

KINEMATIC ANALYSIS OF PENALTY KICK IN SOCCER

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ABSTRACT: Kinematics of the instep penalty kick to four different targets (50cm²) placed at the upper left (UL), lower left (LL), upper right (UR), and lower right (LR) corners in the goal. Five colligate male soccer players were examined for their knee flexion and ankle extension strategies. The swing, ball contact and follow through phases were analyzed by using a dual camera and Pictran software system. Results revealed that participants had significantly higher ankle extension while hitting the target at the UR ($m=77.6$ deg, $sd=10.5$) and LR ($m=84.4$ degree, $sd=10.1$) corners. In conclusion players presented similar knee flexion but not ankle extension kinematic strategies at the contact and follow through phases of the instep penalty kick to different corners in the goal.

Keywords: *Digital photogrammetry, kinematics, motion analysis, penalty kick.*

Futbolda Penaltı Atışının Kinematik Analizi

ÖZET: Futbolda penaltı atışı, kalenin sağ üst, sağ alt, sol üst ve sol alt köşlerine 50 cm büyüklüğünde bir hedef konularak gerçekleştirilmiştir. 5 adet sporcunun topa vuruş sırasında diz ve ayak bileğinde oluşan açılar kinematik olarak incelenmiştir. Hareketin başlangıç anından itibaren topa vuruş anına kadar olan görüntüleri çift kamera ile çekilmiştir. Çekilen görüntüler Pictran fotogrametri yazılımı ile değerlendirilmiştir. Değerlendirme sonucunda topa vuruş esnasında dizde oluşan açılar, ayak bileğinde oluşan açılara göre istatistiksel olarak daha anlamlı bulunmuştur.

Anahtar Kelimeler: *Digital fotogrametri, hareket analizi, kinematik, penaltı atışı.*

INTRODUCTION

Biomechanics and movement analysis in soccer can be defined as the characteristics of a skill quantitatively. Quantifying the movement of certain task like of the penalty kick can be used to improve the performance of that skill (Bases 2008).

The free kick in soccer including the penalty kick is the full-tension and almost always deterministic moment of a game. Although each player develops individual skills and strategies, the most frequently used technique is the instep kick. Previous studies (Asami and Nolte, 1983; Bloomfield et al., 1994; Barfield, 1997) in young and seasonal

professional players focused on the variables that predict the success of the instep kick. Elite compared to young players developed a relatively constant mechanical strategy for the instep kick (Ben-Sira, 1980; Gainor et al., 1978; Hay, 1996; Tsaousidis and Zatsiorsky, 1996). From the mechanical point of view, the instep kick is a multiplanar movement and the motion of a single segment within a linked system is nonlinear and cannot be solely attributed to muscle forces and moments acting on the lower extremity (Barfield, Kirkendall, Yu, 2002). Biomechanical analysis of a well executed instep kick requires the assessment of the whole lower extremity kinetic chain.

Previous studies focused on the ball velocity as an indication of success in instep kick. However, a well documented kinematic analysis of this movement in relation with success was not documented in some detail. The instep kick can be divided into 3 phases. These are swing, ball contact and follow-through. Each phase should be executed successful enough to kick the ball to the desired location. Therefore, the aim of this study was to investigate the ankle extension and the knee flexion differences of instep kick during penalty where the success was indicated 4 different locations, the upper left (UL), the lower left (LL), the upper right (UR), and the lower right (LR) inner corners of the goal.

METHODS

Five collegiate male soccer players (age= 21.5±2.2 years; body weight= 68.4±4.6 kg; body height= 1.74±5.6 m; soccer experience= 10.4±5.0 years) volunteered for the study. Each player executed 5 successful instep penalty kicks to the targets (50 cm²) placed at the 4 (UL, LL, UR, and LR) inner corners of the goal. Five reflective markers were used to define the thigh, the shank and the foot. Markers were placed on the a) right anterior superior iliac spine, b) lateral condyle of the right knee, c) lateral malleolus, d) posterior of the calcaneus and e) distal metatarsal head of the fifth phalanx.



Figure 1. Penalty Kick.
Şekil 1. Penaltı atışı.

