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Section I - Kinesiology

Biomechanical Responses of Instep Kick between Different Positions in Professional Soccer Players

by
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The purpose of this study was to investigate some selected biomechanical characteristics of lower extremity between professional soccer defenders, midfielders and strikers. The kicking motions of dominant legs were captured from fifteen Olympic professional soccer players; (height: 181.93 ± 7.03 cm; mass: 70.73 ± 10.85 kg; age: 20.8 ± 0.77 years), volunteered to participate in this study, using four digital video cameras. There were significant differences between midfielders and defenders in (1) lower leg angular velocity ($p \le 0.001$), (2) thigh angular velocity ($p \le 0.001$), (3) lower leg net moment ($p \le 0.001$), (4) thigh net moment ($p \le 0.001$), and (5) ball velocity ($p \le 0.012$). There were significant differences between midfielders and strikers in lower leg net moment ($p \le 0.001$). There were significant differences between strikers and defenders in; (1) lower leg angular velocity ($p \le 0.001$), (2) thigh angular velocity ($p \le 0.001$), (3) lower leg net moment ($p \le 0.001$), (4) thigh net moment ($p \le 0.001$), and (5) ball velocity ($p \le 0.024$). In conclusion, midfielders can perform soccer instep kicking strongly and faster than defenders and there is, however, no significant difference between midfielders and strikers, but midfielders` ball velocity is higher than strikers` ball velocity.

Key words: Biomechanics, instep kick, soccer, different position

Introduction

Soccer is a sport requiring high-intensity, intermittent, non continuous exercise that includes agility, many sprints of different durations, rapid accelerations, jumping, among others (Little and Williams, 2005; Little and Williams, 2006). According to these characteristics and physiological demands, researchers started to investigate the effect of different position of soccer players in these physiological aspects. Their investigation demonstrated that during a soccer competition, midfielders cover greater total distances than any other players in the other positions. This is reinforced by the work of Reilly and Thomas (1976) who found that midfield players covered the greatest mean distance (9805 m) during a game, as well as more distance sprinting than either centre-backs of full-backs. Defenders, on the other hand, covered less total distance and performed less high-intensity running than players in the other positions, which probably is closely related to the tactical roles of the midfielders and the defenders (Bangsbo, 1994; Bloomfield et al., 2007). The strikers covered a distance at a high intensity equal to the full-backs and midfielders, but performed more sprints than the midfielders and defenders (Davis et al., 1992; Mohr et al., 2003).

Most researches, on the other hand, studied on the biomechanics of soccer skill within the last decade.They reported 2 dimensional and 3 dimensional biomechanical characteristics of body joints and segmental during soccer skill. One of these

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skill is soccer instep kick which is the most important and studied skill; of the actions performed more during soccer (Markovic et al., 2006; Nunome et al., 2006). It is important to achieve a high ball speed in soccer kicking, since this gives the goalkeeper less time to react, thus improving one' s chances of scoring (Markovic et al., 2006; Dorge et al., 1999). Various factors including the distance of the kick from the goal, the type of kick used, the air resistance and the technique of the main kick which determine success of an instep soccer kick (Kellis and Katis, 2007). Previous researches have investigated soccer instep kicking biomechanics under different conditions, however, there is lake of to date any research about biomechanical comparison of soccer instep kicking between different positions in soccer. Our purpose, therefore, is to investigate the biomechanics of lower extremity segments during soccer instep kicking between Olympic professional defenders, midfielders and strikers. We hypothesized that strikers would have better biomechanical response during an instep kick than defenders and midfielders due to their role during a soccer match.

Material & methods

Fifteen Olympic professional soccer players; (n = 15; height: 181.93 ± 7.03 cm; mass: 70.73 ± 10.85 kg; age: 20.8 ± 0.77 years), who had no history of major lower limb injury or disease, volunteered to participate in this study after providing their informed consent (Table 1). The Sport Centre Ethics Committee gave approval for all procedures. All participants were training regularly for the premier league teams and each had more than 10 years of professional soccer practice (mean 10.6, ± 2.1 years).

