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Comparative Study of Female and Male Soccer Players in Kicking Motion

Keiko Sakamoto[a], Sungchan Hong[a], Yusuke Tabei [a],Takeshi Asai[b]

[a]*Graduate school, Institute of Health and Sport Science, University of Tsukuba, Tennoudai 1-1-1, Ibaraki, 305-8574, Japan*
[b]*Institute of Health and Sport Science, University of Tsukuba, Tennoudai 1-1-1, Ibaraki, 305-8574, Japan*

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Abstract

This study compares the male and female soccer players' technical characteristics of ball impact and swing motion before the impact in instep kicks and inside kicks. High-speed video cameras and 3D motion capture were used to examine the characteristics and mechanics of the kicks. During both types of kick, the female players exhibited lower ball velocity, foot velocity immediately before the impact, striking mass, and average ball-to-foot velocity ratio than the male players. The ball-to-foot velocity ratio decreased as the distance of the impact point from the foot's centre of gravity increased. The results of this study suggested that when training female players it is important to instruct them how to impact the ball near the foot's centre of gravity under a variety of conditions. Moreover, the female players exhibited lower inclination of hip and thigh immediately before the impact compared to the male players.

Keywords: Impact; female players; kicking; pelvis

1. Introduction

A number of studies have investigated the interaction between the ball and the foot during ball impact [1] and swing motion [2]. Identifying the technical mechanism of the impact would contribute to improve the performance. However, in the majority of cases, research that has been carried out focused on male soccer players; studies on the kicking action of female soccer players are scarce [3], [4]. The population of female players is increasing worldwide, and it is necessary to determine the technical characteristics of female players and the training methods suitable for them.

* Corresponding author. Tel.: +81-29-853-2711; fax: +81-29-853-2711.
E-mail address: s0930492@u.tsukuba.ac.jp.

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Because gender differences may affect kicking performance, the competitiveness of female players may be enhanced by providing training and coaching that is adapted to their characteristics. Accordingly, this study was designed to compare the ball impact and swing motion kinematics between female and male soccer players to deepen the knowledge of the mechanical and technical characteristics of female players. Accordingly, this study was designed to compare the ball impact and swing motion kinematics between female and male soccer players to deepen the knowledge of the mechanical and technical characteristics of female players.

2. Methods

2.1. Participants and Experimental Procedure

The participants consisted of 17 male soccer players (height: 172.0 ± 4.4 cm, weight: 65.7 ± 4.8 kg) and 17 female soccer players (height: 161.4 ± 4.5 cm, weight: 56.0 ± 3.4 kg). In total 34 athletes specializing in soccer at a university with a department of physical education participated in this study. The goals and the content of the experiment were explained to the participants beforehand and an informed consent was obtained. The participants were instructed to kick a placed soccer ball (FIFA-approved size 5 ball, weight: 430 g, pressure: 900 hp; Adidas, Herzogenaurach, Germany) with the dominant foot at full strength towards the goal (height: 2.44 m, width: 7.32 m). The kicking techniques used were the instep kick (a kicking action involving the instep) and the inside kick (a kicking action that scoops the ball with the inside surface of the foot, performed while the ankle is flexed) (Figure 1). The test kicks were recorded by 3 high-speed video cameras (FASTCAM 1024 PCI model 100KC, speed: 1000 Hz, exposure time: 1/5000 s, resolution: 1024 × 1024 pixels; Photron, Tokyo, Japan). A camera was installed on the right side (on the side of the kicking leg) and another was installed on the right-rear side with respect to the kicking direction, which recorded data synchronously (Figure 2). The third camera was set up normal to the swing plane of the kicking foot, and was used to measure the horizontal velocity of the foot. Moreover, VICON 3D motion capture (ten high-speed cameras, 250Hz) was used to analyse the swing motion. The three-dimensional motion of the ankle was measured using the direct linear transformation (DLT) method [5].

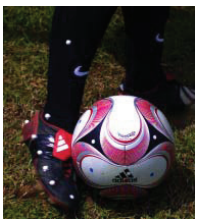
a)  b) 

Fig. 1. Location of impact on the foot [a = Instep kick, b = Inside kick]

