Differences in kinematics parameters in soccer kick between male and female

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ORIGINAL

DIFFERENCES IN KINEMATICS PARAMETERS IN SOCCER KICKS BETWEEN MALE AND FEMALE

DIFERENCIAS EN PARÁMETROS CINEMÁTICOS DEL GOLPEO EN FÚTBOL ENTRE HOMBRES Y MUJERES

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RESUMEN

El objetivo fue conocer las diferencias en el golpeo con el empeine entre hombres y mujeres y buscar sus posibles causas.

Metodología: Veintidós futbolistas experimentados, once hombres y once mujeres, de edades entre 17-19 años fueron estudiados. Realizaron tres golpeos que fueron registrados mediante un sistema de captura de movimiento en 3D. Se analizaron la Velocidad lineal Máxima (Vmax.), Velocidad lineal en el Impacto (Vimp), ambas en m/s.

Resultados: Se hallaron diferencias estadísticamente significativa en Vmáx.Pie: Hombres (16,34±2), Mujeres (14,52±1,15). También en Vimp.Pie fue mayor en Hombres (16,34±2,05) que en Mujeres (14,52±1,15), sin embargo la

Vimp.Cadera fue mayor en Mujeres (1,27 ± 0,31) que en Hombres (0.94 ± 0,33).

Conclusiones: Existen diferencias en la mecánica del golpeo entre hombres y mujeres, aunque éstas no fueron debidas al empleo de distintos patrones motores, sino la desaceleración menos eficaz de las articulaciones más proximales (cadera y rodilla) por parte de las mujeres.

PALABRAS CLAVE: Golpeo, Fútbol, Biomecánica, Técnica, Velocidad.

ABSTRACT

The aim of this study was to discover if there are any differences between men’s and women's instep kick as well as their possible causes.

Methods: Twenty-two expert footballers (11 male and female), aged 17-19 participated in the study. The participants performed up to three kicks, which were filmed by a three-dimensional motion capture system. The variables analysed comprised maximum velocity (Vmáx)(m/s) and velocity at kick (Vkick) (m/s).

Results: We found statistically significant differences in Vmáx.Foot: Men (16.34±2), and Women (14.52±1.15). Vkick.Foot also was higher in men (16.34±2.05) than women (14.52±1.15), but the Vkick.Hip was higher in women (1.27 ± 0.31) than in men (0.94±0.33).

Conclusion: There are differences in the mechanics of kicking between male and female, which cannot be associated to the use of different motor patterns, but less effective deceleration of the more proximal joints (hip and knee) in women.

KEY WORDS: Kick, Soccer, Biomechanics, Technique, Velocity

1 INTRODUCTION

The instep kick is the most studied action in soccer since it is considered the main technical skill for the success of this sport. It is generally accepted that the pattern of motion of a kick is a proximal to distal segmental sequence, therefore it is in accordance with an open kinetic chain. The instep kick has been described and analyzed by numerous studies from a kinematics perspective (Dorge, Bull Andersen, Sorensen, & Simonsen, 2002; Elliott, Bloomfield, & Davies, 1980; Nunome, Asai, Ikegami, & Sakurai, 2002; Nunome, Lake, Georgakis, & Stergioulas, 2006; Putnam, 1991; Wickstrom, 1975).

This skill presents multiple alternative performances, depending on the velocity and position of the ball as well as the nature and purpose of the kick. Of all the kinds of kicks, the most studied has been the maximum velocity instep kick of a stationary ball which is common in penalty kicks (Lees & Nolan, 1998).

The kick is a skill which is learned during childhood, therefore we could think that this action is easy to perform. But the ability to kick in a mature and effective way can be found in a few experienced players (Lees, 1996). Elliott, Bloomfield & Davies (1980) analyzed kick skill in young players between 2-12 years. The authors suggested that kick skill developed rapidly between 4 and 6 years, however, in 80% of the children studied the pattern reached maturity at the mean age of 11.2 years.

Similarly, Phillips (1985) conducted a study that compared the kick between professionals and amateurs. The author showed that there were few biomechanical differences between both groups, but performance in the professional group was more consistent than in the amateur group.

Biomechanical research on the instep kick has been focused on analyzing different variables and populations. These studies were aimed at discovering which variables are most relevant and which are their optimum values, considering successful maximum kick speed (Nunome et al., 2002, Putnam, 1991).

The velocity of the ball depends on several factors, among which the most important are: technical elements of the skill (kinetic chains), muscle strength, power, status of muscle fatigue, approach speed of the player, skill level, maturity and mechanical characteristics of the foot and the ball at impact (Lees & Nolan, 1998; Nunome et al., 2006; Tsaousidis & Zatsiorsky, 1996).

