American Journal of Applied Sciences 7 (10): 1334-1340, 2010
ISSN 1546-9239

Kinematic Comparison of Successful and Unsuccessful Instep Kick in Indoor Soccer

[1]Naghme Gheidi and [2]Heydar Sadeghi
[1]Department of Physical Education and Sport Sciences,
Azad University, Saveh Branch, No 16, Salman Alley, Pourebtehaj Street,
Bahounar Avenue, Tehran, P. O. Box 19865-54713, Iran
[2]Department of Physical Education and Sport Sciences,
Tarbiat Moallem University, Tehran, Iran

Abstract: Problem statement: Kicking is one of the most important skills in indoor soccer. Kicking accuracy is an important component of this skill. The instep kick is often used when tacking a penalty kicks, as a combination of increased ball speed and kick accuracy can be maintained. The purpose of this research was to compare selected kinematic parameters of the kicking foot during the performance of successful and unsuccessful penalty kick from a 6 m distance. **Approach:** Fourteen right footed elite players (seven males and seven females) with an average age of 23±1.7 and 23±2.4 years, height of 182.2±4.73 and 160.7±4.84 cm, weight of 72.4±4.04 and 53.7±4.33 Kg respectively, were selected. For sampling, a kinemetrix 3D motion analyzer with 3 cameras (50 Hz), was used. In the center of the indoor soccer gate a target with a 1 meter radius was marked. The kinematic parameters of successful and unsuccessful kicks were compared by using independent t-test. The level of significance was set to $\alpha = 0.05$. **Results:** The results of analysis showed that the values of maximum linear velocity of ankle, knee, the mean value of velocity prior to the kick, angle of the ankle and mean value of angular velocity of the shank and thigh in women before the kick and, the linear velocity of toe, ankle, angular velocity of shank, thigh at the time of impact, the maximum and mean value of velocity in follow through in men before the kick was significantly higher in the unsuccessful kicks than the successful ones. **Conclusion:** Accurate kicks have lower linear as well as angular velocity compared to the unsuccessful kicks. However, these differences are more pronounced before the kick in women at the time of impact and after the kick in men.

Key words: Kinematic, instep kick, indoor soccer, kinemetrix 3D motion

INTRODUCTION

Indoor soccer is a derived version of soccer that compared to soccer places a greeter premium on ball control. This sport is international and recognized by FIFA as a great skill developer. Kicking is the most offensive technique in the game and the team which executes more successful kicks at the intended target is more likely to win the game (Kellis and Katis, 2007). There are various types of kick among which instep kick has the highest rate of applications since it is highly accurate and quick to perform (Barfield *et al*., 2002) and is very often used for penalty kicks (Scurr and Hall, 2009).

The precision and accuracy of a kick is an important part of indoor soccer skill. Precision can be defined as the ability to kick the ball toward a specific target (Scurr and Hall, 2009). Numerous biomechanical researches has been conducted to evaluate the precision of instep kick, however, there are insufficient research findings in regard to the precision versus power of kicks (Kellis and Katis, 2007). For example, Wesson (2002) reported that the precision of a kick can be determined by recording the angle between the direction of the kick and the desired direction. Godik *et al.* (1993) determined that kicking accuracy depends on how fast the player approaching the ball (Kellis and Katis, 2007). Lees and Nolan (1998) concluded that there is a decrease in ball speed, linear as well as angular velocity of the joints during accurate kick compare to the powerful kicks. These authors attributed this change to the decrease in the range of motion of hip, knee and

Corresponding Author: Naghme Gheidi, Department of Physical Education and Sport Sciences, Azad University, Saveh Branch, No 16, Salman Alley, Pourebtehaj Street, Bahounar Avenue, P.O. Box 19865-54713, Tehran, Iran Tel: 00989122040942

ankle joints (Lees and Nolan, 2002). Teixeira (1999) also conducted a research in which the biomechanical characteristics of accurate kicks were contrasted with imprecise kicks and concluded that target setting causes reduction in the speed and duration of movement (Teixeira, 1999). Dichiera *et al*. (2006) compared the kinematic of lower extremities of the individuals performing accurate and inaccurate kicks and concluded that the formers have more thigh flexion in the kicking as well as the supporting foot in addition to more knee flexion in the supporting foot during the execution. Andersen and Drge (2009) also evaluated the influence of accuracy of performance on the maximal speed of the ball relevant to a penalty kick concluded that every player uses a self-selected optimal speed for gaining the desired speed and precision. In general, the majorities of the researches comparing the accurate versus the powerful kicks have concluded that considering the trade-off of speed-accuracy, the accurate kicks have lower angular and linear velocity and differences in regard to joint angles relative to the powerful kicks. In addition, they investigated the factors that may have effect on precision and speed of kicks.