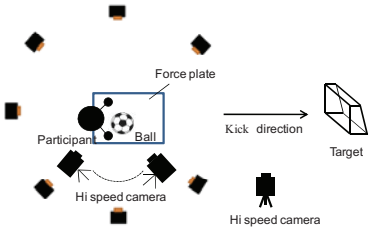


Fig. 2. Set-up of the experiment

2.2. Data Analysis

To investigate the dorsi-plantar flexion (∠a) and internal–external rotation (∠b) of the foot at impact, changes in the ankle angles were evaluated (Figure 3a, b). The positive and negative directions of rotation were extension (-)/flexion (+), internal rotation (+)/external rotation (-), and inversion (+).In addition, to investigate the angular displacement of pelvic lopsidedness (left flexion (+) / right flexion (-)) and hip joint angle (∠c), knee joint angle (∠d), thigh inclination (∠e), shank inclination (∠f) (Figure 3c, d). This study calculated the average foot velocity, the ball velocity, and the angular displacement for ankle joint

and swing motion. The ball velocity is defined as the average of five frames after the ball is detached from the foot, and the foot velocity was calculated one frame before the foot touches the ball. In addition, the difference between the maximum and minimum displacement of foot joint during the foot contact with the ball was defined as the angular displacement. Descriptive statistics were used to determine means and standard deviations. A two-way analysis of variance was performed to determine gender and kick difference.

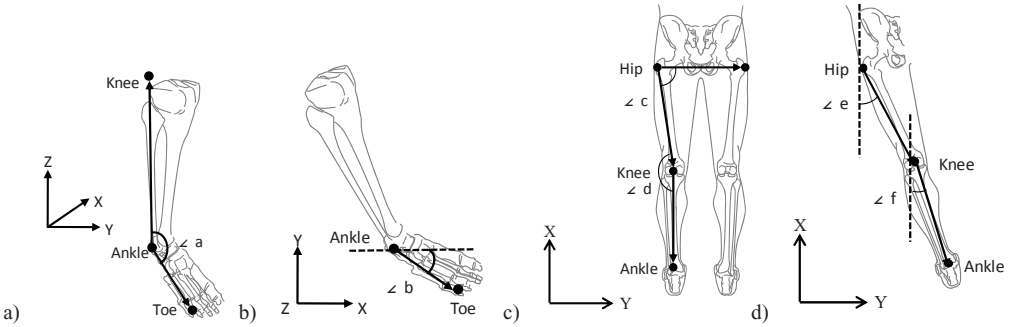


Fig. 3. Definition of angles [a = Dorsi-plantar flexion, b = Internal-external rotation, c = Joint angles of knee and hip, d = Inclination of thigh and shank]

3. Results and Discussion

3.1. Comparison of Male and Female Players

The average ball velocity for the female players' instep kick was 22.0 ± 2.6 m/s and 19.0 ± 2.1 m/s for the inside kick, compared to the male players scoring 26.6 ± 2.6 m/s for the instep kick and 21.9 ± 2.0 m/s for the inside kick. Thus, the average ball velocity of the female players was 17% lower than the male players for the instep kick and 13% lower for the inside kick, both of which were significantly different ($p < 0.05$).

For the female players, the average foot velocity just before impact was 18.0 ± 1.8 m/s for the instep kick and 14.0 ± 1.3 m/s for the inside kick. One reason for this difference might be that compared to the swing of the inside kick, the extension action of the leg in the swing of the instep kick is easier. In this study, the average foot velocity of the instep kick for the female players was approximately 1.8 m/s higher than that (16.2 ± 2.3 m/s) for female players reported by Barfield et al. (2002). Compared to the female participants in the present study the status of the players in Barfield et al. (2002) were elite players. Although this effect is considered to have been small. In the present study, the foot velocity of the female players immediately prior to impact was approximately 12% lower than the males for the instep kick and approximately 10% lower for the inside kick, both of which were significantly different ($p < 0.05$). These results are thought to be reflective of gender differences in physical characteristics such as leg extension power, as well as differences in swing technique.

The average striking mass of the female players in this study was lower than that of the male players for both instep and inside kicks ($p < 0.05$). This can be attributed primarily to the differences in muscle mass and body type, represented by body height and weight. In addition, the striking mass is a relatively abstract mechanical quantity and is thought to be affected by the posture and the fixity of the joint during impact. The average ball-to-foot velocity ratio of the instep kick was 1.23 ± 0.16 for the female players and 1.31 ± 0.18 for the male players, a 6% lower value for the female players that was significantly different ($p < 0.05$). The significant difference in ball-to-foot velocity ratios for the instep kick between

males and females in the present study may have been due to the locking of the ankle joint of the female players at impact being less than that of the male players.

The average value of the inside kick was slightly lower for the female players than for male players (1.37 ± 0.14 vs. 1.41 ± 0.16, respectively), but the difference was not significant. Comparing this average value to that for the instep kick, the ball-to-foot velocity ratio of the inside kick had a tendency to be larger. However, this analysis compared only the average values of the instep kick and the inside kick, and differences in ball impact location are expected to have a large effect on the ball-to-foot velocity ratio. Consequently, an investigation of the relationship between ball-to-foot velocity ratio and ball impact location would be valuable.