The velocity of the ball depends on the velocity of the foot at the instant of impact as well as the impact quality between foot-ball (Andersen, Doerge, & Thomsen, 1999; Asai, Carré, Akatsuka, & Haake, 2002; Levanon & Dapena, 1998)

In order to achieve maximum release velocity of the ball, these studies suggest that the soccer player should maximize foot velocity (angular velocity of the leg) and hit the ball with the top of the foot, close to the ankle (Carré, Asai, Akatsuka, & Haake, 2002; Nunome et al., 2006; Shinkai, Nunome, Isokawa, & Ikegami, 2009).

There are few studies on the influence of gender on the kick technique in soccer. These studies have shown that women have the ability to hit the ball with kinematic characteristics similar to men (Barfield, Kirkendall, & Yu, 2002; Shan, 2009). However, women generally show a lower release velocity of the ball in relation to men (Barfield et al., 2002).

There are few studies conducted with women soccer players, despite the fact that this discipline is one of the few female sports with professional leagues.

2 AIM

The aim of this study was to determine efficacy differences in kinematic parameters of the instep kick between men and women.

3 METHODOLOGY

The sample consisted of 22 participants between 17-19 years, who had played football in official competition for at least five years. Participants were divided into two groups according to gender.

Group M (male) n = 11. All were junior soccer players who competed in the National League which is the second most important national competition for junior males. Also, they were players for a team that play in the Spanish First Division.

Group F (female) n = 11. All were soccer players who competed in the National Super League which is the most important national competition for women. Also, they were players for a team that play in the Spanish First Division.

At the time of study none of the subjects were suffering from any injury or was in the process of recovery from illness or health issue.

All subjects had been previously informed about the purpose of the study and the type of tests to which they would be subjected, and signed informed consent forms before participating in the study according to the Declaration of Helsinky.

To record and anlayze data, a three-dimensional photogrammetric technique was used which consisted of the following elements:

- A vest, a cap and 21 reflective markers
- Motion capture system (CLIMA, STT ®, Spain)
- 3D analysis software (SOCCER ANALYSER STT ®, Spain)
- Excel Calculation Program (2007, Microsoft ®)
- Statistical Treatment Package (SPSS 16.0)
- Four cameras at the rate of 50 Hz (M50IR PAL, JAI) that were positioned as shown in Figure 1.

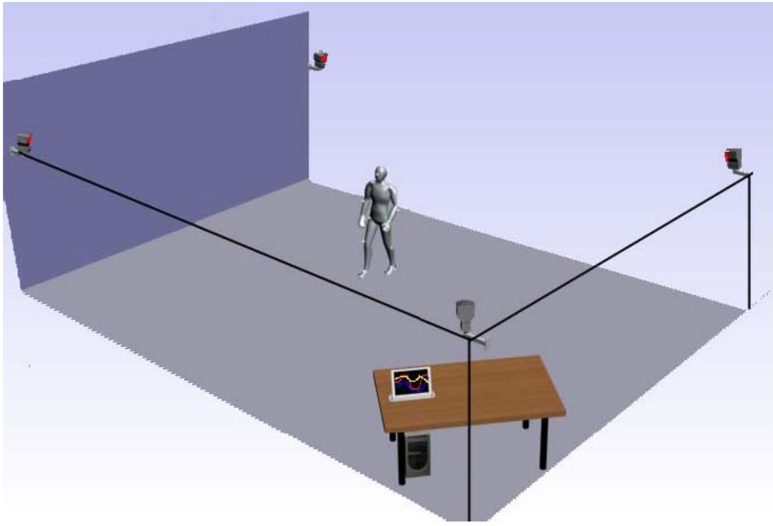

Figure 1. Location of the cameras in the optical tracking system for CLIMA motion capture.

CLIMA is an optical system for capture and analysis of automatic movement. This system allows us to view the captured image using a 3D view application, or real images of the action performed.

The calibration process enabled us to define a global framework for all cameras used in the optical system of motion capture. The main objective of the calibration process was to compute the extrinsic and intrinsic parameters for each specific camera. The extrinsic parameters were the vectors and angles which defined the position and orientation of each camera. The intrinsic parameters were numerical factors which defined the optic characteristics used for each camera. The number and characteristics of the intrinsic parameters depend on the mathematical model used for lenses. The system used a nonlinear mathematical model, which takes into account the geometric distortion caused by the short focal length of the lens. For this particular case, the intrinsic parameters included the scale factors, the radial coefficients, and the tangential coefficients of distortion.

Subsequent to the calibration process and in order to obtain a biomechanical model which represents the movements of the athlete, 21 external markers were used according to the CLIMA system manual (Figure 2).

Figure 2. Location of the external markers to record motion with CLIMA optical tracking system

The research protocol used was the following:

Generic warm-up (8-10 minutes)

– Articular mobility in all axes of motion of shoulder, cervical spine, lumbar spine, hip, ankle and knee

– Cardiovascular exercise: Five minutes of running at low intensity

– Stretching. Exercises for muscle elasticity and range of motion, especially focusing on the structures of the lower limbs and torso

Positioning of the markers for capturing 3D, as described in Figure 2.