The weight of the ball, surface irregularities and its internal pressure can influence the game (Lees and Lake, 2003) and also the ball size can also have effect on the kinematic of the kick (Teixeira, 1999). Considering the differences in the size and weight of the ball in soccer and indoor soccer and lack of adequate research findings in this regard, it seems necessary to conduct a research that attempt to compare the kinematic of a successful versus unsuccessful kick in indoor soccer to shed light on characteristics of an accurate kicks, thus improving the execution of this vital technique. The vast majorities of the researches reported up to date have employed male subjects (Kellis and Katis, 2007) and have also emphasized the speed as the determining factor for success despite the fact that no appropriate kinematic analysis have been applied (Goktepe *et al*., 2008). Over the foot kick is a skill that is performed in three phases including the swing, the ball impact and the follow through phases. A successful performance requires successful execution of all these stages (Goktepe *et al*., 2008). Most of the researches conducted earlier have examined the mean and the moment of ball impacting kinematics (Scurr and Hall, 2009; Lees and Nolan, 2002). Therefore, the present research was designed to compare the kinematic variables of ball impact, swing and follow through phases of successful and unsuccessful penalty kicks from the six meter distance performed by male and female players. The question addressed in this research was that whether under similar circumstances (same approach, distance to the target), are there any significant differences between the kinematic variables of accurate versus inaccurate kick?

MATERIALS AND METHODS

In this research fourteen right footed elite players (seven men and seven women) from country's Indoor soccer league with an average age of 23±1.7 and 23±2.4 years, height of 182.2±4.73 and 160.7±4.84 cm, weight of 72.4±4.04 and 53.7±4.33 Kg and BMI of 21.79±0.67 and 20.77±2.29 Kg m^{-2} respectively, were selected. The participants had at least a history of two years of continuous participation in the indoor soccer league. All subjects declared from physical or orthopedic injury, which would prevent them from exerting instep kicking. Prior to the start of the protocol, the subjects were asked to kick a stationary ball with high force and also to hop to identify their preferred foot (Barfield *et al*., 2002).

The subjects performed a warm up activity including some stretch exercises and instep kicking for 5 min prior to the performance of the main task. All the participants were wearing sport clothes and indoor soccer shoes. Following the warming up activities, the place of the anatomic markers were determined and after cleaning the skin, the markers were placed on their position. Overall, 5 markers were placed on the anatomical positions including the highest point of iliac crest, major trochanter, lateral epicondyle of the femur, lateral malleolus and the lateral aspect of the distal head of the fifth metatarsus (Dorge *et al*., 2002). Then the subjects were asked to kick the ball with the instep portion of the foot from a six meter distance (first penalty point in indoor soccer) starting with one step angled approach of 45° to a stationary indoor soccer ball (the best angle for approaching (Scurr and Hall, 2009)). In the center of the full size indoor soccer goal (2×3 m) a target with a 1 m radius was marked. Four kicks were filmed for each player. Any kick that hit the assigned target was considered as a successful performance and those which missed the target were recorded as unsuccessful ones. For the purpose of recording the sample kicks from every player, a kinemetrix 3D motion analyzer equipped with three 50 Hz digital cameras, was used. All the recorded pictures were analyzed by using the kinemetrix 3D motion analyzer software to analyze the spatial position of the markers.

In summary, the kinematic variables including the linear velocity of toes, ankle, knee, hip, the angle of ankle, knee, hip joints and the angular velocity of the

thigh and shank were measured. In regard to the movement phases of the kick, a selection of kinematic information of the lower extremities in two separate conditions of successful and unsuccessful men and women were compared separately. The information was filtered by the kinemetrix 3D motion analyzer software by moving average method. The kinematic parameters of successful and unsuccessful kicks were compared by using independent t-test at $\alpha<0.05$ threshold.