As all participants preferred to kick the ball using their right leg, the right leg was considered the preferred leg. After an adequate warm up, players randomly assigned to a series of five maximal velocity instep place kicks of a stationary ball with dominant limb; essentially, this corresponds to the penalty kick in soccer. A ball was kicked 11 m towards a target; middle of goal post around 2×2 m in size. To minimize movement in the frontal plane, the participants were restricted to a 3 m straight run-up from a position directly behind the ball at an approach angle of 0°. At finally, one kick could be selected with a good foot–ball impact and adequate centre of goal targeting for analyzing. A FIFA-approved size five soccer ball (mass = 0.435 g) will be used for each kicking session and its inflation is controlling throughout the trials at 700 hPa.

Four digital video cameras (Panasonic NV-GS60, Japan) were used to capture limb motion at 60 Hz. All four video cameras adjusted the reference point as the penalty point and placed equally spaced to ensure the spacing between two consecutive cameras covers an angle of 90˚ from the penalty point. An external audio refer to foot–ball impact sound was used to synchronize the four video cameras. The calibration frame with 16 calibration points that is covering a 1.5 m long 1.5 m wide 1.5 m high space used to calibrate the space in which subjects is performing instep kicking. Outdoor experience on the grass has been limited using of a force plate to capture kinetics data, so kinetics variables calculated by inverse dynamics analysis (Robertson et al., 2004). Reflective spherical markers (9 mm in diameter) were fixed securely onto lateral side of the bony anatomical landmarks of the right and left legs, including fifth metatarsal head, the heel, the lateral malleolus, the lateral epicondyle of the knee, the lateral greater trochanter and center of ball. Peak Motus version 9 videographic data acquisition system (Vicon Motion Systems, USA) was used to manually digitize the video records of the calibration frames, and subjects' performances. This software also was used to estimate 3-D coordinates of 10 body landmarks and the center of the soccer ball for each trial from dominant leg toe off to at least ten frames after the soccer ball left the kicking foot. An invers dynamics method was used to calculate kinetics variables. At finally, one kick could be selected with a good foot–ball impact and adequate centre of goal targeting for final analyzing.

Some of important kinematics and kinetics parameters during forward and impact phases which refer to optimal kick, selected for analysis. Resent study was focused on lower extremity, so it investigated the maximum of thigh angular velocity (TAV), maximum of lower leg angular velocity (LAV), maximum of thigh moment (TM), maximum of lower leg moment (LT) at forward and impact phases and finally maximum of ball velocity (BV) after impact. The foot velocity was represented by the velocity of the foot's centre of mass, which was defined by the toe and heel markers. The foot velocity was computed for each component as the first derivative of linear regression lines fitted to their non-filtered displacements (three points before ball impact).The absolute magnitude of the foot

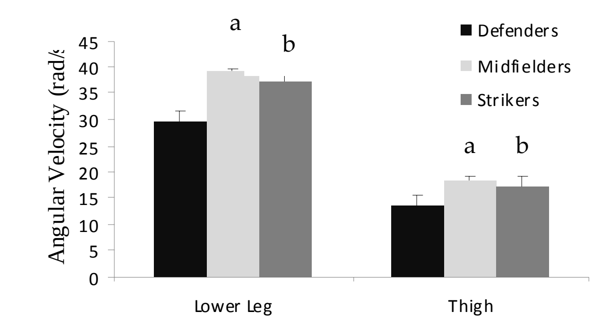

Figure 1
Lower leg and thigh angular velocity during soccer instep kicking between different positions of soccer players. Significant differences ($p < 0.05$) are shown a) between midfielders defenders and b) between strikers versus defenders

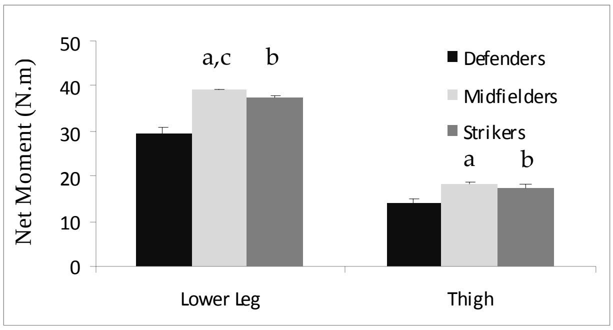

Figure 2
Lower leg and thigh net moment during soccer instep kicking between different positions of soccer players. Significant differences ($p < 0.05$) are shown a) between midfielders defenders, b) between strikers and defenders, and c) between midfielders and strikers

velocity was calculated from the values of its components. From the results of a previous study (Nunome et al., 2002; Nunome et al., 2006) the foot joint motion was assumed not to have a substantial influence on the leg swing motion during kicking. Thus, the shank and foot segments were combined and defined as one segment (lower leg), so that the kicking leg was modeled as a two - link kinetic chain composed of the thigh and lower leg.

