Aging of skeletal muscles: A shear wave elastography approach to detect changes in mechanical properties in vivo

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BACKGROUND AND AIM:

Skeletal muscle performance changes with age. Ultrasound shear wave elastography (SWE) was shown to represent in vivo muscle mechanics both in active [1] and passive [2,3] states. Hence, it has the potential to show muscular changes occurring due to aging non-invasively. We aimed to investigate the mechanical properties of the biceps brachii muscle (BB) using SWE in relation to elbow joint position and function. We hypothesized that SWE does reflect the changes in mechanical properties of the BB due to (i) activity level changes, (ii) length changes imposed by the joint position, and (iii) aging both in passive and active states. Therefore, SWE offers an advanced understanding of alterations in individual muscle's contribution to joint function with age.

METHODS:

Healthy young (7 males, 7 females, 28.07 ± 5.06 years old) and older (5 males, 5 females, 67.80 ± 5.69 years old) adults participated. Simultaneous electromyography and SWE of the BB and isometric elbow torque measurements were performed at five elbow angles (60°, 90°, 120°, 150°, and 180°). The BB was investigated during rest, maximum voluntary contraction (MVC), and isometric ramp contractions (up to 25%, 50%, and 75% of MVC torque). The shear elastic modulus was deduced from SWE. Two- or three-way ANOVA was performed to detect effects of joint position, activity level, and age.

RESULTS:

At passive state, the shear elastic modulus increased with increasing elbow angle for both groups ($p<0.001$). Significant differences were found between 60° and 120°/150°/180° ($p<0.001$ for all) and 90° and 150°/180° ($p<0.001$, $p<0.01$). Shear elastic modulus was higher for the older adults compared to the young ($p<0.001$). Differences located at 120° and 150° elbow angles were more than twofold.

MVC torque was lower for older adults ($p=0.01$) with the highest torque obtained at 60° elbow angle, decreasing with the increasing angle for both age groups ($p<0.001$, Fig 1). During sub-maximal contractions, the active shear elastic modulus changed significantly with joint position, activity level, and age ($p<0.001$ for all).

CONCLUSIONS:

The present findings support the hypotheses posed. We found that for both active and passive states, the shear elastic modulus represents muscle's length-dependent force production characteristics in vivo. The shear elastic modulus increased with increased torque for each joint position. Moreover, SWE reflects the decreased active force production capacity with age, and in the passive state, it detects the increased

stiffness that occurred due to aging. Our findings suggest that SWE can also be used to detect muscular alterations following e.g. neuromuscular diseases.

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References:

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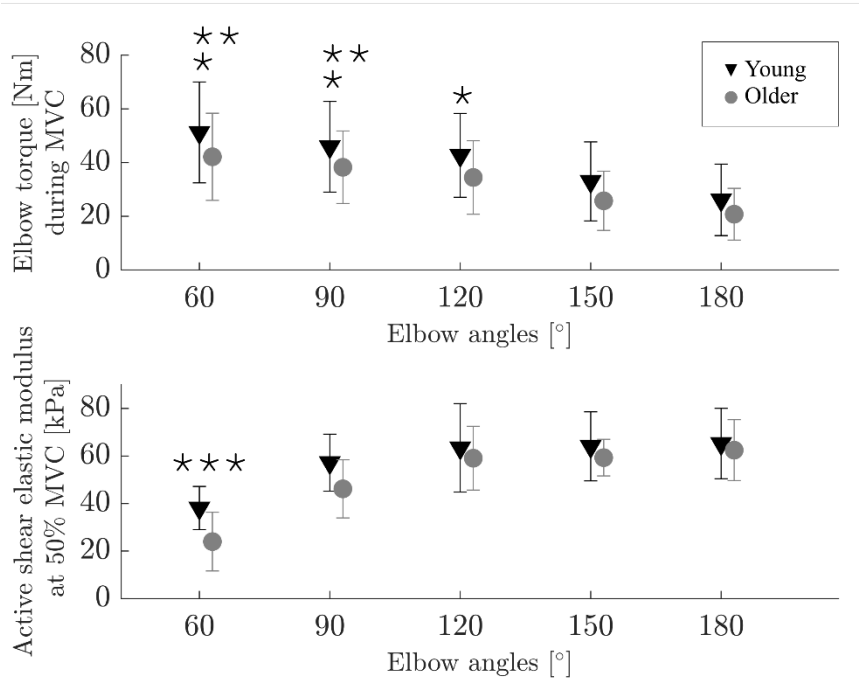

Figure 1. Elbow torque during MVC (top) and active shear elastic modulus at 50% of MVC (bottom) are shown as mean values and standard deviation with respect to the elbow angles (60°-180°) studied. Two-way ANOVA post-hoc results ($p<0.05$): (*) and (**) mark significant differences with the values measured at 180° and 150° elbow angles, respectively. (***) indicate significant differences between the values measured at 60° and 90°, 120°, 150°, and 180° elbow angles.