AN INVESTIGATION OF FULL BODY KINEMATICS FOR STATIC AND DYNAMIC THROW-IN IN PROFICIENTPROFICIENT AND NON-PROFICIENTPROFICIENT SOCCER PLAYERS WHEN THEY TRIED TO HIT A SPECIFIC TARGET.

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The purpose of this study was to identify the kinetic differences between proficient and non-proficient players during one ability: Throw-in. Twelve players were recruited from the local university to perform the experiment. Many studies have been conducted to explain the biomechanics of this ability, however there is about a lack of research, investigating the comparison between proficient and non-proficient players. The hypotheses of this study were that a) peak knee flexion angles would be higher for dynamic style for proficient and less proficient subjects, and b) peak vertical ground reaction force (GRF) would be higher for the dynamic style. Our results showed a markedly difference in the peak flexion angles for proficient players. The results may be useful to develop training strategies to help to the players to achieve precise throws.

KEY WORDS: Kinematics, comparison, hip flexion, peak angles.

INTRODUCTION: The throw-in is a method for restarting the game and can be used as an attacking manoeuvre near to the goal mouth. The farther a player can throw the ball, the larger the area in which his team mates may receive the ball and the greater the scoring opportunities. In soccer, there are several styles of throw-in, whereby static and dynamic styles are the most used styles during a game (Lees, 1998). In a static throw-in, the movement is performed whit the feet side by side on the ground, while the dynamic throw-in the movement is performed some steps further back from the touch-line. Both styles are initiated by flexing the knees and taking the ball backwards with respect to the body, there is an upward extension of the knee joint and a marked pushing of the hips both forwards and upwards. This serves to prepare the upper body for the recoil that will propel the ball forwards. As the upper body starts to come forwards, there is a sequential unwinding starting with the hips, followed by the shoulders, elbows and, finally, the wrist and hands until ball release. Linthorne & Everret et al. (2006) studied the release angle that maximizes the distance attained in a long soccer throw in. The release angle was calculated as the mathematical expression for the relation between release speed and release angle. They found that using a low release angle the player released the ball with a greater release speed and concluded that the optimal release angle is about 30°. Currently, it is still not known how lower and upper extremity biomechanics affect the proficiency of a throw-in, for both static and dynamic styles. Therefore, the objective of this study was to investigate the differences between proficient and less proficient subjects during soccer throw-in (static and dynamic), through examination of the peak GRF, joint kinematics and kinetics. We hypothesized that: a) Peak knee flexion angles would be higher for dynamic style for proficient and less proficient subjects, and b) Peak vertical ground reaction force (GRF) would be higher for dynamic style.

METHODS: Twelve healthy male participants were recruited from the local university, with a mean age of 23 ± 2.0 years, height of 1.74 ± 0.08 m and weight 66.0 ± 8.7 kg. The exclusion criterion was a history of lower extremity injuries/diseases that might affect the throw biomechanics. All the participants signed informed consent before participation, in accordance with the university's Institutional Review Board. Anthropometric data such as, height, weight, shoulder off-set, elbow width, wrist width, hand width, knee width, ankle width, leg length and inter-anterior superior iliac spine distance were acquired from the participants. To eliminate the effect of shoe type on the subject performance, all subjects wore the same F50 shoe model (ADIDAS, Germany) sizes from 9-11(USA). The study was carried out a motion analysis laboratory. Two forces plates (AMTI, UK), embedded into the floor, were used to determinate GRF data at sampling rate of 1000 Hz. A motion-capture system (Vicon Mx, Oxford Metrics, UK), consisting of six infrared cameras, was employed to collect kinematics data at a sample rate of 100 Hz. The force plates were synchronized to the motion capture system; both were calibrated according to the manufacturer's recommendation before the throw trials were conducted. Thirty five retro reflective markers (14-mm diameter) were attached to the participant's full body based on the Plug-In-Gait Marker set, to facilitate capture of the participants' soccer throw-in motion. One white board (170 x 190 cm) was placed from a distance of 5.5 m away from the throw point. The white board was divided in a grid of 5-cm-sized squares, with the purpose of quantifying the deviation (distance between hitting location of ball and actual target position) for "x" axis and "y" axis. One target (15-cm diameter) marked in black, was placed in the center of the board. The participants were instructed to perform a throw-in from a distance of 5.5 m away and they were asked to employ their natural throw-in style for dynamic and static task. In the case of static style, the participants threw the ball from a stationary position landing both feet on the force plate. For dynamic style, the initial position of the participant was two steps away from the force plate. Once he was told to start, the subject moved the two steps and once he was on the force plate, he threw the ball. The participants were given 5 min of practice and 5 min of rest before commencing the actual throw trial. A trial was considered successfully when the participant hit the white board. Three trials were conducted and the results were averaged from each set of three trials. All the trials were recorded using a standard video-camera (SONY, Japan) to determine the deviation of the ball respect the target. All the videos obtained during the trials were analyzed to calculate the spatial deviation from the impact location of the ball on the board to the actual target location, using tracking software (Tracker Video Analysis and Modeling Tool Open Source Physics, USA). Based on the deviation values obtained from the video analysis, the athletes were ranked, accordingly to the proficiency obtained. The top nine athletes were classified as proficient, while the bottom nine athletes were classified as less proficient. The software, Vicon Workstation 5.1 and Polygon 3.5, were used for data collection and processing respectively. The kinematics data were smoothed using a Woltring filter. The peak angle for the hip, knee, angle, shoulder, elbow and wrist during the two phases of soccer throw-in. The Throw-in phase was taken as the time between the subject's hands hold the ball and till the ball is launched .The recovery phase was taken at the event after the subject launched the ball till the subject recovered his start position. Two Factor (Style x proficient\non-proficient) ANOVA, followed by Holm-Sidak post-hoc testing, was used to compare the peak angle at Throw-in phase, and recovery phase. All significance levels were set at p=0.05.