The mean angular displacement for dorsi-plantar flexion during instep kicks tended to be lower in male players than that in female players. Similarly the values found during inside kicks tended to be slightly lower in male players than in female players. However, the gender differences in the mean values during instep kicks and inside kicks showed no statistical significance. The mean angular displacement for internal and external rotations during impact tended to be higher in female players than in male players during both instep and inside kicks. However, no statistically significant difference was found.

3.2. Relationship between the Ball-to-Foot Velocity Ratio and the Impact Point

The ball-to-foot velocity ratio near the centre of gravity for the instep kick was ~1.35 for the female players (the *y*-intercept of the quadratic regression curve), which was slightly lower than ~1.45 for the male players (Figure 4a, b).

From these results, it can be inferred that kicking technique has a greater effect than the mechanical properties of the ankle joint on the tendency of the lower ball-to-foot velocity ratio at impact among the female players.

Looking at the overall relationship between impact distance and ball-to-foot velocity ratio for the instep and inside kicks of the male and female players, for all of the test kicks, a trend was found for the ball-to-foot velocity ratio to be higher near the centre of gravity of the foot and it also decreases with increasing distance. This may be due to the moment around the centre of gravity that arises with increasing distance from the centre of gravity of the foot, and therefore, a lower amount of energy is transmitted to the translational motion of the ball. Consequently, it is conceivable that for both male and female players and for both the instep and inside kicks, impacting the ball at the centre of gravity of the foot is an important technical point, as it increases the ball-to-foot velocity ratio.

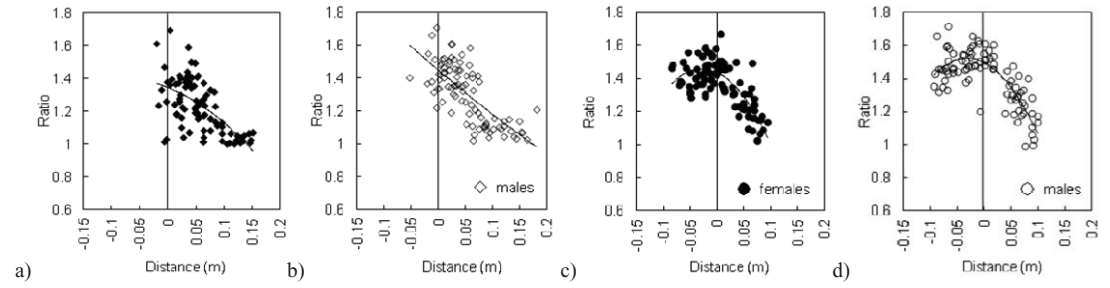


Fig. 4. Relationship between the impact distance and ball-to-foot velocity [a = the instep kick of female; b = the instep kick of male; c = the inside kick of female; d = the inside kick of male]

3.3. Angular displacement of pelvic motion (pelvic lopsidedness)

Referring to the angular displacement of pelvic lopsidness in instep kicks, left flexion was a trend for male players' pelvis. Otherwise, the female's pelvis tended to right flexion just for impact. This can be considered as the typical characteristics of kicking action in female (Figure 5a). Moreover, looking at the angular displacement of pelvic lopsidness in inside kicks, there was a trend of left flexion for both male and female players (Figure 5b).

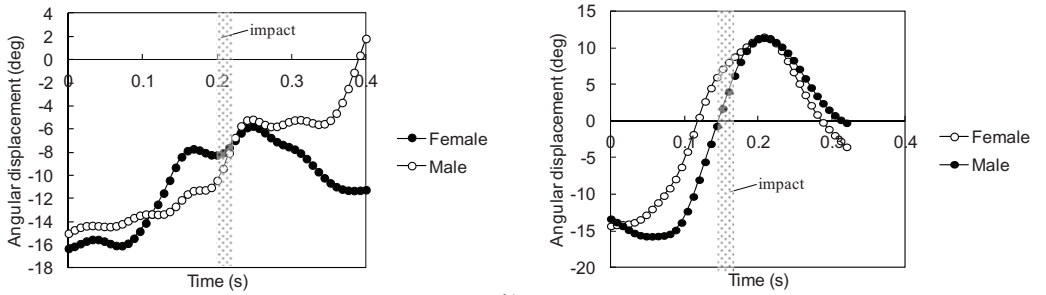


Fig. 5. Examples of Angular displacement of pelvic lopsidedness for female and male players [a = instep kick; b = inside kick]