The instep penalty kicks were recorded at a stereoscopic view with two digital cameras

(Dragonfly Express, Point Grey Research, 2006) at a frame rate of 60 frames/second. The cameras were placed at approximately 90 degree angle to each other. A cage that covered the volume of 1.0 m x 1.0 m x 2.0 m at 12 control points was used to calibrate the space in which the instep penalty kicks were performed (Figure 1). Photogrammetric restitutions were conducted using the Pictran Software (Technet GmbH, Germany). Adjustment process was provided in bundles of 6-8 control points. Three dimensional coordinates of the marked points were defined after the adjustment process was completed. Ankle extension and knee flexion were determined from the images. The swing, ball contact and follow through phases were assessed according to Barfield et al (1998).

RESULT

Analysis of variance results revealed that there was no significant knee flexion difference when the instep kick was used to hit the UL, LL, UR and LR targets at the swing, contact and follow through phases (Figure 2). Players tend to use the similar knee flexion strategy for all targets.

Results revealed that there was no significant ankle extension difference at the swing phase. However, ankle extension differed significantly at ball contact ($F_{(3,16)}=11.61$, $p=.00$) and follow through ($F_{(3,16)}=3107$, $p=.05$) phases.

Pair-wise comparison of the contact phase revealed that players had significantly higher ankle extension when shooting the ball to the UR corner ($m =77.6$ degree, $sd=10.5$) and LR corner ($m=84.4$ degree, $sd=10.1$) when compared to the LL corner ($m =56.2$ degree, $sd =9.6$) and UL corner ($m=59.6$ degree, $sd =4.2$).

Results for the follow through phase revealed that players presented significantly higher ankle extension when shooting the ball to the LR corner ($m =66.8$ degree, $sd =7.05$) when compared to the LL corner ($m =56.2$ degree, $sd =5.97$) (Figure 3).

DISCUSSION & CONCLUSION

Players presented a similar knee flexion strategy while shooting the ball to different locations in the goal in each phase of the instep kick. However, ankle extension at ball contact and follow through phases were different when the LR and LL corners were targeted. To

our knowledge, this perhaps is the first study comparing lower extremity joint kinematics at instep penalty kick to different locations in the goal.

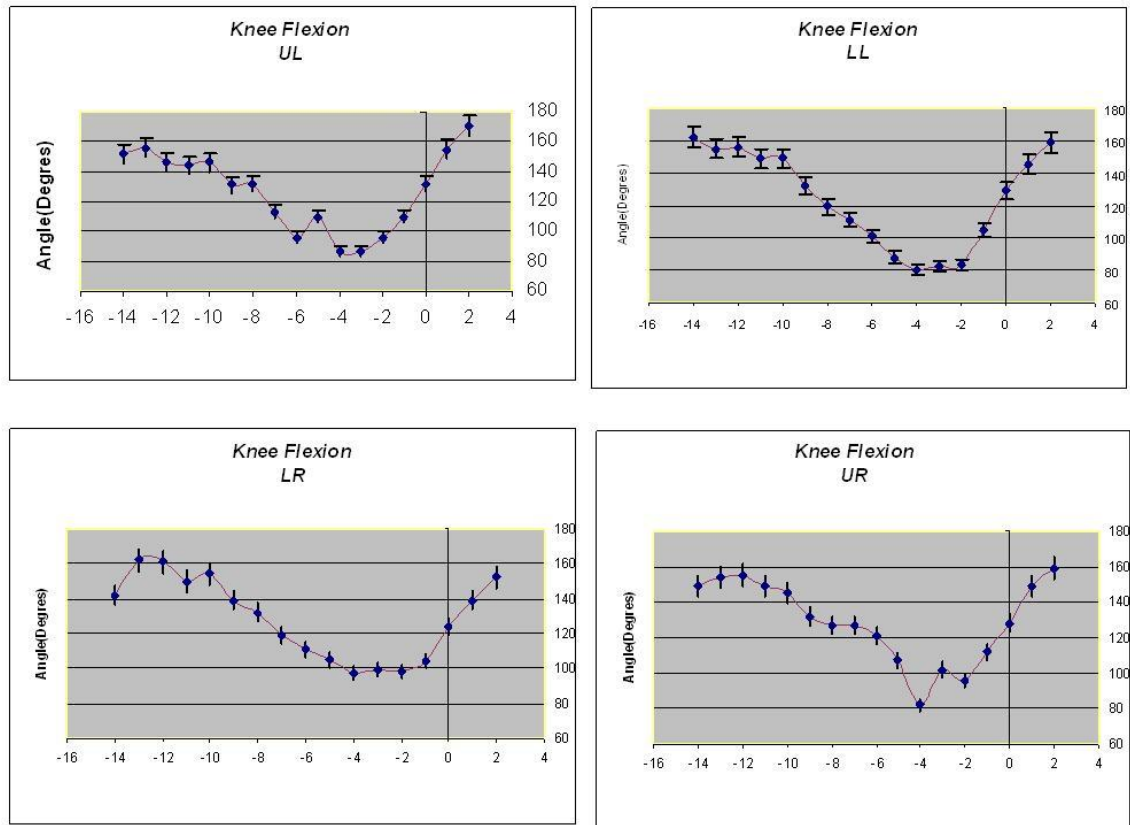


Figure 2. Knee flexion strategy of players.
Şekil 2. Diz fleksiyon açısı.

