SPORT TK-EuroAmerican Journal of Sport Sciences

https://revistas.um.es/sportk Online ISSN: 2340-8812

Received: **20/09/2021.** Accepted: **21/11/2021.** Published: **30/04/2022**

A comparative study of instep kicking swings, ball impacts, and ball speeds in male and female football players

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ABSTRACT

This research aims to compare swings, ball impacts, and ball velocities of instep kick between male and female players. The research used comparative design method, in which two groups of males and females were compared. This research used eight Indonesian football players as sample: four males and four females. The instrument used for data collection in this research is football long pass test. Video documentation was taken with high-speed camera unit with 1000 fps ability. The data collected were then analyzed through Kinovea, in which swing angles, foot angular velocities, ball impact times, ball velocities, and resulting ball distances were calculated. Non-parametric Mann-Whitney test were used to compare each instep kick of male and female players. Results show that no difference on instep long pass swing and ball impact between male and female players was observed. On average, male players performed instep kicking with kicking foot knee flexion angle of 104.75^0, hip angle of 77.25^0, kicking foot knee extension angle of 158^0, kicking foot steepness angle of 58.25^0, average power of 209.38 J/s (watt), and average kicking foot angular velocity of 0.11 rad/s, which resulted in average ball impact of 10.27 Ns that caused average post-impact ball velocity of 22.83 m/s and average ball distance of 26.63 meters. Meanwhile, female players performed instep kicking with kicking foot knee flexion angle of 93^0, hip angle of 74.25^0, kicking foot knee extension angle of 148^0, kicking foot steepness angle of 56.25^0, average power of 237.28 J/s (watt), and average kicking foot angular velocity of 0.11 rad/s which resulted in average ball impact of 10.32 Ns that caused average post-impact ball velocity of 22.94 m/s and average ball distance of 26.87 meters. The results show that the average ball distance of male players was closer to 25-meter target than those of female players. In order to achieve 25-meter kicking accuracy, female players contributed greater power and steeper kicking foot angle than their male counterparts. In conclusion, to master instep

kicking technique, female players need to pay attention to their power and body position during kicking.

KEYWORDS

Swing; Ball Impact; Ball Velocity; Instep Kick; Football

1. INTRODUCTION

Kicking skill is not easily achievable. In order to be able to do it correctly, players need huge technical skill expertise. It should be noted that most kicks are done by using instep kick or side foot kick technique (Rada et al., 2019). The foot parts used to kick the ball should be able to be utilized optimally according to the needs. It is because each foot part has different functions and objectives in doing football kick. Therefore, in doing kicking, one should have several considerations. Of all techniques used to score goals in football, a maximal instep kick is one of the techniques frequently used (Shan et al., 2019). Instep kick technique is a football technique which provides great contribution in football game. It is the most common technique when a shot or a long pass is needed. Hence, a player should be able to do instep kick well and correctly. To obtain good instep kick ability, every footballer should be able to do abilities involving leg swings, trunk rotations (or twists), and arm movements. A good instep kick technique also needs linear velocity, angle velocity, shank and thigh acceleration, angle momentum, power, and impulse during its implementation (Adesida, Papi, & McGregor, 2019).

This study investigates interaction between ball and foot during ball impact and swing movements. Foot velocity gives efficient impact to the ball. Most of the previous studies in this field observed male players. Players control their leg swings in the context of continuous system from segmental, proximal, to distal and add some fine tunings from the resultant ball velocity by changing ball impact force (Nunome, Inoue, Watanabe, Iga, & Akima, 2018). Kinetic movement (resultant angle impulse from joint and moment interaction) is clearly identified in proximal and distal segments in responding to the three levels of work targets, which supports final distal velocity on the controlled foot, in the context of continuous system from segmental, proximal, to distal. Players tend to kick the ball in the lower surface area than the ball center and more on the medial side of the foot by using a slightly upright foot position (Nunome, Inoue, Watanabe, Iga, & Education, 2018). Meanwhile, the usage of this technique among female players is found to be very minimal, let alone the comparison of kicking technique mechanisms between male and female players. The existence of

women's football club becomes an urge to determine the appropriate characteristics of kicking technique or practice for female players, since sex and gender differences can influence kicking performance.