The effect of different position on selected biomechanics variables was determined using one-way analysis of variance (ANOVA) for repeated-measures. A significance level of $p \leq 0.05$ was considered statistically significant for this analysis. When justified, posttest Tukey was used to compare each above defined kinematic and kinetic variables of kicking between different positions.

Results

The results for the kinematics and kinetics responses during soccer instep kicking between three different positions which are defenders, midfielders and strikers are presented in Figures 1-3.

Kinematics result showed that there were significant differences between midfielders and defenders in (1) lower leg angular velocity (2240.79 ± 29.001 0.s^{-1} and 1702.39 ± 114.26 0.s^{-1} respectively; $p \leq 0.001$) (Figure 1), (2) thigh angular velocity (1055.20 ± 12.03 0.s^{-1} and 780.85 ± 58.35 0.s^{-1} respectively; $p \leq 0.001$) (Figure 1), and (3) ball velocity (30.14 ± 5.40 m.s^{-1} and 22.19 ± 2.80 m.s^{-1}) respectively; $p \leq 0.012$) (Figure 3). There were significant differences between strikers and defenders in; (1) lower leg angular velocity (37.29 ± 1.75 0.s^{-1} and 1702.39 ± 114.26 0.s^{-1} respectively; $p \leq 0.001$) (Figure 1), (2) thigh angular velocity (994.004 ± 47.44 0.s^{-1} and 780.85 ± 58.35 0. $^{-1}$ respectively; $p \leq 0.001$) (Figure 1), and (3) ball velocity (29.29 ± 1.56 m.s^{-1} and 22.19 ± 2.80 m.s^{-1} respectively; $p \leq 0.024$) (Figure 3).

Kinetics result showed that there were significant differences between midfielders and defenders in (1) lower leg net moment (88.87 ± 1.15 N.m and 67.52 ± 4.53 N.m respectively; $p \leq 0.001$) (Figure 2) and, (2) thigh net moment (20.01 ± 0.22 N.m and 14.81 ± 1.10 N.m respectively; $p \leq 0.001$) (Figure 2). There were significant differences between midfielders and strikers in lower leg net moment (88.87 ± 1.15 N.m and 77.69 ± 3.51 N.m respectively; $p \leq 0.001$) (Figure 2). There were significant differences between strikers and defenders in (1) lower leg net moment (77.69 ± 3.51 N.m and 67.52 ± 4.53 N.m respectively; $p \leq 0.001$) (Figure 2) and, (2) thigh net moment (18.61 ± 0.89 N.m and 14.81 ± 1.10 N.m respectively; $p \leq 0.001$) (Figure 2).

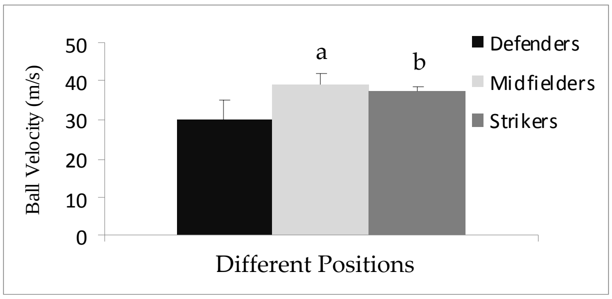

Figure 3
Ball velocity during soccer instep kicking between different positions of soccer players. Significant differences ($p < 0.05$) are shown a) between midfielders and defenders and b) between strikers and defenders

Table 1

Basic characteristics of soccer players representing different field positions

	All players	Defenders	Midfielders	Strikers
Age (years)	20.8 ± 0.77	21 ± 0.7	20.6 ± 0.89	20.8 ± 0.83
Height (cm)	181.93 ± 7.03	185.2 ± 3.11	179.4 ± 7.23	181.2 ± 9.44
Mass (kg)	70.73 ± 10.85	77.4 ± 9.44	66.6 ± 13.10	68.2 ± 8.13

Discussion

The purpose of this study was to compare the biomechanical characteristics of instep kick between three different positions which are defenders, midfielders and strikers in professional soccer players.