3.4. Joint angles of Lower body and inclination of plant leg immediately before the impact

Figure 6a, c shows the average angles of the hip and knee joint immediately before the impact of instep and inside kicks. The average the average angles of the hip joint immediately before the impact for the female players' instep kick was 60.4 ± 5.3° and 46.5 ± 7.6° for the inside kick, compared to the male players scoring 72.3 ± 9.4° for the instep kick and 52.5 ± 8.6° for the inside kick. The average the average angles of the knee joint immediately before the impact in instep kicks by female players was 166.9 ± 5.5°, and that in inside kicks was 155.8 ± 8.2°. In contrast, the values for male players were 175.5 ± 7.9° for the instep kick and 157.4 ± 4.6° for the inside kick. Referring to the plant leg's knee and hip joint angles, no significance was found in knee joint angle between male and female players. However, female players scored smaller hip joint angle and this difference was found significant.

Figure 6b, d shows the average inclination of thigh and shank joint immediately before impact for instep and inside kick. The average inclination of thigh joint immediately before impact for the female players' instep kick was 40.1 ± 5.0° and 39.4 ± 4.1° for the inside kick, compared to the male players scoring 32.3 ± 5.2° for the instep kick and 37.8 ± 5.8° for the inside kick. The average inclination of shank joint immediately before impact in instep kicks by female players was 27.0 ± 4.4°, and that in inside kicks was 15.2 ± 5.7°. In contrast, the values for male players were27.8 ± 3.2° for the instep kick and 15.2 ± 3.2° for the inside kick. Referring to the plant leg's thigh and shank joint inclination, no significance was found in shank joint inclination between male and female players. However, female players scored smaller thigh joint inclination this difference was found significant. It is thought that the pelvis width for female players is wider than for male players and Q-angle (the angles formed where a line that links the center of ASIS and a kneecap and a line that links the center of a tibial tuberosity and a kneecap) is high influenced the differences of swing motion between female and male. Female players impact the ball in a way which seems typical to females.

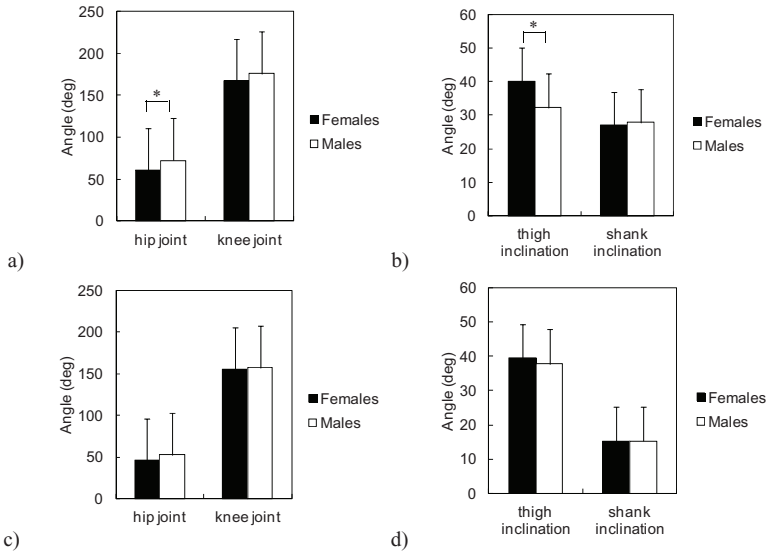


Fig. 6. Comparison of joint angles of plant leg for female and male players [a = Angles of hip and knee joint before impact for instep kick, b =Inclination of thigh and shank for instep kick; c = Angles of hip and knee joint before impact for inside kick, d = Inclination of thigh and shank for inside kick]. The bars and asterisks represent significant differences between males and females ($^{*}p < .05$); significant differences between kicks are not shown on the graphs

4. Conclusion

This study was designedwto compare the ball impact and swing motion kinematics between female and male soccer players to extract the mechanical and technical characteristics of female players.

For the instep and inside kicks, the ball velocity, foot velocity immediately prior to impact, and average ball-to-foot velocity ratio were smaller for the female players than for the male players. For both kicks for males and females, there tended to be a lower ball-to-foot velocity ratio the further the impact point was from the centre of gravity of the foot. The mechanical properties of the ankle joint of female players during the instep kick may involve slightly lower dynamic stiffness than that of the male players. In addition, the lower dynamic stiffness of the ankle joint of female players is believed to have a comparatively greater effect on the instep kick, suggesting that acquisition of the technique of impacting the ball with the centre of gravity of the foot is even more important. This study analyzed only the moment of ball impact, and to investigate gender differences in more detail, it will be necessary to analyze the entire kicking action.

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