There are significant differences between male and female players related to ball kicking movement, namely in lower extremity alignment and muscle activation (Brophy et al., 2010). Male players activate certain hip and muscles during instep kick movements more intensively compared to their female counterparts. By analyzing football kick movement in detail, differences in instep kicking based on sex and gender can be understood. Male players activate hip flexors (inside the hip) during kicking and hip abductors (outside the hip) for foot support more intensively compared to their female counterparts (Hides, Oostenbroek, Franettovich Smith, & Mendis, 2016). Hip abductor activation can help protect players from injury. Kicking foot's hip extension in male players were found to be greater than their female counterparts, which were done when the supporting foot touched the ground and the precise moment before ball impact and which impact ball velocity achieved soon after kicking (Navandar, Garcia, Veiga, Torres, & Navarro, 2013). Pelvic acceleration was found to be greater in male players than their female counterparts (Ruscello et al., 2020). Since female players tend to have less activation, their hips tend to be steep during kicking which can increase burden on the knee joints and consequently increase the potentials of injury. This study is designed to compare swing kinematic movement, ball impact, and post-impact ball velocity between male and female players to deepen understanding on the biomechanics of the male and female players' kicking technique.

2. LITERATURE REVIEW

2.1. Football long pass

Long pass refers to the effort of maintaining ball possession by maneuvring in the field between one player and his/her teammates with the objective of advance movements (Ganesh, Sri Teja, Munnangi, & Rama Murthy, 2019). Long pass can be defined as an act of directing the ball to one of the controlling player's teammates to position the ball in a favorable condition against their opponent. It is a ball kicking technique for passing the ball to one's teammates. The long pass technique widely used by players and has the most accuracy is performed by using inner foot. There is wider area in inner foot for the players to kick the ball which give better ball control. In addition, inner foot is the more appropriate surface to perform long passes. The basic principles of football kicking with inner foot are found in the supporting foot, the kicking foot, part of the ball surface

kicked, body position, and eye sight. The supporting foot position determines ball direction. The correct foot movement during ball kicking consists of lifting the kicking foot backwards and positioning it to transverse perpendicularly to the target or to the supporting foot, then swinging it towards the inner foot, causing contact to the center surface of the ball. In performing this, players must have their bodies tilted frontwards with their arms open to the side of their bodies to maintain balance. Foot-to-ball contact accuracy is important to the kicking result perfection. The part of the ball kicked is highly influential to the ball direction.

2.2. Biomechanics of football instep long pass

Biomechanics is the scientific discipline studying human movement in performing a movement technique (Márquez, Vargas, Palencia, Castillo, & Arévalo, 2018). It uses concepts of physics and engineering to explain movements on various body parts and the force working on them during the movements. Biomechanical elements related to ball kicking movement are power, velocity, fore, energy system, and hormones. The factor playing the most important role in football is the power of hamstrings and quadriceps in running, jumping, and ball kicking (Peek, Gatherer, Bennett, Fransen, & Watsford, 2018). The power in question is muscular power. Muscles which have strong power included *quadriceps femoris* and *gluteus maximus*. The higher the leg swing velocity before touching the ball is, the shorter the foot-to-ball contact time will be, resulting in higher ball velocity. In general, the steps of ball kicking movement are as follows: the supporting foot is placed slightly behind the ball. The kicking foot is swung backwards and its knee is flexed. Leg swing causes action-reaction on the opposite arms, in accordance with Newton's third law or more popularly known as action-reaction law which states that if a certain body part produces force to the other body parts, two similarly-sized forces will emerge, namely the force which runs in the same direction and that which runs in the opposite direction. Leg swing is followed by pelvic rotation around vertical axis of the supporting foot and the upward movements of the kicking foot thigh while the kicking foot knee is still extended. When close to touching the ball, the thigh slows down its movement.

a) Swing: The main factor influencing kicking foot velocity is the hip rotation and the subsequent hip extension and ankle flexion right before contact with the ball (Aziz & Bylbyl, 2019). This is because the hip angle allows the leg to be tilted to the frontal plane with respect to the ball when the supporting foot is slightly flexed. When leg swings from lateral to medial plane, the pelvis experience transversal rotation of vertical axis and frontal rotation of anterior-posterior axes,

followed by body bending. The impact of this multiplanar involvement is the occurrence of greater action-reaction in accordance with Newton's third law.

