

Flexor Muscle and Elbow Joint Gap Changes After 10 Week Forearm Strengthening

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INTRODUCTION: The overarm throwing motion is one of the fastest human movements, generating elbow valgus stress that can exceed the ulnar collateral ligament's (UCL) tensile strength [1]. With pitchers throwing harder and more frequently, UCL injuries are rising [2]. The pitching motion creates a maximum valgus stress of 64 Nm in the elbow, with an average ultimate moment of 34 Nm for the UCL [3]. This discrepancy between the valgus stress in pitching and the ultimate moment of the UCL is believed to be due to the flexor-pronator muscles acting as dynamic stabilizers to the UCL [4]. These muscles are often injured in congruence with UCL injuries [3]. To combat these injuries, a unique training device was created. The FlexPro Grip allows for isometric applications of force in four directions: flexion, extension, ulnar deviation, and radial deviation. The creators of the FlexPro Grip claim that the device optimally targets and strengthens the muscles and tendons throughout the forearm for rehabilitating and preventing UCL injuries. The purpose of this study was to investigate changes in flexor muscle strength, cross-sectional area, and ulnohumeral joint (UHJ) space gapping before and after baseball pitchers complete a 10-week program using the FlexPro Grip training device. This cohort will be compared to a control group of participants who do not complete the program. We hypothesized that there will be a significant increase in flexor muscle cross-sectional area (MCSA) and significant decrease in joint loaded UHJ gapping in participants who complete the 10-week FlexPro Grip program and no significant changes in those who do not use FlexPro Grip.

METHODS: This study was a prospective cohort study approved by the University's Institutional Review Board. Participants were healthy Division I male baseball pitchers (18 FlexPro Grip group, 18 control group) from two local universities who reported having no pain and full participation in all games and practices. Only male participants were included because each Division I baseball team included only male pitchers. Additionally, there are no current female Division I baseball pitchers in the NCAA. All participants signed informed consent prior to enrolling in the study. Participants were excluded if they violated compliance, had an injury or pain, or were not throwing. Participants' UHJ gaps (mm) were measured using ultrasound in both unloaded and loaded conditions. UHJ gapping was defined as the shortest distance from the distal-medial corner of the trochlea to the proximal edge of the sublime tubercle (Fig. 1). Measurements were taken with participants lying supine, arm abducted to 90°, and elbow flexed at 30° and 90°. Loaded testing was performed by strapping a 2.5-kg weight to the wrist to induce valgus stress while remaining in a relaxed position. The MCSA (mm²) of the flexor digitorum profundus (FDP), flexor carpi ulnaris (FCU), and flexor digitorum superficialis (FDS) were measured using ultrasound in the supine testing position with 30° of elbow flexion, unloaded, and at rest. The difference in UHJ gapping between the loaded and unloaded conditions at 30° (D30) and 90° (D90) of flexion were calculated. The FlexPro Grip training protocol consisted of a periodized ramp up training protocol to increase forearm flexor muscle strength. Participants followed coaches' instructions on training frequency and intensity. Training days included variations of ulnar deviation, fingertip flexion, mid finger flexion, finger extension, and radial deviation. After 10 weeks, all variables were remeasured for both cohorts. A two-way (Between Group, Within Time) mixed ANOVA ($\alpha = 0.05$) for each variable was performed to assess changes in UHJ gap and MCSA before (pre) and after (post) the 10-week period.

RESULTS: Significant interactions between group and time were present for all conditions, excluding unloaded UHJ gapping (Table 1). The FlexPro Grip pre to post displayed a significant decrease in UHJ gapping for all conditions and a significant increase in MCSA. The control group presented almost no significant change except for an increased UHJ gap which was opposed to the desired decrease.

DISCUSSION: Decreases in UHJ gapping and an increase in MCSA are beneficial towards protecting the UCL by enhancing the elbow's ability to withstand stress and providing functional stability to the elbow joint. Smaller UHJ gaps are associated with improved stability of the medial elbow joint and reducing the risk of injury, which is critical when placing stress on the elbow [5]. Additionally, higher elbow stability signifies a more secure and less lax joint structure. The FlexPro Grip group presenting decreased UHJ gapping under all conditions after the 10-week protocol allows us to deduce FlexPro Grip is effective in reducing injury risk due to UCL stress. The FDP, FDS, and FCU play a critical role in protecting the UCL by providing dynamic support to the UHJ, especially during movements that involve high valgus stress like pitching. The FlexPro Grip group presenting significant increases in their MCSA further indicates that FlexPro Grip is an effective tool for protecting and stabilizing the UCL as these muscles provide critical stabilization and resistance to valgus forces.

SIGNIFICANCE: This study identifies that the UHJ gapping decreases (unloaded and loaded) and MCSA increases after training with a 10-week FlexPro Grip program. Utilizing this training protocol may help more baseball pitchers prevent and recover from UCL injuries more effectively by training the extrinsic protective muscles to the elbow under valgus loads.

REFERENCES: [1] Werner et al. (2001), *Am J Sports Med*, 29(3); [2] Mahure et al. (2016), *J Shoulder Elbow Surg* 25(6); [3] Izeku et al. (2022), *J. Shoulder Elbow Surg.*, 31(8); [4] Udall et al. (2009), *Am J Sports Med*, 46(9); [5] Hitoshi et al. (2021), *J. Shoulder Elbow Surg.*, 30(9)

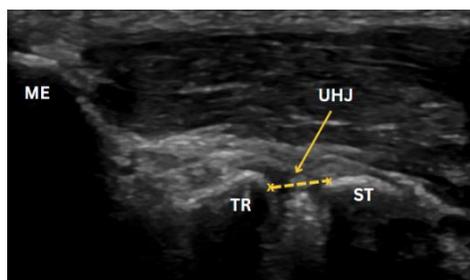


Figure 1: Ultrasound image of the medial elbow. TR: trochlea; ST: sublime tubercle; UHJ: ulnohumeral joint gap

Table 1: Interaction Effects

Condition	P-Value
30° Loaded	<.001
90° Loaded	<.001
D30	<.001
D90	<.001
FDS	<.001
FCU	.003
FDP	.003

ANOVA Group x Time significant interaction effects (p<0.05) for tested conditions.