Changes in muscular coactivation during elbow flexion/extension movements: a comparison of young adults and older adults with no or pre-frail symptoms

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Summary

In older adults, increased muscular coactivation serves as a mechanism to enhance joint stability. However, it also results in greater stiffness and reduced flexibility, which may elevate injury risk. This work investigated differences in muscular coactivation of the biceps brachii, brachioradialis and triceps brachii in healthy young and older adults. Additionally, differences in older adults were analyzed based on the number of frailty-related symptoms. Participants performed full-range elbow flexion and extension movements on a pulley machine at varying angular velocities. Surface electromyography recorded muscular activation of the biceps brachii, brachioradialis and triceps brachii, while elbow kinematics were captured using a motion capture system. The results showed higher coactivation in older adults, with coactivation levels increasing in older adults with greater frailty scores. Despite this, the groups exhibited similar coordination patterns across angular velocities. These findings contribute to a better understanding of age-related changes in muscular function.

Introduction

Age-related increases in muscular coactivation have been observed to enhance joint stability [1]. However, this increase comes at a higher metabolic cost, leading to fatigue and reduced flexibility, further elevating injury risk. This may contribute to the development of frailty in older adults (OA) [2]. This work examines muscular coactivation differences between healthy young (YA) and OA during elbow flexion and extension at varying angular velocities. Differences in OA are further analyzed based on frailty symptoms: no symptoms (FS0) vs. 1 or 2 symptoms (FS1).

Methods

15 healthy YA (7 male, 8 female, age 26.2 years ± 3.2) and 12 healthy OA (4 male, 8 female, age 76 years ± 6.5) participated in the study. The protocol was approved by the RWTH Aachen Human Ethics Committee.

Participants completed full-range elbow flexion and extension movements on a pulley machine with a 1kg load for 45 seconds, followed by 1-minute rest, completing over 20 repetitions. Muscular activation of the biceps brachii (BB), brachioradialis (BR) and triceps brachii (TB) was recorded using surface electromyography (sEMG) following SENIAM guidelines, with normalization via the mean amplitude method. Elbow kinematics were captured using a motion capture system with an upper-body biomechanical model. Time-normalized sEMG envelopes were categorized by elbow flexion and extension phases and four 20° angular velocity ranges (20°-140°/s). Statistical analysis was conducted using a two-way ANOVA.

Results and Discussion

The results show that OA exhibited significantly greater muscular activation than YA to execute movements. Furthermore, within the OA group, muscular activation increased with higher frailty scores (Example in Figure 1).

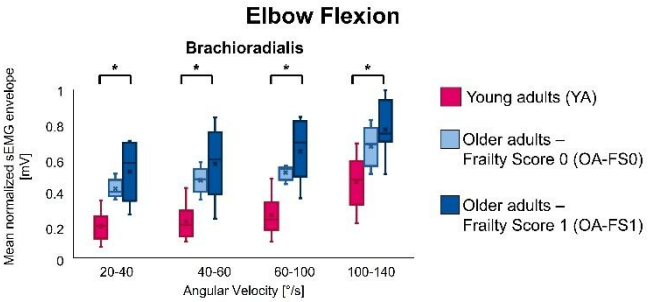

Figure 1: Mean normalized sEMG envelope of the Brachioradialis during elbow flexion in YA, OA-FS0 and OA-FS1. * indicates significant differences between the three groups.

The two-way ANOVA revealed that age-related changes in muscular activation were independent of movement velocity, indicating that the effects of aging and frailty remained consistent across angular velocities. To maintain joint stability and successfully perform the movement, OA displayed increased muscular coactivation, as evidenced by the overactivity of all muscles involved in the movement.

Conclusions

This work revealed age-related changes in muscular activation of the elbow flexors and extensors. To compensate for these changes, perform the task and maintain joint stability, OA relied on increased muscular coactivation. These findings contribute to a better understanding of muscular function and changes in OA at intermediate risk of frailty.

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References

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