b) Ball contact: The foot position during ball kicking is highly important to the kick's success. The desired foot positions are ankle plantar flexion, hip abduction, and foot eversion. Foot angular velocity influences change of ankle plantar flexion during impact (Peacock & Ball, 2019).
c) Ball velocity: There is a linear relationship between foot angular velocity and ball velocity. The foot angular velocity is a combination of hip rotation and flexion power of hips & quadriceps. The highest ball velocity occurs when the ball is impacted with the part of the foot closest to the ankle, meaning that dorsiflexion at the end of the impact does not cause performance improvement. Ball velocity increases when impact position on the foot moves in a distal manner due to the increasing velocity of impact point on foot while moving further from the axis of rotation (the knee) (Peacock & Ball, 2019).

3. METHODS

3.1. Design and participants

This reseearch used comparative method. The sample consisted of eight Indonesian football players, namely four male players (average height and weight of 168 cm and 65.1 kg respectively) and four female players (average height and weight of 166 cm and 64.5 kg respectively).

3.2. Procedures

Participants were instructed to perform instep long pass. Long pass test was conducted by positioning the ball in dead ball position. The players were instructed to perform long ball pass bola to a circle target with the diameter of 4 meters, positioned at a distance of 25 meters from the ball position (Padrón-Cabo, Rey, Pérez-Ferreirós, & Kalén, 2019). Kicking tests were recorded by using two 1000 fps high-speed camera which were positioned at the right side of the kicking foot and at the area related to the kicking direction. Cameras were used to understand the kicking leg swing and velocity. Then, Kinovea software was used to analyze swing angle. This study calculated the average swing angle, foot angular velocity, ball impact, ball velocity, and ball distance. Ball velocity was calculated starting from the moment after the ball was off the feet. Foot velocity was calculated

starting from the moment before the foot touched the ball. Hip angle was defined as the angle of the shift from backswing to frontswing stage during contact with the ball.

3.3. Statistical analyses

Kolmogorov-Smirnov test was used for data normality test with $p < 0.05$. The data were found to be not distributed normally, so that non-parametric Mann-Whitney test was conducted to compare the differences of instep kick between male and female players. Significance of $p < 0.05$ was determined. Data analysis were conducted through SPSS 16.

4. RESULTS

4.1. Data description

Table 1 shows the description of instep kick data difference between male and female players. It shows that there was no difference found on the swing and ball impact of instep long pass between male and female players. On average, male players performed instep kicking with kicking foot knee flexion angle of 104.75^0, hip angle of 77.25^0, kicking foot knee extension angle of 158^0, kicking foot steepness angle of 58.25^0, average power of 209.38 J/s (watt), and average kicking foot angular velocity of 0.11 rad/s which resulted in average ball impact of 10.27 Ns that caused average post-impact ball velocity of 22.83 m/s and average ball distance of 26.63 meters. Meanwhile, female players performed instep kicking with kicking foot knee flexion angle of 93^0, hip angle of 74.25^0, kicking foot knee extension angle of 148^0, kicking foot steepness angle of 56.25^0, average power of 237.28 J/s (watt), and average kicking foot angular velocity of 0.11 rad/s which resulted in average ball impact of 10.32 Ns that caused average post-impact ball velocity of 22.94 m/s and average ball distance of 26.87 meters. The results show that the average ball distance of male players was closer to 25-meter target than those of female players.

Table 1. Data description

Variables		Male	Female	p
Swing	Kicking foot knee flexion angle	104.75^0	93^0	0.144
	Hip angle	77.25^0	74.25^0	0.773
	Kicking foot knee extension angle	158^0	148^0	0.486
Ball impact	Foot angular velocity	0.11 rad/s	0.11 rad/s	0.766
	Post-impact ball velocity	22.83 m/s	22.94 m/s	0.885
	Kicking foot steepness angle	58.25^0	56.25^0	0.309
	Ball impact	10.27 Ns	10.32 Ns	0.885
	Power	209.38 J/s (watt)	237.28 J/s (watt)	0.773
Ball distance		26.63 m	26.88 m	0.773

4.2. Instep kick movement analysis

a. Swing phase

1) Male players

Figure 1. Sample 1 swing movement

Figure 1 shows Sample 1 when he performed swing movement with 94^0 backswing angle, 79^0 hip angle, and 157^0 frontswing angle.

