UPPER AND LOWER EXTREMITY REACTION FORCES DURING VERTICAL ROCK WALL CLIMBING

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Introduction

Rock climbing has become increasingly popular as a recreational hobby and competitive sport. A great risk for injury exists for rock climbers including falling from heights, ligamentous injuries of the lower and upper extremities, and overuse of the forelimbs and hands [1]. The most common injuries in climbing are found in the upper extremity and include finger pulley rupture, physical wrist fractures, and chronic injuries such as chronic rotator cuff tear and brachialis tendonitis [2]. It can be predicted that substantial loading on the forelimbs predisposes even the most experienced rock climbers to injury. Despite such assumptions, there exists a gap in the literature exploring the force distribution on the limbs during vertical climbing and how this may explain the higher instance of forelimb injuries versus hindlimb injuries in human climbers.

Methods

In this study, we present isolated fore- and hindlimb substrate reaction forces of 45 participants, gathered using a triaxial force plate mounted to a treadmill climbing wall (Figure 1.). Each participant completed a total of 5 to 10 trials. From the data, the peak force and impulse were calculated.

Results

Both fore- and hindlimbs produced solely propulsive forces during climbing (Figure 2.). However, the magnitude of these forces was significantly greater in the hindlimb (~60% of body weight) versus the forelimbs (~15% of body weight). In the normal plane, we observed the forelimb contributing solely as a pulling force equal in magnitude to the pushing forces of the hindlimb. Both fore- and hindlimbs exert greater magnitudes of lateral force (~15% body weight) than medial (~5% body weight).

Discussion

Broadly, patterns of limb loading during climbing in humans closely match global expectations drawn from comparative animal data [3]. An unusual pattern was found concerning the relatively low magnitude of propulsive forces in the forelimbs. This may represent an active strategy for reducing overuse injuries in the highly mobile, but relatively weak forelimbs. By understanding the peak force and impulse as humans climb, injury prevention strategies can be developed to mitigate acute and chronic injuries in climbers. Adapting climbing techniques to off load high forces applied to the forelimbs and hands through shifting their COM closer to the wall in the tangential plane may be expressed in climbers with greater expertise to avoid such acute injuries as previously described. Future studies will aim to assess differences in limb loading patterns between novice and skilled climbers.

Figure and Tables

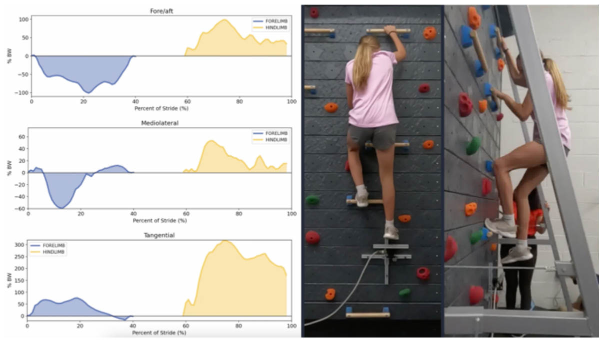

Figure 1: Experimental set up of human data collection for single limb forces. Single limb forces were collected using a triaxial force plate (model OR6-7-2K, AMTI) and custom mounted onto the treadwall.

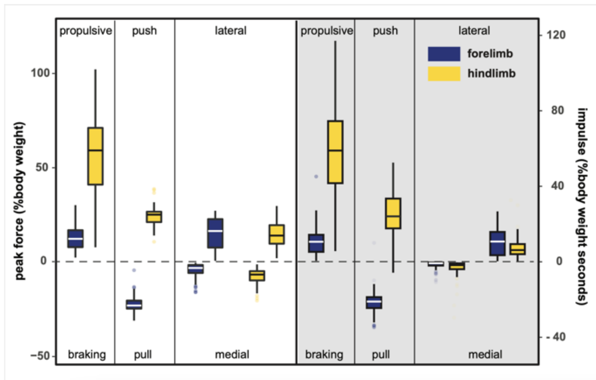

Figure 2: Box and whisker plot of the peak force (left) and impulse (right, in the shaded region) from 10 individuals (n = 174) comparing forelimb to hindlimb in the fore-aft (braking/propulsive), tangential (pull/push), and mediolateral axes. All forelimb boxes are denoted in blue and all hindlimb forces are in gold.

References

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