RESULTS AND DISCUSSION

The mean and standard deviation presented in Table 1, describes the linear velocity of the kicking foot demonstrates kinematic variables at the time of impact, the peak values, the average of before and after the kick. In general, successful kicks had lower linear velocity than the unsuccessful kicks, but from all of the selected linear variables in the women's group, the maximum linear velocity of the ankle and the knee and the average linear velocity prior to the kick in successful kicks were significantly lower than the unsuccessful kicks. However, the average linear speed of the women's ankle and toes after the kick in successful kicks was somehow more than that of the unsuccessful kicks. This difference was not statistically significant. In male's group, there was a significant difference between the velocity of ankle and toe at the ball impact, the maximum speed and the average linear velocity after the kick in the successful and unsuccessful kicks.

With regards to the curves of linear velocity in both sexes (curves of 1-4), the unsuccessful kicks in women had significantly higher linear velocity before kicking the ball. In men also, most of the difference is related to the speed of kick at the ball impact in ankle, knee and in overall the speed of follow through. In addition, the time pattern of maximum speed of the kicking leg joints, hip, knee, ankle and toe was within the proximal to distal sequence.

In Table 2, the mean and the standard deviation of the selected angular variables at ball impact, maximum values, the mean prior and after the kick is presented. The results of analysis showed no significant difference between the angle of knee and hip of the successful and unsuccessful kicks. Despite the fact that successful kicks had a lower mean flexion of the knee and hip, these differences were not statistically significant. However, only ankle plantar flexion in both genders was statistically lower in the successful than the unsuccessful kicks.

The angular velocity of the shank and thigh at the ball contact, maximum angular velocity and the mean angular velocity of these two parts after the kick were significantly less in the successful than the unsuccessful kicks in the male subjects. With regards to the curve of angular velocity of shank in male (Fig. 5), at impact and after the kick angular velocity of shank in successful kick was lower.

However, in women, only the mean angular velocity of the thigh and shank before impact was significantly higher in the unsuccessful kicks. With regards to the curve of angular velocity of shank in women (Fig. 6), we can see this result.

Table 1: Mean and standard deviation for linear velocity (m sec^{-1})

	Gender					
	Female			Male		
Variables	Successful kick	Unsuccessful kick	p-value	Successful kick	Unsuccessful kick	p-value
Toe velocity at impact	14.66±1.43	15.22±1.80	0.052	15.54±1.810	17.56±1.880	0.031*
Ankle velocity at impact	11.86±1.32	12.10±1.50	0.069	14.62±1.500	16.88±1.610	0.040*
Knee velocity at impact	00.40±0.98	4.06±1.20	0.090	3.58±0.870	4.04±1.080	0.057
Hip velocity at impact	1.54±0.12	1.36±0.24	0.059	1.22±0.140	1.38±0.160	0.064
Peak value toe velocity	15.00±1.40	15.22±1.70	0.054	17.16±1.620	18.10±1.750	0.033*
Peak value ankle Velocity	11.86±1.33	12.94±1.62	0.032*	16.62±1.900	17.38±1.790	0.049*
Peak value knee Velocity	7.04±0.60	7.42±0.82	0.049*	7.44±0.760	8.06±0.930	0.041*
Peak value hip velocity	2.84±0.08	3.08±0.14	0.051	3.71±0.090	3.74±0.100	0.069
Mean of toe velocity before impact	10.60±0.76	12.56±1.04	0.019*	13.85±1.520	13.91±1.710	0.080
Mean of ankle velocity before impact	9.38±0.62	10.93±1.01	0.022*	12.29±1.300	12.50±1.720	0.061
Mean of knee velocity before impact	6.46±0.23	4.78±0.74	0.048*	6.23±1.060	6.57±1.120	0.087
Mean of hip velocity before impact	1.82±0.14	2.13±0.22	0.043*	2.01±0.230	1.92±0.210	0.076
Mean of toe velocity after impact	7.11±1.49	6.85±1.81	0.061	2.01±0.230	7.42±1.610	0.016*
Mean of ankle velocity after impact	6.04±1.23	5.66±1.38	0.059	5.25±1.630	6.36±1.790	0.021*
Mean of knee velocity after impact	2.59±0.51	2.84±0.32	0.082	2.91±0.720	3.52±0.820	0.032*
Mean of hip velocity after impact	0.97±0.04	1.19±0.09	0.082	1.50±0.060	1.63±0.100	0.014*

