The Effect of Full-body Weight-bearing on Palmar Pressure Distribution

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Introduction: Axial loading of the wrist stresses the distal radioulnar joint, increasing susceptibility to triangular fibrocartilage complex injury and ulnar abutment. Athletes such as gymnasts regularly bear high loads through the wrist, while the geriatric demographic often exerts additional pressure on the upper extremity thorough use of assistive devices such as canes. Despite the high prevalence of wrist load-related injuries, there is limited research on load transmission across the wrist and into the hand. Our study examined the distribution of palmar pressure during a weight-bearing activity (handstands) to discern high-pressure regions and their correlation with wrist joint anatomy. Additionally, we investigated the role of hand dominance in maintaining balance and center of pressure (COP).

Methods: Fifteen participants conducted a 45-second handstand on an emed pressure platform system after approval by the institutional review board (IRB) and informed consent was obtained. Within a 35-second window during which the participant was stable in the handstand position, COP and force distribution on the palmar surface were analyzed. The palm was subdivided into four anatomical regions (hypothenar, thenar, metacarpals, and fingers) and within each, the maximum force (MF), mean pressure (MP), and contact area were calculated. Ulnar variance (UV) values were measured on images obtained in a weightbearing CT machine (WBCT), in which participants completed an additional handstand hold. The relationship between MP and palmar region was assessed using ANOVA with pairwise Tukey's HSD tests. Regression analysis was used to relate mean thenar/hypothenar pressure to UV. The influence of hand dominance on COP location and MF was analyzed using binomial and paired t-tests.

Results: Mean pressure was significantly higher in the thenar and hypothenar regions than in the fingers and metacarpal regions ($p<0.05$ for all). There was not a significant difference in MPs between the hypothenar and thenar regions (9.7 kPa difference, $p=0.183$). Every 1.00 mm increase in UV corresponded to a 2.8% increase in MF in the hypothenar region ($p=0.0371$). In 93% of participants, the COP was closer to their dominant hand during the stabilized phase of a handstand ($p<0.05$), and among all participants the dominant hand had an average 26.9 N (95% CI [12.7, 41.2]) greater MF than the nondominant hand ($p<0.05$).

Discussion: This investigation underscores the equivalence of the thenar and hypothenar zones in distributing palmar pressure during handstands. The notable association of UV with hypothenar MF distribution indicates that force transmission to the palm through the wrist joint is contingent on radioulnar positioning. Furthermore, this research emphasizes the role of hand dominance in weight distribution among athletes.

Significance/Clinical Relevance: Collectively, our findings shed light on the biomechanics underpinning upper extremity loadbearing. Our findings are of interest as altered values in UV are associated with chronic wrist conditions, such as Kienbock's disease in the setting of negative variance and ulnar abutment in positive variance. Palmar pressure distributions during weight-bearing activities may assist in the development of these disease processes, and by utilizing pressure mapping devices and WBCT, activity modification strategies can be created for early treatment prior to severe pathologic consequence. Future research into palmar pressures after soft-tissue injury may give rise to advanced diagnostics and therapeutics for common sports ailments, such as triangular fibrocartilage complex tears, and related conditions affecting the general population.

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Figures:

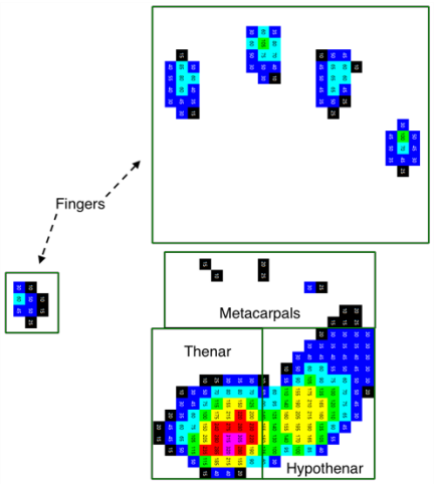

Figure 1: Masked regions of the maximal pressure picture achieved throughout a 35-second handstand capture of a right hand.

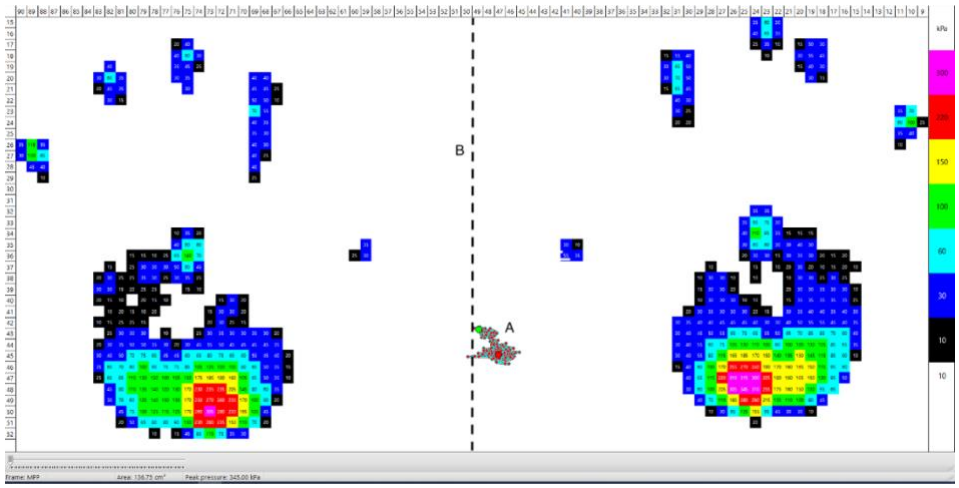

Figure 2: Maximal pressure picture of both hands, including center of pressure movement (A) towards the dominant hand in respect to the midline (B) throughout a 35-second handstand capture.