Effect of Finger–Ball Friction on Pitching Performance, Upper Limb Motion, and Forearm Muscle Activity in Baseball

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Summary

This study demonstrated that pitchers who did not exhibit significant differences in pitch control between finger–ball friction conditions (water- and rosin-applied conditions) showed significant changes in hand velocity and hand trajectory. However, these changes were not associated with forearm muscle activity. Additionally, maximum elbow varus torque increased in five of eight pitchers under the water-applied condition, with one showing a significant difference.

Introduction

In baseball pitching, fingertip-ball friction is believed to affect performance and elbow stress. Studies show that low friction reduces spin rate and control, altering upper limb movements to decrease centrifugal force[1]. To counteract slippage, increasing fingertip force on the ball (normal and tangential) is also considered effective, likely raising forearm muscle activity. However, no studies have measured forearm muscle activity under varying friction conditions. This study investigates how fingertip-ball friction influences the relationship between pitching performance, upper limb motion, and forearm muscle activity.

Methods

Eight experienced pitchers were instructed to throw a fastball at a 0.1 m² target behind home plate with approximately 90% of their maximum pitch velocity. Two friction conditions were tested: a water-applied and a rosin powder-applied conditions. Hand velocity and the radius of curvature of the hand marker's trajectory were obtained from the position coordinates of the second metacarpal marker using an optical motion-capture system (OptiTrack, Acuity Inc.). Surface electromyography (EMG) signals from seven forearm muscle groups (pronator teres [PT], flexor carpi radialis [FCR], flexor carpi ulnaris [FCU], flexor digitorum superficialis [FDS], extensor carpi radialis [ECR], extensor carpi ulnaris [ECU], and extensor digitorum [ED]) were recorded using a small wireless myoelectric sensor (Pico, COMETA). Ball velocity and spin rate were measured using a ballistic analysis device (Rapsodo PITCHING 2.0, Rapsodo Japan). Ball arrival position was determined based on video camera images. The root mean square (RMS) waveform was calculated from the raw EMG data, and time-series changes in %MVC (maximum voluntary contraction) were computed. The %IEMG, representing the normalized integral EMG during the acceleration phase.

Results and Discussion

The pitchers were classified into two groups: those whose control was significantly affected by the friction conditions ($p < 0.05$) and those whose control was not affected ($p > 0.05$). Fig. 1 shows the relationship between the ratio of hand velocity and pitching radius across different friction conditions. As shown in Fig. 1, pitchers with greater differences in pitching motion between conditions did not show significant differences in pitch control between conditions. However, changes in %IEMG had no significant effect on the difference in the pitch control across friction conditions. In conclusion, modifications in upper limb motion are more influential than changes in grip force for maintaining pitch control under varying friction conditions. This alteration of upper limb movement may affect contribute to increased elbow varus torque, potentially elevating the risk of elbow medial collateral ligament injury. Additionally, five pitchers showed a tendency for the maximum internal rebound torque to increase under the water-applied condition.

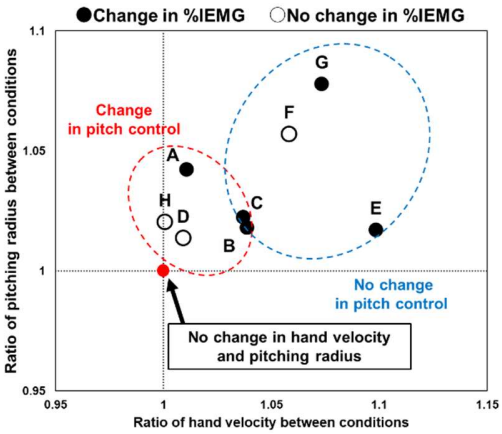

Figure 1: Relation between the ratio of hand velocity and pitching radius among finger-ball friction conditions

Conclusions

Pitchers without significant control differences across friction conditions showed changes in hand velocity and pitching radius, but no link to forearm muscle activity. In the water-applied condition, five pitchers had increased elbow varus torque, with one showing a significant difference.

Reference

[1] Suzuki S et al. (2023). Abstract of ISB – ISB2023