Multiplanar Kinematics of the Dart Throwing Motion in Adults with Symptomatic and Asymptomatic Wrists

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INTRODUCTION: Wrist injuries are prevalent in up to 10% of the general population [1,2] and over 15 million Americans. Wrist injuries can often lead to wrist instability and altered mechanics [3,4]. Altered wrist mechanics can inhibit proper wrist function which is important for overall mobility and quality of life [5]. Healthy wrist motions have been established in the literature, but few studies have directly compared symptomatic and asymptomatic wrist kinematics. Those studies typically only examined single-plane range of motion tasks (e.g., pure flexion/extension) [6,7]. No current studies were found to compare the wrist kinematics of functional activities such as the dart throwing motion (DTM) – a functional oblique motion from maximum radial extension to maximum ulnar flexion – which is used in most activities of daily living [8]. Abnormal dart throwing motions are known to correlate to reduced wrist function and overall mobility in everyday life. Thus, restoring proper wrist motion during therapy is critical. Therefore, we compared wrist kinematics of the dart throwing motion between individuals with symptomatic and asymptomatic wrists. We hypothesized that wrist motions in symptomatic individuals would be reduced during the DTM [6].

METHODS: Twenty adults with asymptomatic wrists (14 F, 6 M; 22-49 y, 30.4±7.7 y) and twenty adults with a symptomatic wrist (12 F, 8 M; 25-69 y, 41.7±15.0 y) participated. This study was approved by IRB and informed consent was obtained from each participant prior to the study. Symptomatic participants had a previously diagnosed wrist injury or degenerative disease treated without surgical intervention. Asymptomatic participants had no previously diagnosed wrist injury or degenerative disease. A 15-camera Vicon motion capture system tracked 14 retro-reflective markers (120 Hz) on the hands, wrists, and forearms while participants performed a DTM with a relaxed, opened hand (Figure 1). Asymptomatic participants performed the task with their dominant limb; symptomatic participants used their symptomatic wrist. Wrist kinematics were calculated with our previously established inverse kinematics model [9]. Group averages were computed for maximum wrist flexion-extension and radial-ulnar deviation angles and ranges of motion (ROMs). Wilcoxon rank sum tests were used to assess between-group comparisons (p<0.05).

RESULTS SECTION: The symptomatic group of participants had significantly less extension (p=.011) and sagittal plane ROM (p=.025) during the DTM (Figure 2). The symptomatic participants also had significantly more radial deviation (p=.002) and frontal plane ROM (p=.029) during the DTM. There were no differences in peak wrist flexion (p=.140) and ulnar deviation angles (p=.490) during the DTM between groups.

DISCUSSION: The reduced peak extension angles and sagittal plane ROM seen in the symptomatic group is supported by other studies of planar tasks that found similar, reduced sagittal plane motion in participants with symptomatic wrists [6]. An interplay of pain and tendon tightness may contribute to the reduced wrist extension and sagittal plane ROM observed in the symptomatic participants [5,6]. Restricted flexion-extension ROM during the dart throwing motion can indicate reduced wrist function and increased joint loading during daily tasks [6,10].

Unlike studies that found no difference in radial-ulnar motions, the symptomatic participants in this study had increased peak radial deviation angles, which could be attributed to ligament laxity and wrist instability [4,11]. Greater laxity and wrist instability is known to disrupt wrist mechanics and lead to subsequent joint complications [11]. Also, the increased radial-ulnar deviation ROM may be a compensation for reduced wrist flexion-extension, given that sagittal plane motions are critical for functional tasks [10]. This compensatory mechanism has not been identified in previous studies due to investigation of single-plane tasks only. These results highlight the importance of examining multiplanar motions to determine underlying mechanisms of symptomatic wrists.

SIGNIFICANCE/CLINICAL RELEVANCE: Our results suggest the importance of assessing multiplanar motions in those with a history of wrist injury or degenerations because it comprehensively translates to function in daily activities. Furthermore, we identified potential compensatory motions used by those with symptomatic wrists to complete tasks, such as the DTM.

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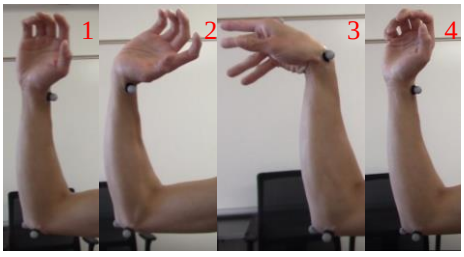

Figure 1. Sequence of motion for the dart throwing motion (DTM), starting from position 1 and ending at position 4.

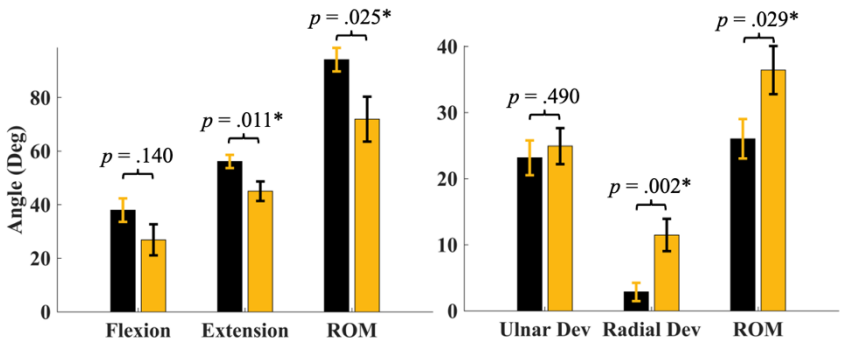

Figure 2. Average maximal sagittal and coronal plane angles and ROM during the DTM. Asymptomatic: black; symptomatic: gold. *Denotes significant difference between groups (p<0.05).