Figure 2. Sample 2 swing movement

Figure 2 shows Sample 2 when he performed swing movement with 116^0 backswing angle, 96^0 hip angle, and 155^0 frontswing angle.

Figure 3. Sample 3 swing movement

Figure 3 shows Sample 3 when he performed swing movement with 103^0 backswing angle, 61^0 hip angle, and 178^0 frontswing angle.

Figure 4. Sample 4 swing movement

Figure 4 shows Sample 4 when he performed swing movement with 106^0 backswing angle, 73^0 hip angle, and 142^0 frontswing angle.

2) Female players

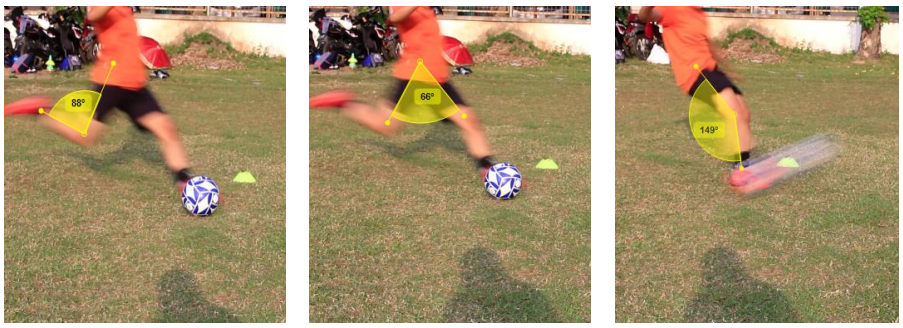

Figure 5. Sample 5 swing movement

Figure 5 shows Sample 5 when she performed swing movement with 88^0 backswing angle, 66^0 hip angle, and 149^0 frontswing angle.

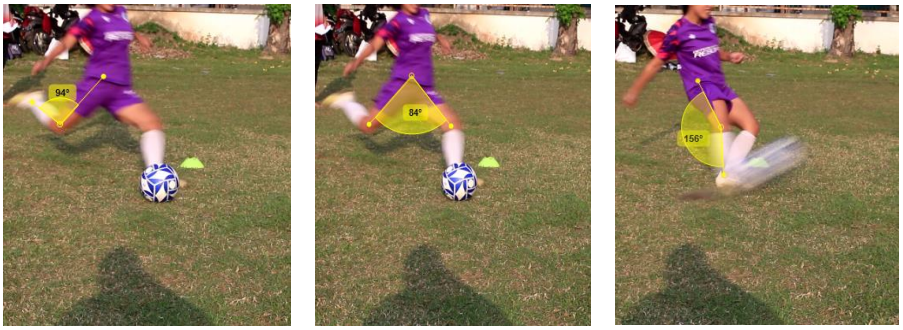

Figure 6. Sample 6 swing movement 6

Figure 6 shows Sample 6 when she performed swing movement with 94^0 backswing angle, 84^0 hip angle, and 156^0 frontswing angle.

Figure 7. Sample 7 swing movement

Figure 7 shows Sample 7 when she performed swing movement with 84^0 backswing angle, 70^0 hip angle, and 157^0 frontswing angle.

Figure 8. Sample 8 swing movement

Figure 8 shows Sample 8 when she performed swing movement with 106^0 backswing angle, 77^0 hip angle, and 130^0 frontswing angle.

b. Foot-to-ball contact phase

1) Male players

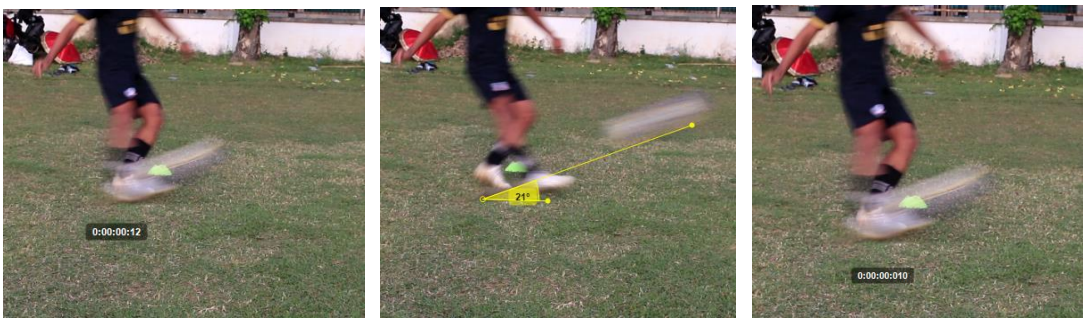

Figure 9. Foot-to-ball contact of Sample 1

Figure 9 shows the contact of Sample 1's foot with the ball, in which swing time, impact time, and elevation angle were measured to be 12 seconds, 1 second, and 21^0 respectively.