RESULTS: The deviation results were the factors that allow us to classify the subjects in proficient or less proficient players. In the case of the proficient players, their deviation values were lesser by almost the half of the proficient players.

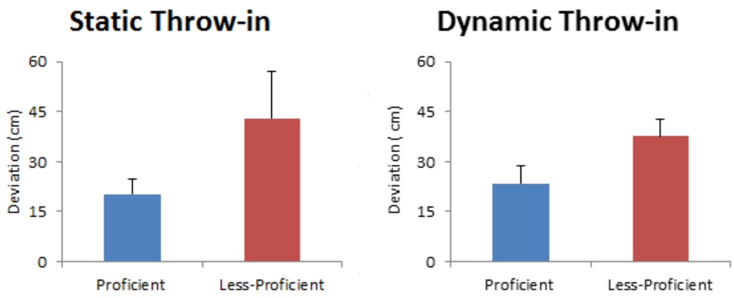

Figure 1: Comparison of the deviation for all the targets between the proficient and less-proficient players.

For the non-dominant side during the Throw-in phase, we found a higher ($p<0.05$) hip flexion angles for dynamic style in proficient and less proficient players, and a higher knee flexion angle only in less proficient subjects. Moreover, during the recovery phase, we found a higher ($p<0.05$) flexion angle in hip and knee joints in the less proficient players (Table 1).The peak vertical GRF was higher ($p<0.05$) for the dynamic style for proficient players and less proficient players during the Throw-in phase (Table 2).

Table 1
Summary of mean (SD) of peak joint angles in non-dominant side between proficient and less proficient players for both throw-in styles, in sagittal plane. * Significant difference (p<0.05)

Peak Joint Angles (Degrees)					
Classification	Joint	Phase	Static	Dynamic	P-value
Proficient	Hip	Throw-in	10.52 (0.08)	34.35(11.9)	0.007*
Less Proficient	Hip	Throw-in	1.98(4.89)	45.62(11.73)	0.001*

DISCUSSION: The purpose of this study was to investigate the differences in dominant and dominant side biomechanics between proficient and less proficient subjects during two styles of soccer throw-in. Our key findings indicated that: (1) peak vertical GRF was higher at the non-dominant support leg for proficient players in both styles, (2) The hip plays an important role in determining throw proficiency for both styles, (3) The hip peak flexion is different in the two styles, in the case of the static throw in, the angle was higher for proficient players whereas in the case of the dynamic style, the value was lesser. During the throw-in phase and based on our results we found that the proficiency is related to exhibited a high value of ground reaction force for both styles. The ground reaction force allows to the subjects to have more impulse and therefore, to exert more accurate hits. The differences in the peak hip flexion angles could be because in the static throw in the proficiency is related to exert a small flexion angle around 10°, whereas in the case of dynamic style the proficiency is related to exert an angle of 30°. Kibler et al. (2006) studied the role of the core stability in sports, and his results showed that hip and pelvis are responsible for maintain body stability and that they are involved in almost all extremity activities such as running, kicking and throwing.

Table 2.
Summary of mean (± SD) peak vertical ground reaction forces (GRF) between proficient and less proficient subjects for non-dominant leg side, in static and dynamic throw-in. * Significant difference (p<0.05).

Vertical GRF (BW units)				
Classification	Phase	Static	Dynamic	p-value
Proficient	Throw-in	0.62(0.05)	1.06(0.07)	0.001*
Less-Proficient	Throw-in	0.54(0.01)	0.87(0.04)	0.002*

CONCLUSION: Interestingly, our results only showed a significant difference in lower body kinematics. These results may suggest that the lower body plays a key role to make an accurate throw. Furthermore, the GRF could be an important parameter in the accuracy of hit a target, especially in the case of the dynamic style, because with high values of vertical GRF the player may help to propel the upper body and perform an accurate hit. The results found in the present study, may help to understand the biomechanics of the lower body and upper body in two different styles of throw-in. Moreover, the results could help to soccer players about the correct range of motion that they need to perform to achieve a precise throw. Additionally, the results could contribute to develop specific muscular training to increase the accuracy and distance of the throw-in skill during a soccer game.

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