Forearm muscle coordination in climbers: Repeatability and load sharing between finger flexors and extensors

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Summary

The study showed fair to good repeatability of supersonic shear wave imaging (SSI) measurement to analyzes the contraction of extrinsic hand muscles in rock climbers. The flexor digitorum superficialis (FDS) is significantly stiffer in crimp than in slope finger position, whereas the flexor digitorum profundus (FDP) was significantly stiffer in slope than in crimp position over the force range from 0% to 45% of maximum voluntary contraction (MVC). The extensor digitorum communis (EDC) showed contribution as antagonist with significant differences between crimp and slope from 40% to 45% of MVC. These findings highlight the role of muscle-specific coordination patterns in adapting to different climbing grips, which could inform training strategies or injury prevention in climbers.

Introduction

In rock climbing, the forearm strength is a determining factor of performance. The force produced at the fingertip is mainly generated by three extrinsic muscles of the hand: FDP, FDS and EDC [1]. SSI is a suitable tool to better understand muscles' contraction and muscle load sharing [2]. However, although the method was used on lower and upper limbs main muscles, no previous study has analyzed the extrinsic muscles of the hand with the aim of understanding the associated muscle coordination. The aim of this study was to 1) evaluate the repeatability of SSI apparent shear modulus measurements for the FDP, FDS, and EDC during an isometric force ramp and 2) compare the apparent shear modulus of these muscles between two climbing grips: crimp and slope.

Methods

Seventeen experienced climbers participated in this study (26 ± 4 years). Shear wave elastography imaging was performed using an aixplorer mach 30 (Supersonic Imagine®), on the FDP, FDS and EDC muscles. The probe was positioned one-third of the forearm length from the elbow and fixed with ProbeFix Dynamic USONO®. Kistler force sensor (9017B) was used to measure the force produced at the fingertip on a 14mm edge. The finger and forearm were placed according to [3] to test the crimp and slope prehension. After having determined the individual MVC in crimp and slope grips, isometric ramps of force ranging from 0% to 45% MVC were performed over 30s for each of the three muscles. This protocol is repeated twice to test the measurement repeatability. Throughout the ramp, participants received visual feedback. The apparent shear elasticity modulus was averaged over a rectangular region of the colored map. The repeatability was assessed using a curve-level ICC method [4]. The comparison of muscles between crimp and slope grips shear modulus was assessed using Statistical Parametric Mapping (SPM).

Results and Discussion

The ICC results showed a fair repeatability for FDP (ICC=0.56) and EDC (ICC=0.47) and a good repeatability for FDS (ICC=0.65). The muscle size, presence of aponeuroses and the muscle depth may partly explain the lower repeatability compared to the literature. In addition, participants themselves may not exhibit identical muscle coordination across different trials. The SPM revealed that the shear modulus was higher for the slope condition for FDP for the whole isometric ramp, while the opposite was found for the FDS, suggesting different use of these muscles depending on the condition. For EDC the shear modulus was higher for slope condition from 40% to 45% of MVC, suggesting higher co-contraction in this condition.

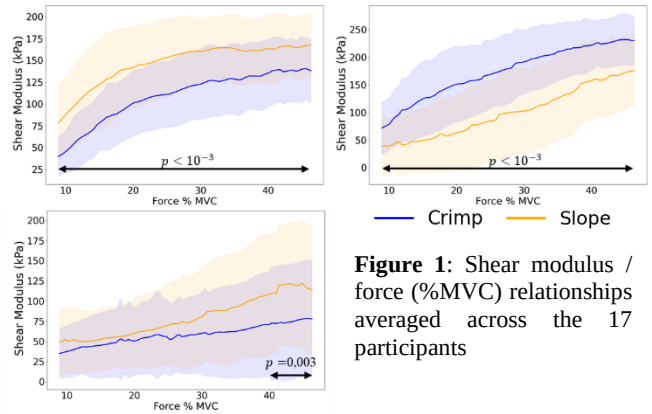

Figure 1: Shear modulus / force (%MVC) relationships averaged across the 17 participants

Conclusions

We can conclude that 1) the SSI technique could be applied on the FDP, FDS and EDC muscle, but with cautious use and interpretation due to fair repeatability. 2) Distinct patterns were found for FDP, FDS and EDC, suggesting different coordination, depending on the task. This approach could contribute to enhance our comprehension of hand muscular coordination involved in climbing.

Acknowledgments

Funded: "PerfAnalytics", ANR-20-STHP-0003 and "Investissements d'avenir", ANR-15-IDEX-02.

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