Figure 10. Foot-to-ball contact of Sample 2

Figure 10 shows the contact of Sample 2's foot with the ball, in which swing time, impact time, and elevation angle were measured to be 12 seconds, 1 second, and 19^0 respectively.

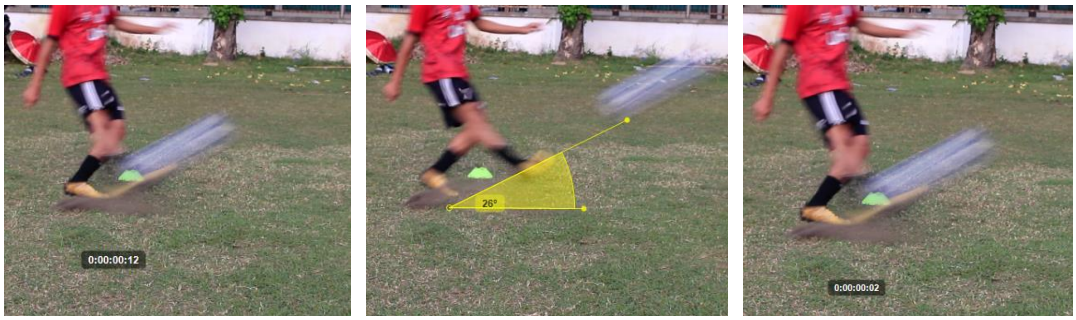

Figure 11. Foot-to-ball contact of Sample 3

Figure 11 shows the contact of Sample 3's foot with the ball, in which swing time, impact time, and elevation angle were measured to be 12 seconds, 2 second, and 26^0 respectively.

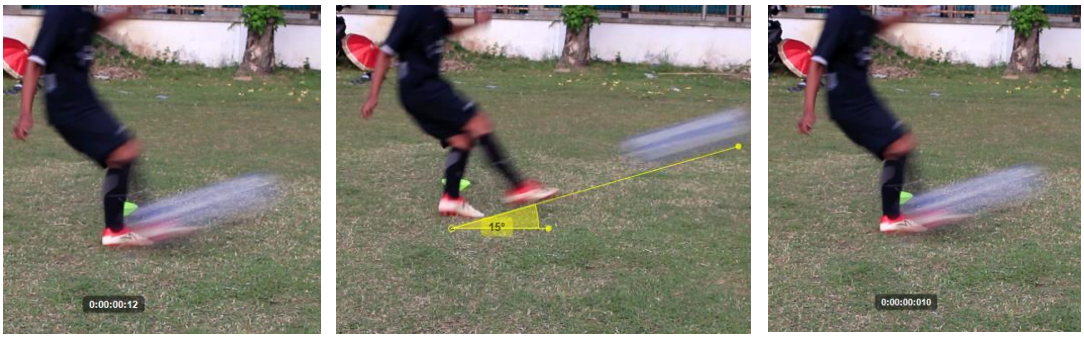

Figure 12. Foot-to-ball contact of Sample 4

Figure 12 shows the contact of Sample 4's foot with the ball, in which swing time, impact time, and elevation angle were measured to be 12 seconds, 1 second, and 15^0 respectively.

2) Female players

Figure 13. Foot-to-ball contact of Sample 5

Figure 13 shows the contact of Sample 5's foot with the ball, in which swing time, impact time, and elevation angle were measured to be 12 seconds, 1 second, and 21^0 respectively.

Figure 14. Foot-to-ball contact of Sample 6

Figure 14 shows the contact of Sample 6's foot with the ball, in which swing time, impact time, and elevation angle were measured to be 12 seconds, 1 second, and 25^0 respectively.