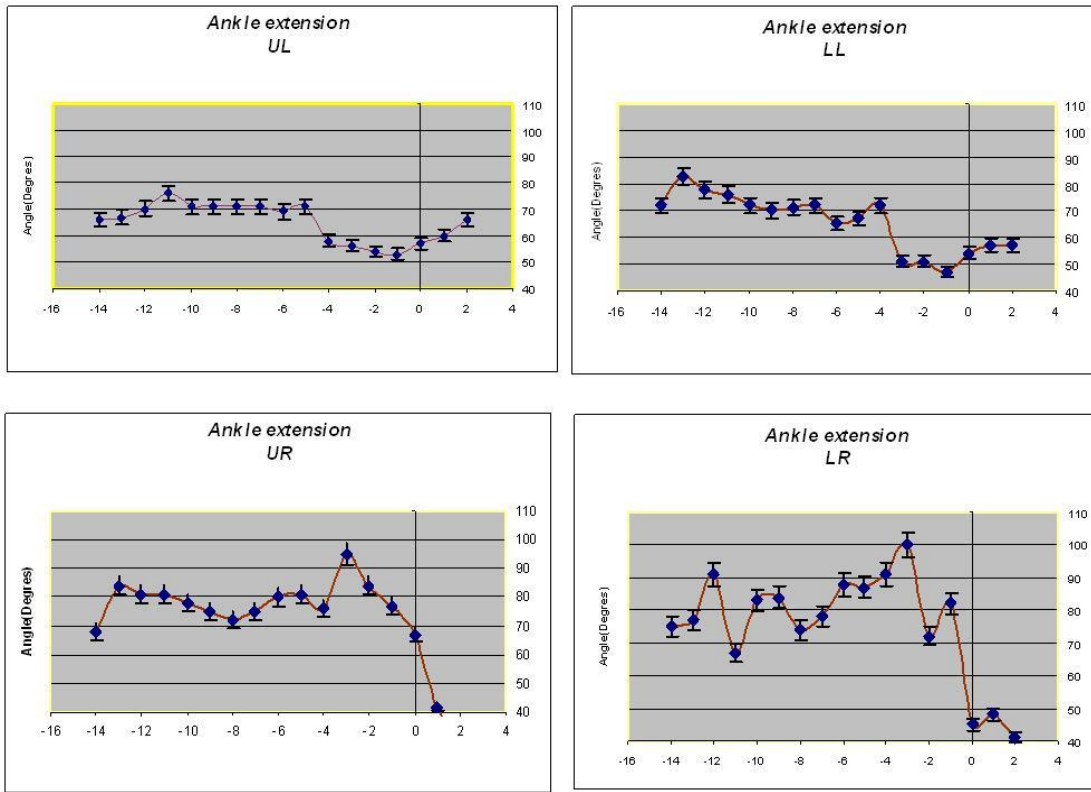


Figure 3. Ankle extension strategy of players.

Şekil 3. Ayak bilek açısı.

The study was limited to collegiate male soccer players. The advantage of the study was field measurements. Shinkai et al. (2007) focused on the motion of the foot at the contact phase of the kicking movement. They found that the foot was plantarflexed, abducted and everted during the contact with the ball. They also suggested that after the foot contact with the ball it does not have any effect on the velocity of the ball (Shinkai, 2007).

Apriantono et al. (2006), investigated the effect of muscle fatigue on the kinematics of instep kicking and found that fatigue does have a negative effect on the kinematics of the movement. (Apriantono, 2006). As we think about the penalty kick in an actual game, it can be said that as the player develops fatigue, the kinematics of his/her kicking action could be

negatively affected and the probability of missing the penalty is increasing. Nunome, (2006), found that highly skilled soccer players have better inter-segmental motion for both the preferred and non-preferred leg.

In conclusion, our results presented that players had similar knee flexion but not ankle extension kinematic strategies at the contact and follow through phases of the instep penalty kick to different corners in the goal.

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