UPPER LIMB MOMENT-GENERATING CAPACITY IN MIDDLE AGED ADULTS

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INTRODUCTION

A strong relationship between muscle volume and isometric strength has been identified at the shoulder, elbow, and wrist in healthy, young adults (Holzbaur, 2007b). However, factors beyond muscle atrophy, such as increased co-contraction and decreased voluntary neural drive, contribute to the strength decreases observed in populations over the age of 65 (Klein, 2001; Hakkinen, 1996). In addition, it has been suggested that age-related muscle atrophy occurs at different rates for the elbow flexors and extensors (Klein, 2001). Few studies have investigated age-related changes in isometric strength and muscle size for middle-aged adults, and most of the data comparing isometric strength in different age groups in the upper limb are focused at the elbow. The objective of this study is to identify and characterize changes in muscle volume and isometric moment-generating capacity at the shoulder, elbow, and wrist associated with middle age.

METHODS

Ten nonimpaired subjects (5 females, 5 males, 46-60 years, average 53.2 years) were studied. All subjects provided informed consent. Isometric joint moments produced during a maximum voluntary contraction were measured for six muscle groups using a Biodex System3 (Biodex Medical Systems, Shirley, NY). Maximum shoulder abduction and adduction moments, elbow extension and flexion moments, and wrist flexion and extension moments were assessed. For each muscle group, we collected three trials of three-second duration, with 60 seconds of rest between trials. The maximum moment generated for any trial was used for analysis.

The same subjects were imaged supine in a 1.5T MRI scanner (GE Healthcare, Milwaukee, WI). Axial images were acquired from shoulder to wrist using 3D spoiled gradient echo sequences with 3 mm sections. Shoulder images were obtained with the body coil; elbow and forearm images were acquired using a flexed array long bone coil (Medical Advances, Milwaukee, WI). We reconstructed the three-dimensional geometry of the deltoid, brachioradialis, and extensor carpi ulnaris (ECU) through manual segmentation (3D-Doctor, Able Software Corp., Lexington, MA), to calculate the volumes of muscles crossing the shoulder, elbow, and wrist, respectively.

We evaluated the relationship between muscle volume and maximum isometric moment at each joint using regression analysis. We compared results for these middle-aged subjects to results from younger adults (24-37 years, average 28.6 years) previously studied using this protocol (Holzbaur, 2007b). We tested the effects of age, gender, and joint on isometric strength using a PA-GEE regression model. Finally, deltoid and brachioradialis volumes were normalized by ECU volume in each subject to allow comparisons of the distribution of

muscle volume in the upper limb (Holzbaur, 2007a).

RESULTS AND DISCUSSION

For the middle-aged adults, moment-generating capacities for shoulder abduction and adduction (Fig. 1), elbow flexion and extension, and wrist flexion were significantly correlated to the volume of a single muscle crossing that joint ($p<0.01$), with an average of 80% of variation accounted for by muscle volume. ECU volume explained 32% of wrist extension variation ($p=0.09$). For all muscle groups except wrist extension, the slope between moment and muscle volume for the middle-aged adults was within the 95% confidence interval observed for the young adults.

Age affected the isometric moments produced at the shoulder more than at the elbow or the wrist ($p<0.001$). On average, shoulder, elbow, and wrist moments produced by the middle-aged adults were 23%, 10%, and 6% smaller than those produced by the younger adults, respectively. Similarly, the ratio of muscle volumes between deltoid and ECU was significantly lower in middle-aged adults compared to younger adults (Fig. 2; $p=0.005$) while the ratio of muscle volumes between brachioradialis and ECU was comparable for the two age groups in these 20 subjects. . These results suggest a higher degree of atrophy for the shoulder muscles in the middle-aged subjects, consistent with the larger difference in isometric shoulder strength.

We conclude that, while muscle volume accounts for variability in isometric strength at a comparable level in middle-aged and younger adults, middle-aged adults exhibit relatively greater atrophy of proximal muscles compared to distal muscles. This difference in volume distribution is reflected in the isometric strength of the limb.

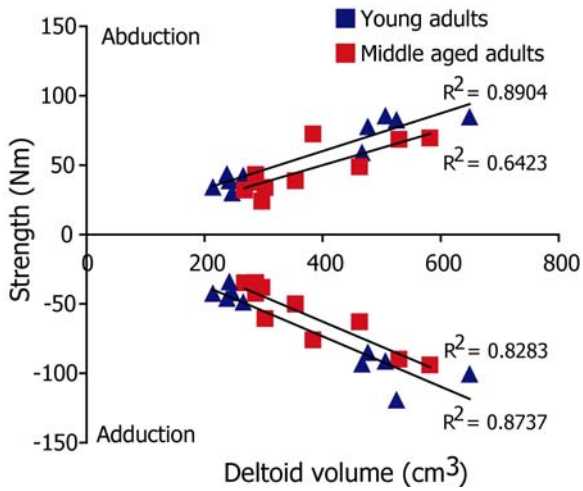

Figure 1: Moment-generating capacity of shoulder abductors and adductors compared to deltoid muscle volume.

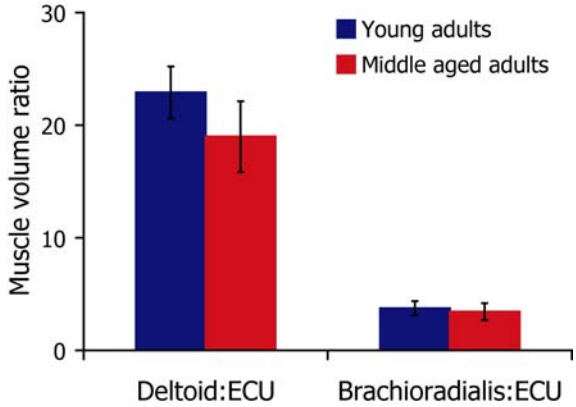

Figure 2: Ratios of muscle volume comparing deltoid, brachioradialis, and ECU.

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