*: Significant difference ($p<0.05$); Mean of velocity before impact: Mean values from ground contact to impact; Mean of velocity after impact: Mean values from impact to end of follow through; Peak value velocity: Peak value of velocity from support foot contact to end of follow through

Table 2: Mean and standard deviation of joint angles (deg) and segmental angular velocities (deg sec^{-1})

	Gender					
	Female			Male		
Variables	Successful kick	Unsuccessful kick	p-value	Successful kick	Unsuccessful kick	p-value
Angle of ankle at impact (deg)	109.36±4.300	124.01±6.200	0.031*	114.34±4.1000	128.91±8.600	0.028*
Angle of knee at impact (deg)	129.36±8.300	137.17±9.100	0.054	147.50±10.800	149.91±11.60	0.062
Angle of hip at impact (deg)	163.35±10.20	165.06±11.60	0.082	146.86±11.400	146.96±9.500	0.087
Angular velocity shank at impact (deg sec^{-1})	1495.06±120.6	1518.98±135.1	0.059	1504.04±99.400	1650.00±114.2	0.041*
Peak value shank Angular velocity (deg sec^{-1})	1538.00±99.80	1543.2±111.24	0.067	1859.68±124.33	1996.50±129.8	0.043*
Mean of shank Angular velocity before impact (deg sec^{-1})	880.08±76.10	984.69±84.30	0.042*	1506.74±110.60	1457.09±118.4	0.069
Mean of shank Angular velocity after impact (deg sec^{-1})	604.91±81.30	553.78±91.40	0.076	307.74±79.800	373.27±88.90	0.049*
Angular velocity Thigh at impact (deg sec^{-1})	360.04±67.80	366.92±75.40	0.069	351.30±87.400	400.00±98.20	0.045*
Peak value Thigh Angular velocity (deg sec^{-1})	645.34±79.60	657.02±84.50	0.066	701.98±92.100	777.80±97.90	0.043*
Mean of Thigh Angular velocity before impact (deg sec^{-1})	570.26±65.80	648.26±74.10	0.046*	559.62±64.050	631.73±61.03	0.055
Mean of Thigh Angular velocity after impact (deg sec^{-1})	346.35±54.70	330.11±55.90	0.056	211.76±53.900	276.67±52.70	0.049*

*: Significant difference ($p<0.05$); Mean of velocity before impact: Mean values from support foot contact to impact; Mean of velocity after impact: Mean values from impact to end of follow through; Peak value velocity: peak value of velocity from support foot contact to end of follow through

The purpose of this research was to compare the kinematic of successful and unsuccessful instep kick of indoor soccer players from a distance of 6 meters to a target. In this research the kinematic of the kicking leg at the swing phase (before to impact), ball impact and follow through phase (after the impact) was investigated under the ordinary condition where no special consideration was given to the speed of performing the kick (player's preference). Godik *et al.* (1993) concluded that the precision of the kick depends on the speed of approach. The author stated that when the player approaches the ball in his own speed, he has more precision, on the contrary, if a player approaches the ball with the maximum possible speed, the precision of the kick decreases. The author purposed that for the proper precision it seems that there is an optimal speed (Kellis and Katis, 2007). Andersen and Drge (2009) agreed with the conclusion of Godik *et al.* (1993) who proposed that there is a 85% reduction in accuracy in the trade-off between accuracy and speed in performing a kick. On the other hand, Scurr and Hall (2009) claimed that the angle of approach does not have any significant effect on kick accuracy since the angles of 45 and 60° has been identified as the most appropriate angle for performing the skill. In the present research, the angle (45°) as well as the distance of approach (one step) was kept constant to control these two variables.

