Does Foot Function Affect Pitching Motion? Players with Impaired Foot Function Show Inconsistent Pitching Motion

Hideaki Nagamoto[1], Takayuki Muraki[2], Hirofumi Katsutani[3], Daisuke Kurokawa[4], Hiroyuki Takahashi[5], Hirofumi Tanaka[6], Nobuyuki Yamamoto[7], Toshimi Aizawa[8], Tsukasa Kumai[3]
[1]Tohoku Univ Sch of Med, [2]Tohoku University, [3]Waseda University, [4]JCHO Sendai Hospital, [5]Kesen-Numa City Hospital, [6]Hyakutake Orthopedic Hospital, [7]Tohoku University School of Medicine, [8]Tohoku University School Of Medicine

INTRODUCTION: Baseball pitching requires integrated and coordinated motion of the entire body from the lower to the upper extremity. To efficiently transfer the ground reaction force from the ground, lower extremity and foot must work as a stable yet dynamic base of support. Functional impairment and mechanical deterioration in any parts of the body can lead to reduction in efficient energy transfer. The foot is the initial point of the pitching motion, and integral part during pitching motion through its importance as a stable base. From our retrospective study, players with disabled throwing shoulder and elbow tended to have high rates of impaired toe function and floating toes in both feet, which insisted that these pathologies may have a relationship with the occurrence of throwing injuries. Furthermore, we have recently reported that players with disabled throwing shoulder/elbow had higher prevalence of impaired foot function compared to those without it. However, there are no reports regarding how impaired foot function affects the pitching motion. The purpose of this study was to investigate the relationship between foot function and pitching motion.

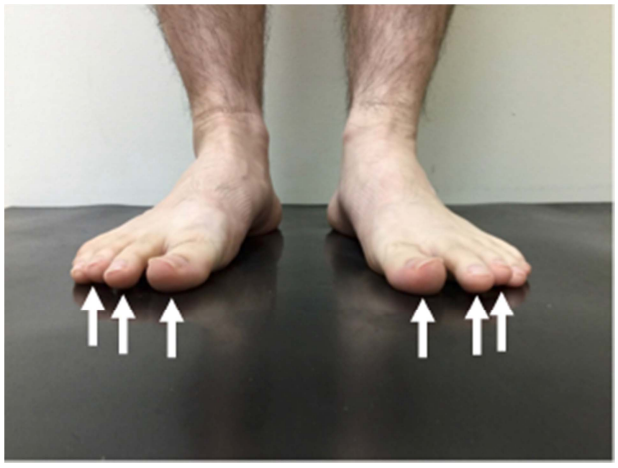
METHODS: A total of 15 youth male baseball players (average age of 14.9 years) were included in the study. All the players had no complaint of shoulder/elbow pain at the time of measurement and evaluation. Also, nobody had a history of foot and/or ankle surgery or injury. Foot function was evaluated by floating toes according to the previous reports. Players were instructed to stand on a solid mat on both feet, having them in shoulder width apart. While standing in upright position, players gazed at a marker 2 m ahead at eye level. Floating toes were defined if all the toes were not in contact with the mat (Figure 1). Pitching motion was recorded by two high-speed cameras (one from the back of the catcher for coronal view and the other from the third base side or first base side according to the dominant hand for sagittal view). From the movie, a static image of the ball releasing point was captured and by using software, three measurement points of ball, wrist, and leading foot was defined. Distance from the origin to the aforementioned three measurement points were measured for the 10-best pitches. X-component in the coronal image defined the crosswise direction and anteroposterior direction in the sagittal view while the Y-component defined the vertical direction in both images (Figure 2). Relative standard deviation (RSD) of each measurement point was calculated from the average distance and its standard deviation (SD). The relationship between floating toes and SD, and RSD was statistically analyzed using Student's t-test. P value of $<.05$ was considered to be statistically significant.

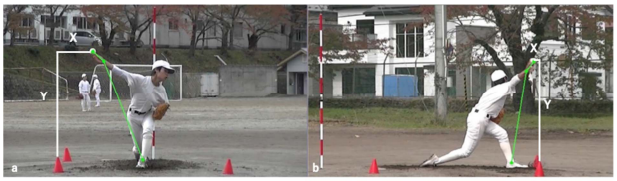
RESULTS: Seven players (47%) showed floating toes on the throwing side and five players (33%) on the non-throwing side. Players with floating toes on the throwing side showed significantly higher SD in X-component of the ball, wrist, and leading foot compared with those without them in sagittal image (0.054 vs. 0.044, $P = 0.04$, 0.04 vs. 0.03, $P = 0.02$, and 0.03 vs. 0.021, $P = 0.01$, respectively). Relative standard deviation of the Y-component of the ball from coronal view of the players with floating toes on the throwing side was 7.29, and the X-component of the ball and wrist from sagittal view was 116.14 and 60.74, respectively. Those of the players without the floating toes on the throwing side was 2.82, 29.49, and 24.39, respectively, which the difference was statistically significant ($P = 0.04$, 0.02, and 0.04, respectively).

DISCUSSION AND CONCLUSION:

The study revealed that players with floating toes on the throwing side showed significantly higher SD of the ball, wrist, and leading foot from the sagittal view, and higher RSD of the ball from coronal and sagittal view and those of the wrist from the sagittal view, compared with those without floating toes. Previous literature has revealed that having floating toes affect gait pattern, kinetics, or kinematics of the proximal joint. Another study has reported that those with floating toes showed disability in dynamic balance, decreased step length, and speed during walking. Those with floating toes also showed lower ability to control their posture and dynamic balancing and weakening of motion adjustment ability, including sensory factors required for executing accurate motion. From these previous facts may insist that having floating toes may have affected the accurate execution of pitching motion, resulting in inconsistency in ball, wrist, and leading foot at the ball releasing point. Further study to analyze how improvement in foot function affect pitching motion is required to reveal the true effect of foot function in baseball pitching motion.

Relationship between foot function and pitching motion was investigated. Players with floating toes on the throwing side showed significantly higher SD of the ball, wrist, and leading foot in anteroposterior direction in sagittal view, and RSD of the ball in crosswise direction in coronal view and anteroposterior direction of the ball and the wrist in sagittal view compared with those without them, by using the static image of the ball releasing point. Pitching motion of the players with floating toes on the throwing side may show inconsistency compared to those without them.




X
Y
a
X
Y
b