Efficient elastic tissue motions indicate general motor skill

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Summary

Research into general motor skill could transform movement training and injury prevention. We examined indicators of general motor skill shared by expert athletes across diverse disciplines during simple movements. Using ultrasound and accelerometry during a reaching task, we compared world-class athletes, regional-level athletes, and non-experts. We found that world-class experts showed reduced inefficient elastic tissue motions — both transverse elastic tissue motions and physiological tremors — compared to others. This establishes elastic tissue motion as a key indicator of general motor skill.

Introduction

Spearman's discovery of "g" (general intelligence) in 1904 [1] prompted researchers to search for a motor equivalent [2]. While studies found no correlation between performance across different sports [3,4], suggesting motor skills are discipline-specific [5], the holistic organization of connective tissues in the body [6-8] may provide an anatomical substrate for general motor capability. We investigated whether elastic tissue (muscles and associated connective tissue) behavior could reveal such general motor skill.

Methods

We studied elastic tissue motions during reaching tasks across world-class (n=11), regional-level (n=14), and untrained participants (n=11). Using ultrasound videos analyzed with deep learning and optical flow algorithms, plus accelerometry, we measured upper arm tissue movements. Our analysis focused on both actuation-related muscle motions and inefficiencies that do not contribute to muscle work — transverse tissue movements orthogonal to muscle fiber direction and physiological tremors [9].

Results and Discussion

We discovered that world-class experts minimize inefficient muscle motions compared to both regional level athletes and non-experts: both transverse elastic tissue motions and physiological tremors (Figure 1).

Conclusions

Our findings establish that elastic mechanisms have a role in general motor skill. Previous studies of elastic mechanisms during healthy movement focused mainly on efficiency and injury. This study broadens our understanding of elastic mechanisms while revising conventional views of athletic expertise and the general nature of motor skill.

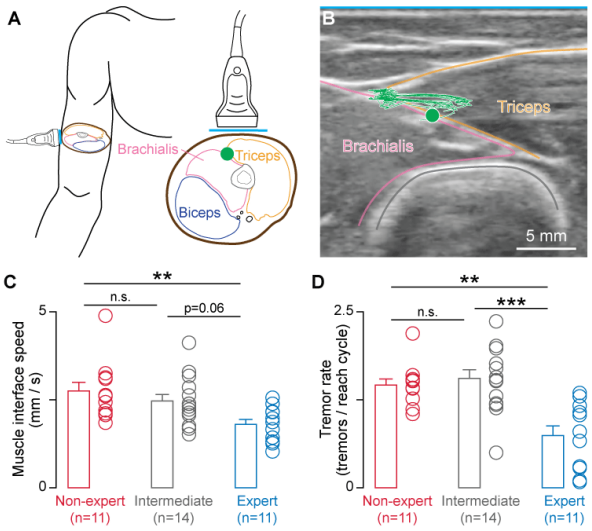

Figure 1: **Movement experts have reduced inefficiencies in elastic tissue motions.** (**A**) Ultrasound probe placement on upper arm cross-section, with 3.75 cm probe length shown in blue. (**B**) Representative ultrasound image showing motion path of a tracked point. (**C**) Point speed during reach cycle differed between groups (ANOVA, p = 0.0092), with experts showing different muscle interface speeds than non-experts (**p = 0.0084). Non-expert and intermediate speeds were similar (p = 0.58). (**D**) Tremor rates were lower in experts compared to both non-experts (**p = 0.0013) and intermediates (***p = 0.00014), while tremor rates in non-expert and intermediate rates were similar (p = 0.85). Error is S.E.M., 'n' indicates participant count, 'n.s.' is not significant.

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