According to the results obtained by this research, it seemed that the mean value of the selected kinematic variables of successful kicks were lower than the unsuccessful kicks (Table 1 and 2). The linear velocity of ankle and toe at the impact time during the successful kicks in men was significantly lower than the unsuccessful kicks, whereas the difference of these two parameters in women are not significantly different.

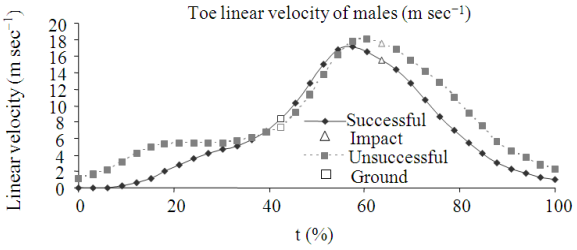

Fig. 1: Toe velocity of males from the beginning to the end of follow through

The maximum linear velocities of ankle and toe in successful kicks of men comparing to the unsuccessful kicks were significantly less. These results are similar to what was reported by Lees and Nolan (2002) earlier, however, in women, there were significant differences only in the maximum velocity of ankle and knee of the successful and unsuccessful kicks. Due to the lack of research finding in regard no contrasting can be made in this regard. Lees and Nolan (2002) employed male subjects and similar results were reported. In addition, it appears that the present research findings are also similar to what was reported by Teixeira (1999) who concluded that target setting that requires good precision leads to the decrease in linear velocity of ankle move.

A careful examination of the curves in Fig. 1-4 reveals that the mean linear velocity of the joints for the accurate in contrast with the inaccurate kicks in women, before and after the kick is reduced. Considering these trade-off of speed and accuracy, it can be concluded that with increasing accuracy, the speed of movement decreases. However, it seemed that men had approximately a similar speed before impact (the mean speed difference before impact was insignificant), however, the difference in the mean speed after the kick was significantly less in successful kicks.

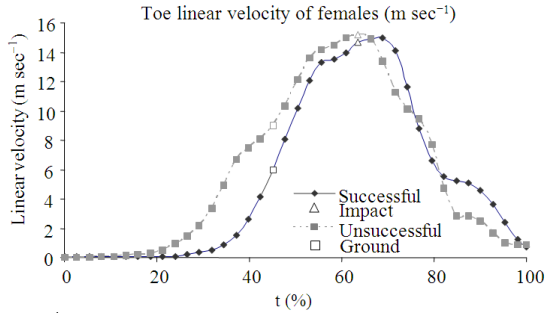

Fig. 2: Toe velocity of females from the beginning to the end of follow through

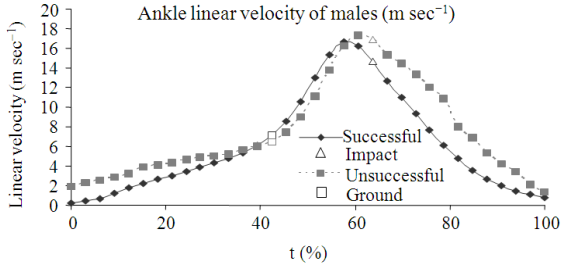

Fig. 3: Ankle velocity of males from the beginning to the end of follow through

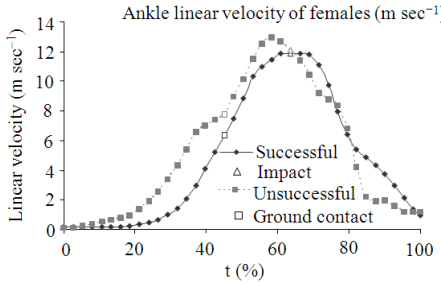

Fig. 4: Ankle velocity of females from the beginning to the end of follow through

These findings can be explained by pinpointing to the importance of the follow through phase in executing of an accurate kick which also conform to the result reported by Goktepe *et al*. (2008) who emphasized on the importance of execution of each phases of movement for an accurate kick. Similarly, with every ballistic movement, execution of follow through causes more transfer of momentum to the ball and its speed (Barfield, 1998), If the follow through is performed with a faster speed, the ball is also sent with higher speed and the possibility of decrease in the precision. Second, the importance of this phase is decrease in risk of injury to the kicking leg.