Figure 15. Foot-to-ball contact of Sample 7

Figure 15 shows the contact of Sample 7's foot with the ball, in which swing time, impact time, and elevation angle were measured to be 12 seconds, 1 second, and 20^0 respectively.

Figure 16. Foot-to-ball contact of Sample 8

Figure 16 shows the contact of Sample 8's foot with the ball, in which swing time, impact time, and elevation angle were measured to be 12 seconds, 1 second, and 22^0 respectively.

c. Body position

1) Male players

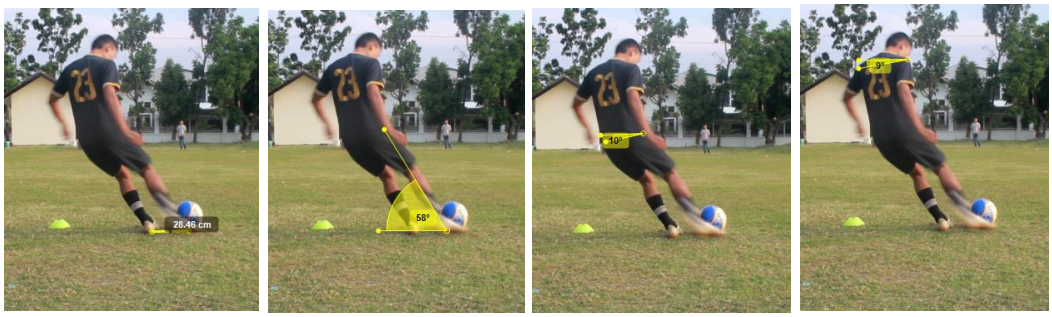

Figure 17. Body position of Sample 1 during instep kick

Figure 17 shows Sample 1's body position during instep kick, with the supporting-foot-to-ball of 28.46 cm, the kicking foot steepness angle of 58^0, the hip steepness angle of 10^0, and the shoulder steepness angle of 9^0.

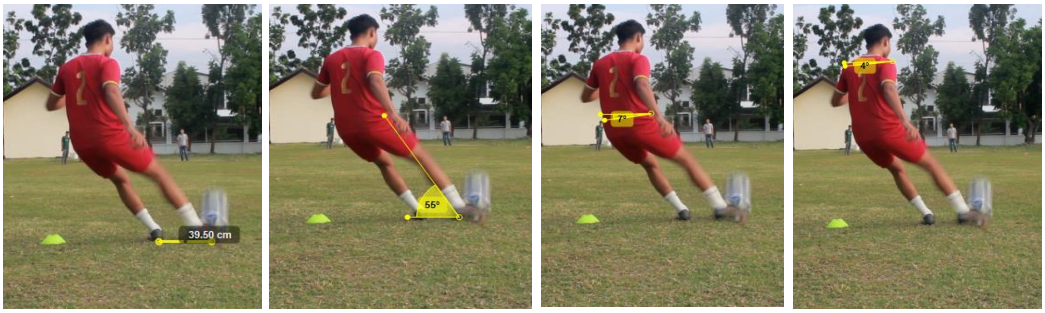

Figure 18. Body position of Sample 2 during instep kick

Figure 18 shows Sample 2's body position during instep kick, with the supporting-foot-to-ball of 39.50 cm, the kicking foot steepness angle of 55^0, the hip steepness angle of 7^0, and the shoulder steepness angle of 4^0.

Figure 19. Body position of Sample 3 during instep kick

Figure 19 shows Sample 3's body position during instep kick, with the supporting-foot-to-ball of 35.57 cm, the kicking foot steepness angle of 56^0, the hip steepness angle of 16^0, and the shoulder steepness angle of 6^0.

Figure 20. Body position of Sample 4 during instep kick

Figure 20 shows Sample 4's body position during instep kick, with the supporting-foot-to-ball of 19.37 cm, the kicking foot steepness angle of 64^0, the hip steepness angle of 8^0, and the shoulder steepness angle of 6^0.

2) Female players

Figure 21. Body position of Sample 5 during instep kick

Figure 21 shows Sample 1's body position during instep kick, with the supporting-foot-to-ball of 34.53 cm, the kicking foot steepness angle of 67^0, the hip steepness angle of 11^0, and the shoulder steepness angle of 9^0.