According to present study`s finding, soccer midfielders and strikers perform instep kick faster than defenders based on biomechanical characteristics. Strikers, furthermore, performed soccer instep kicking faster than defenders. Dependent on recent study, In fact, there is no significant difference between midfielders and strikers except of lower leg net moment, but, midfielders had highest individual values in other variables discussed, especially in the ball velocity.

To date, there is no study which has investigated soccer instep kicking between different positions. There are, on the other hand, a number of researchs that examined physiological characteristics and demands of soccer players in different positions.

It seems that strikers who have more sprinting covering and duration, anaerobic power and their tactical role during competition to scores goal than midfielders and defenders, they must have stronger and faster instep kick in biomechanical perspective versus other positions. In contrast, midfielders have faster soccer instep kicking than the defenders and strikers, especially in the ball velocity. Several studies have reported average ball velocities of the instep soccer kick, and the range in ball velocities of the instep kick of the strikers (29.29 ± 1.56 $m.s^{-1}$) measured in the present study was within the range of average values (24.7 – 29.9 $m.s^{-1}$) reported previously (Asami and Nolte, 1983; Levanon and Dapena, 1998; Dorge et al., 2002; Nunome et al., 2002). In contrast, the average ball velocity of the defenders (22.19 ± 2.80 m/s) and midfielders (30.14 ± 5.40 m/s) were outside this range. There are few possibilities that may explain our finding why midfielders' soccer instep kicking is higher than other positions.

First reason which effects midfielders' soccer instep kicking that they do more forward movement than other position during training and competition. In terms of directions travelled, midfielders were also found to perform the most directly forward movements in comparing to defenders and strikers. Defenders, on the other hand, involved in the highest amount of backwards and lateral movements (Rienzi et al., 2000; Bloomfield et al., 2007). Whereas in our methods for measuring the instep kick, subjects were limited to running forward movement at an approach angle of 0°, and also during game there are a lot of opportunities after rebinds behind of box, and in generally, midfielders use this opportunities with forward movement. It seems possible that midfielders have more experience in kicking the ball at an approach angle of 0° and maybe from psychological perspective their minds were ready for this skill more than other positions.

Second reason could be refer to proximal - to - distal sequential pattern of segment motions which if players can perform it at high level; they will have faster kick and also good result. It seems that midfielders can perform it at high level of correlation between lower leg and thigh segments. Whereas, each playing position has a significant variation in the physical demands depending on the tactical role and the physical capacity of the players (Mohr et al., 2003), midfielders, therefore, cover greater total distances and have higher VO_{2max} than defenders and strikers. Because they perform both defensive and offensive skills and are always required to make long run, the midfielders must have high level of aerobic fitness (Reilly and Thomas, 1976; Withers et al., 1982; Bangsbo et al., 1991; Bangsbo, 1994; O'Donoghue, 1998; Ekblom, 1999; Rienzi et al., 2000; Al'Hazzaa et al., 2001; Bloomfield et al., 2007). The defenders, on the other hand, covered less total distance and performed less high-intensity running than midfielders and strikers, which probably is closely related to the tactical roles of the defenders and their lower physical capacity (Bangsbo, 1994), as also was evident from the results of the Yo-Yo test.

The strikers covered a distance at a high intensity equal to midfielders, but performed more sprints than the midfielders and defenders (Davis et al., 1992; Mohr et al., 2003). In addition, the strikers did not perform as well as midfielders on the Yo-Yo test. Thus, it appears that the modern elite strikers need to have a high capacity to perform high-intensity actions repeatedly (Mohr et al., 2003).

Therefore, this ability of midfielders which can cover greater total distances than any other players in the other positions, probably, it seems that they must have more economy motion to save energy and perform higher intensity task. Hence, their level of muscle co-contraction is optimal or very little that due to move all segments close to best proximal - to - distal sequential pattern of segment motions of soccer instep kicking.