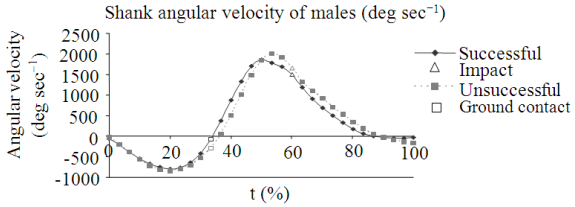

Fig 5: Shank angular velocity of males from the beginning to the end of follow through

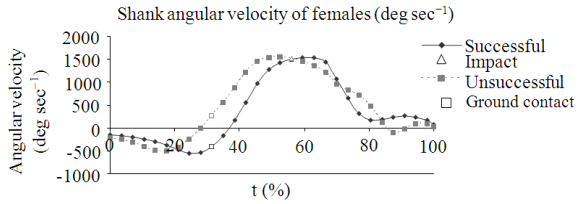

Fig. 6: Shank angular velocity of females from the beginning to the end of follow through

The amount of knee and hip flexion and ankle plantar flexion were higher in the unsuccessful kicks compared to the successful ones. However, this difference was only significant in the ankle plantar flexion. Lees and Nolan (2002) concluded that in successful kicks compared to the high speed kicks, the amount of ankle plantar flexion is significantly less. However, the difference of joint angles in successful and unsuccessful kicks in the present research was lower than what was reported by Lees and Nolan (2002). Such differences can be attributed to the methodology used by the two researches. In addition, confirming these findings, Teixeira (1999) has concluded that when subjects execute kicks to a definite target, they do so with longer time and lower ankle displacement compared when kicking aimlessly. Setting a target imposes accuracy which leads to speed-accuracy trade-off. More plantar flexion puts the ankle in a situation that during execution of the kick, the contact point is more near the ankle than the metatarsals. Previous research have shown that if the ball is kicked with the upper part of the foot (near the ankle), the ball is released with the maximum linear velocity (Kellis and Katis, 2007). Therefore in unsuccessful kicks, the speed of the kick was faster in this research. Dichiera *et al*. (2006) who also investigated the difference of the ankle angle in successful kicks towards specific target at the impact time found that the amount of ankle plantar flexion to different target is significantly different, however, in that research the punt kick and the effect of the ankle angle on target kicking was examined (Dichiera *et al*., 2006).

Evaluation of the angular velocity of shank and thigh revealed that unsuccessful kicks happened to have higher angular velocity. Considering the analysis of performance of women, it was evident that the women had only a lower angular velocity at their shank and thigh on the before impact phase, whereas this condition for men was different and the velocity was at its peak value and the mean values of follow through phase was statistically significant. Considering the relationship between linear and angular velocity, it seems that both sexes at similar stages showed differences. Luhtanen (1987) claimed that angular velocity of the shank are reliable criterion for successful kicks. Lees and Nolan (2002) also examined the angular velocity of the ankle, hip and knee joints and reported results were similar to the finding of the present research. Unfortunately, a similar research for comparing the results was not found.

The kinematic values recorded in this research were lower than those reported by Lees and Nolan (2002), the p-value in observed in Lees and Nolan (2002) were $p<0.01$ and $p<0.001$, respectively, whereas the value observed in the present research was $p<0.05$. This discrepancy may be due to the difference methodology of evaluating, Lees and Nolan (2002) employed accurate and powerful kicks while the present research evaluated successful and unsuccessful kick to definite target were compared.

Kinematic variables employed in this research was similar to those investigated by Barfield *et al*. (2002) and Tant *et al*. (1991), men had a higher angular and linear velocity comparing to the women. In general it can be concluded that in similar circumstances, there is a significant difference between the kinematic values of accurate and inaccurate kick. However, this difference was evident during different sequences of performing the kick.

CONCLUSION

Based on the findings of the present research, it was conclude that there is significant difference between some of the kinematic parameters of successful and unsuccessful kick to definite targets. The general pattern of movement of both successful and unsuccessful kicks was identical, but the accurate kicks had lower angular and linear velocity comparing to the inaccurate ones. This discrepancy in female was observed more at the before the impact phase and in men at the time of impact, maximum values and follow through phase.

