@wfubmc.edu, web: <http://www.sbes.vt.edu/kholzbau/MoBL/index.html>

## INTRODUCTION

Previous studies have shown that isometric strength is directly correlated with muscle volume [1, 2]. It has also been observed that muscle atrophy and reduced strength occur with aging [3]. Upper extremity muscle volumes have previously been measured in young adults (age 24-37) [1, 2]. It was shown that individual muscle volume, as a percentage of total muscle volume, was consistent across test subjects. Furthermore, strength in the upper limb was significantly correlated with muscle volume. However, there are no comparable data for older adults. The objective of this study was to characterize the distribution of upper limb muscle volume and upper limb strength in a group of older adults (age 65 and older) and to compare these assessments to the existing data of young adults.

## METHODS

Six ostensibly healthy subjects (3 females and 3 males) were evaluated (age: 72-80 years; body mass: 54.4-90.7 kg; height: 160-181.6 cm). All participants gave written informed consent. Subjects were imaged supine in a 1.5 T MRI scanner (GE Healthcare, Milwaukee, WI) with a series of spoiled gradient (SPGR) scans. The body coil was used to obtain images of the shoulder and upper arm, with a scan time of approximately 10 minutes. A flexed array long bone coil (Invivo, Orlando, FL) was used to image the upper limb in two successive scans, each approximately 14 minutes in duration.

The MR images were manually segmented (3D Doctor, Able Software Corp., Lexington, MA) to produce a three dimensional reconstruction of the muscles of interest. A reproducibility study, in which each muscle was segmented twice, showed repeatability within 5% muscle volume. Representative muscles for the major functional

groups in the shoulder, elbow, and wrist were chosen for characterization (deltoid, pectoralis major, biceps brachii, triceps, extensor carpi radialis and flexor carpi radialis).

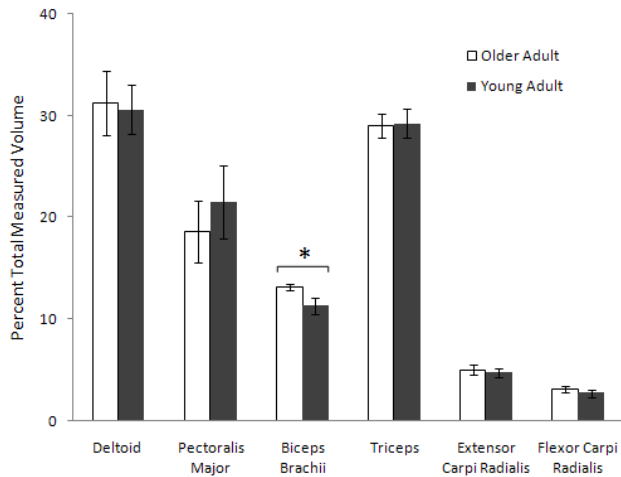
Maximum isometric joint moment at the wrist (flexion, extension), elbow (flexion, extension) and shoulder (adduction, abduction) joints were assessed using a KIN-COM isokinetic dynamometer (Isokinetic International, Harrison, TN). Mean muscle volume of each muscle was determined as a percent of the total muscle volume of the 6 muscles investigated. A Student's t-test was used to evaluate differences between individual muscle volumes and percent of total muscle volume in young and older adults. A regression analysis was used to determine the relationship between the maximum isometric moment at each joint and the muscle volume of the representative muscle crossing the joint.