In anaerobic perspective of football, there are a few studies which have investigated different position in anaerobic performance. They showed that the midfielders were engaged in a significantly less amount of time standing still and shuffling, but they performed as many tackles and headers as the defenders and strikers (Mohr et al., 2003; Bloomfield et al., 2007). Midfielders covered a total distance and distance at a high-intensity similar to the full-backs and strikers. There was a variation in the distance covered a high intensity of 1.9 km among the midfielders in the same game (Mohr et al., 2003). However, midfielders sprinted less than full-backs and strikers. This result is not contrast to Bloomfield`s6 findings in FA league soccer players that the midfielders were engaged in a significantly most time of sprinting. These differences may be explained by the development of the physical demands of players in their position. Cochrane and Pyke (1976) found that the strikers had the fastest sprint times over 40 yards, a finding which is supported by the Mohr et al. (2003) study. The ability to perform short, fast sprints is fundamental to a striker, who needs to reach key goal-scoring positions in advance of defenders. Indeed, the importance of sprinting speed for all soccer players was highlighted by the study of Brewer and Davis (1991) who reported that the main physical difference between elite and non-elite soccer players was the faster sprinting times of the elite players.

Midfielders, in addition, significantly demonstrated inferior anaerobic power compared to strikers and defenders (Wisloff et al., 1998). Al'Hazzaa et al. (2001) and Davice et al. (1992) both reported that there was no significant difference between different position in peak power and average power, but midfielders' value was lowest. Arnason et al. (2004) and Davice et al. (1992) reported that there was no significant difference between different positions in leg extensor power but midfielders' value was lowest after goalkeepers, but there was higher knee flexion/knee extension ratio (H/Q ratio) in goalkeepers, defenders, midfielders and strikers, respectively. In addition, Oberg et al. (1984) showed a significantly higher knee extensor torque in goalkeepers and defenders than in strikers and on the other hand, the knee flexion/knee extension ratio was significantly higher for strikers compared to goalkeepers and defenders. Goalkeepers displayed a greater leg extension power, because the important tasks of a goalkeeper are to react and move quickly, to jump or dive to save or deflect shots, and to cover a large perimeter (Arnason et al., 2004). According to these studies, it appears that there are differences between researches in level of experienced and methods of measuring.

Based on these literatures, strikers and defenders must have faster instep kick than midfielders, because, they have more anaerobic power in leg extension which is a one of important motion during soccer instep kicking. In contrast, our result showed that there were significant differences between midfielders versus defenders and also between midfielders versus strikers in LM (Figure 2). Masuda et al. (2005) reported that there is no significant relation between soccer instep kicking with leg extension at free approach. Hence, this finding supports our result which showed midfielders performed a great value of moment in lower leg during leg extension.

One other posibility to support midfielders have faster instep kicks was due to study limitations. This reason ascribes to subjects' limitation which we were beyond our control selected number of players in each position, nutrition, motive, psychological problems and so on during and before kicking may have affected our result. On the other hand, the rapid development in soccer science, comparing one study to the other based on nationality and time of the year which the data was collected is made difficult. According to the findings of present studies and other study, we can have interesting and different result in compare to each other why these result are just relative to players who participated in these studies as subjects.

In summary, it has been proposed that the greatest physical demands during a game are imposed upon the midfield players due to the role which they play in 'linking' attacking and defensive. According to previous researches and their findings on physiological and physical demands of different position in soccer players, it seems that strikers should have stronger and faster instep kick in biomechanical perspective versus other position. Based on this study, midfielders' instep kicks have higher biomechanical responses and so they are faster than strikers and defenders' instep kick. It appears that midfielders, who have more forward movement and have more economy motion, can have better proximal - to - distal sequential pattern of segment motions of soccer instep kicking.

We concluded that midfielders, who cover greater total distances than any other players, can perform soccer instep kicking significantly faster than defenders. Furthermore, there is no significant difference between midfielders and strikers, but midfielders' ball velocity is higher than strikers. It seems that midfielders successes for instep kicking which must run forward to kick the ball rather than other position. Therefore, midfielders can kick the balls during competition in rebinds and free kick situation behind the penalty box and in front of the goalpost.

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