ACKNOWLEDGEMENT

The execution of this research was the following of conduction of the thesis for the master's degree in the Tarbiat-E-Moalem-E Tehran University. We acknowledge all those whom participated in this research and assisted us in its execution.

REFERENCES

Andersen, T.B. and H.C. Drge, 2009. The influence of speed of approach and accuracy constraint on the maximal speed of the ball in soccer kicking. Scandinavian. J. Med. Sci. Sports. DOI: 10.1111/j.1600-0838.2009.01024.x

Barfield, W.R., 1998. The biomechanics of kicking in soccer. Clin. Sports Med., 17: 711-728. DOI: 10.1016/S0278-5919(05)70113-7

Barfield, W.R., D. Kirkendall and B. Yu, 2002. Kinematic instep kicking differences between elite female and male soccer players. J. Sports Sci. Med., 1: 72-79. http://www.jssm.org/vol1/n3/4/n3-4pdf.pdf

Dichiera, A., K.E. Webster., L. Kuilboer., M.E. Morris and T.M. Bach and J.A. Feller, 2006. Kinematic patterns associated with accuracy of the drop punt kick in Australian football. J. Sci. Med. Sport, 9: 292-298. DOI: 10.1016/j.jsams.2006.06.007

Dorge, H.C., T.B. Anderson, H. Sorensen and E.B. Simonsen, 2002. Biomechanical differences in soccer kicking with preferred and non-preferred leg. J. Sports Sci., 20: 293-299. http://person.au.dk/fil/14557680/DORGE2002.pdf

Goktepe, A., H. Karabork, E. Ak, S. Cicek and F. Korkusuz, 2008. Kinematic analysis of penalty kick in soccer. J. Fac. Eng. Arch. Selcuk Univ., 23: 45-49.

Godik, M., I. Fales and I. Blashak, 1993. Changing the Kicking Accuracy of Soccer Players Depending on the Type, Value and Aims of Training and Competitive Loads. In: Science and soccer II, Reilly, T., J. Clarys and A. Stibbe (Eds.). E&FN Spon, London, pp: 254-260.

Kellis, E. and A. Katis, 2007. Biomechanics and determinants of instep soccer kick: A review. J. Sports Sci. Med., 6: 154-165. http://www.jssm.org/vol6/n2/1/v6n2-1pdf.pdf

Lees, A. and L. Nolan, 1998. The biomechanics of soccer: A review. J. Sports Sci., 16: 211-234. DOI: 10.1080/026404198366740

Lees, A. and L. Nolan, 2002. Three-Dimensional Kinematic Analysis of the Instep Kick under Speed and Accuracy Conditions. In: Science and Football IV, Spinks, W. and T. Reilly and A. Murphy (Eds.). Routledge, London, ISBN: 978-0415241519, pp: 16-21.

Lees, A. and M. Lake, 2003. The Biomechanics of Soccer Surface and Equipment. In: Science and Soccer, Reilly, T. and A.M. Williams (Eds.). Routlege, London, ISBN: 0203417550, pp: 120-135.

Luhtanen, P., 1987. Kinematics and Kinetics of Maximal Instep Kicking in Junior Soccer Players. In: Science and Football, Reilly, T. (Ed.). London, E&FN Spon, ISBN: 0419143602, pp: 441-448.

Scurr, J. and B. Hall, 2009. The effects of approach angle on penalty kicking accuracy and kick kinematics with recreational soccer players. J. Sports Sci. Med., 8: 230-234. http://www.jssm.org/vol8/n2/10/v8n2-10text.php

Tant, C.L., K.D. Browder and J.D. Wilkerson, 1991. A Three Dimensional Kinematic Comparison of Kicking Techniques Between Male and Female Soccer Players. In: Biomechanics in Sport IX, Tant, C.L., P.E. Parrerson and S.L. York (Eds.). Iowa State University Press, Ames, pp: 101-105.

Teixeira, L., 1999. Kinematics of kicking as a function of different sources of constraint on accuracy. J. Perceptual Motor Skills., 88: 785-789. PMID: 10407885

Wesson, J., 2002. The Science of Soccer. 1st Edn., Institute of Physics Publishing, London, ISBN: 0750308133, pp: 210.