Figure 22. Body position of Sample 6 during instep kick

Figure 22 shows Sample 6's body position during instep kick, with the supporting-foot-to-ball of 39.43 cm, the kicking foot steepness angle of 49^0, the hip steepness angle of 10^0, and the shoulder steepness angle of 11^0.

Figure 23. Body position of Sample 7 during instep kick

Figure 23 shows Sample 7's body position during instep kick, with the supporting-foot-to-ball of 37.86 cm, the kicking foot steepness angle of 54^0, the hip steepness angle of 9^0, and the shoulder steepness angle of 4^0.

Figure 24. Body position of Sample 8 during instep kick

Figure 24 shows Sample 8's body position during instep kick, with the supporting-foot-to-ball of 34.56 cm, the kicking foot steepness angle of 55^0, the hip steepness angle of 9^0, and the shoulder steepness angle of 11^0.

5. DISCUSSION

Association football (football/soccer) is a ball game performed by two teams with eleven players each including the goalkeeper. The core of a football game is the players' movement. Players moved to perform throwing, running, kicking, dribbling, and heading. Ball kicking is the basic football-playing technique often used in a football game. A resilient football team is a football team whose all players master basic techniques of football kicking well. Instep kick is a football technique which has great contribution in a football game. Previous research stated that of all analyzed passing, 14.6% was performed by using inner instep kick and 9.1% was performed through instep kick (Mitschke & Milani, 2014). This type of kick is often used for its power and maximum distance, to directly shoot at the goalpost or to perform long passes. Kicking accuracy is influenced by target size and distance, movement velocity, and the movement's own technique. Kicking movement technique is presented based on each phase of kicking movement that can be studied through biomechanics. In biomechanics, kicking phase is started from swing phase, consisting of backswing and frontswing, which influences kicking performance result. Kicking performance lies on two main factors: kicking result and ball velocity. This research focuses on the instep kick performance in the form of kicking accuracy to the target situated at 25 meters from the ball position. Results show that there was no difference in instep kick between male and female players. However, when looked from the average ball distance, kicking results from male players were closer to the determined target distance. On average, male players were able to kick the ball as far as 26.3 meters while their female counterparts were able to kick the ball as far as 26.87 meters. Several factors affecting kicking accuracy were found in swing movement performed by the platers and the size of foot-to-ball impact.

In relation to swing movement, flexion and extension angles of kicking foot knee and hip angle influenced post-impact ball movement. In this research, it was found that male players have greater flexion and extension angles of kicking foot knee and hip angle than their female counterparts. On average, the flexion and extension angles of kicking foot knee and the hip angle in male players were 104.75^0, 158^0, and 77.25^0 respectively, while those in female players were 93^0, 148^0, and 74.25^0 respectively. Swing movement on hip joints contributed to body stabilization. Rotation on hip joint occurs from the back kicking foot take-off to its upward swing which causes flexion on the kicking

foot knee and frontward swing to occur. This starting position aims to gather velocity for kicking until the foot come close to the side of the ball which can give support to the ball impact and speed.

In relation to the size of foot-to-ball impact, the law of conservation of momentum played a role in this condition. The theory states that there is linear relation between foot contact and ball velocity. The greater the impact is, the greater the ball velocity will be. Meanwhile, impact size was influenced by the kicking foot's swing velocity. In this research, the average foot angular velocity between male and female players was found to be similar while the average of ball impact of female players, amounting to 10.32 Ns, was found to be greater than that of male players which amounted to 10.27 Ns. This research shows that the difference in ball impact was influenced by kicking foot steepness angle and power. Female players took a steeper position than their male counterparts. The average kicking foot steepness angle in female players was 56.25^0, while that in male players was 58.25^0. In addition, the average power contributed by female players, amounting to 237.28 J/s (watt), was greater than that by male players which amounted to 209.28 J/s (watt). Based on this research, to achieve 25-meter kick accuracy, female players contributed greater power and steeper kicking foot angle compared to their male counterparts.

6. CONCLUSION

This research is designed to compare the kinematics of instep long pass between male and female football players. Based on this research, to achieve 25-meter kick accuracy, female players contributed greater power and steeper kicking foot angle compared to their male counterparts. This shows that, in mastering instep kicking technique, female players need to pay attention to their power and body position during kicking.

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AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research received no external funding.

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