## RESULTS AND DISCUSSION

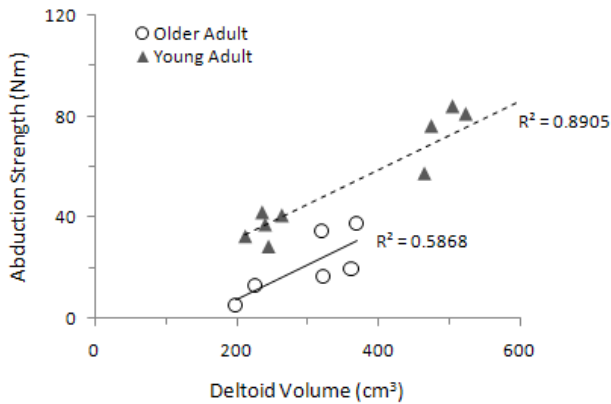
For each of the 6 muscles, the mean volume for the older adults was, on average,  $20.9 \pm 8.6$  percent smaller than the mean for the young adults, despite comparable height and body mass ranges in both groups (young adult height  $171.5 \pm 9.3$  cm and body mass  $69.2 \pm 15.8$  kg [1]; older adult height  $168.9 \pm 10.2$  cm and body mass  $74.0 \pm 13.5$  kg). However, these differences did not reach significance in this subject sample. Each muscle volume was normalized by the total muscle volume for the 6 muscles studied. The volume of biceps expressed as a percentage of the total volume of the six muscles was significantly greater in older compared to younger adults (Figure 1).

For the 6 older adults, over 50% of the variation in maximum isometric joint moment was accounted for by variation in muscle volume. At the shoulder joint, 58% of the variation in abduction was

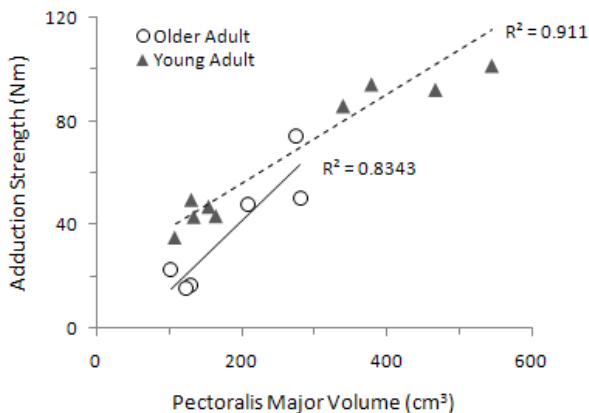
accounted for by the volume of the deltoid muscle ( $p = 0.076$ ) (Figure 2). Likewise, 83% of the variation in shoulder adduction was accounted for



**Figure 1:** Mean muscle volume as a percent of total measured muscle volume  $\pm$  SD for older and young adults; \* indicates significant difference.



**Figure 2:** Isometric shoulder abduction joint moment compared to deltoid muscle volume.



**Figure 3:** Isometric shoulder adduction joint moment compared to pectoralis major muscle volume.

by the pectoralis major muscle volume ( $p = 0.011$ ) (Figure 3). In addition, the relationship between joint moment and muscle volume was consistent with that observed previously for younger adults. For example, the slope for the relationship between abduction joint moment and deltoid volume for the older adults fell within the 95% confidence interval for the young adults. Similarly, the relationships between muscle volume and flexion and extension strength at the wrist and elbow joints for the elderly adults fell within the 95% confidence interval for the relationship observed for the young adults.

## CONCLUSIONS

We conclude that, with the exception of biceps, the distribution of muscle volume remains consistent between young and older adults. The relationship between isometric joint moment generating capacity and muscle volume is maintained when compared to young adults, despite the overall reduction in muscle volume in this subject sample.

This small sample of 6 subjects represents a portion of a larger study of 20 older adults, in which the upper limb strength, function, and muscle volume is being characterized and evaluated. The analyses described here will ultimately include this larger group, which may provide additional insight into whether changes with age exist in the relationship between muscle volume and joint moment. In addition, this larger study incorporates an upper limb training protocol to identify changes in muscle volume and coordination with strength training in older adults.

## REFERENCES

- Holzbaur KR, et al. *J Biomech* **40**, 2442-2449, 2007.
- Holzbaur KR, et al. *J Biomech* **40**, 742-749, 2007.
- Klein CS, et al. *J Appl Physio* **91**, 1341-1349, 2001.

## ACKNOWLEDGEMENTS

Funding for this project was provided by the Wake Forest University Science Research Fund and Cross-Campus Collaborative Research Fund.