Specific warm-up and familiarization with the process. Several kicks were performed simulating a real capture, with markers positioned and respecting the capture zone of the cameras.

Recording instep kicks. The kick was chosen based on the perception of the player. The player chose the best kick from three attempts.

The following variables were studied with regard to the kick leg: maximum hip velocity (maximum value of the linear velocity of the hip during the time of kick), knee velocity (the maximum value of the linear velocity of the knee during the time of kick), maximum ankle velocity (maximum value of the linear velocity of the ankle during the time of kick), maximum foot velocity (maximum value of the linear velocity of the foot during the time of kick), hip velocity at impact (value of the hip linear velocity at the moment of impact), knee velocity at impact (value of linear velocity of the knee at the moment of impact), ankle velocity at impact (value of linear velocity of ankle at the moment of impact), foot velocity at impact (value of linear velocity of the foot at the moment of impact).

All statistical analyses were conducted using SPSS version 16.0. Normality of the data sets was verified using the Kolmogorov-Smirnov test.

If the data was normally distributed within groups, an independent sample Student t-test was applied to determine differences in the kinematic parameters between male and female groups. If the data was abnormally distributed, then a Mann-Whitney U-test was used.

3 RESULTS

Table 1 shows the mean and standard deviations of peak velocities and velocities at impact achieved by each marker (hip, knee, ankle and foot) in both male and female.

Table 1. Peak velocities and velocities at impact (m/s) reached by different segments of the leg kick (mean ± standard deviation).**P* ☐ 0,05 (independent groups t-test)

Parameters	Females	Males
Hip peak velocity	3,00 ± 0,31	3,05 ± 0,32
Knee peak velocity	6,37 ± 0,45	6,56 ± 1,02
Ankle peak velocity	11,18 ± 0,76	12,36 ± 1,75
Foot peak velocity	14,52 ± 1,15*	16,34 ± 2,05*
Hip velocity at impact	1,27 ± 0,31*	0.94 ± 0,33*
Knee velocity at impact	4,31 ± 0,88	3,94 ± 1,07
Ankle velocity at impact	11,37 ± 0,89	11,86 ± 1,93
Foot velocity at impact	14,52 ± 1,15*	16,34 ± 2,05*

Figure. 3. Peak velocity reached by each joint marker in both sexes. Statistical differences were found between males and females only in the foot segment.

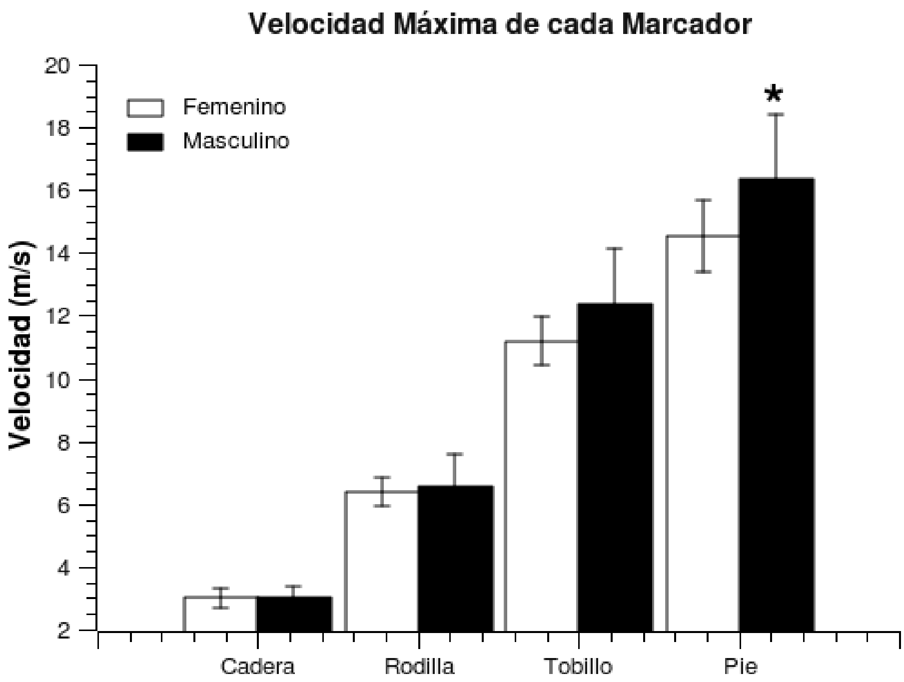

Figure. 3. Peak velocities reached. Male and female comparison. (hip, knee, ankle and foot). **p*< 0,05. T de Student.

Figure 4 shows the values of the velocity at the instant of impact for each marker studied (hip, knee, ankle and foot). This shows that the velocity at impact in proximal segments was greater in females than in males, while in the distal segments it was greater in males than in females.

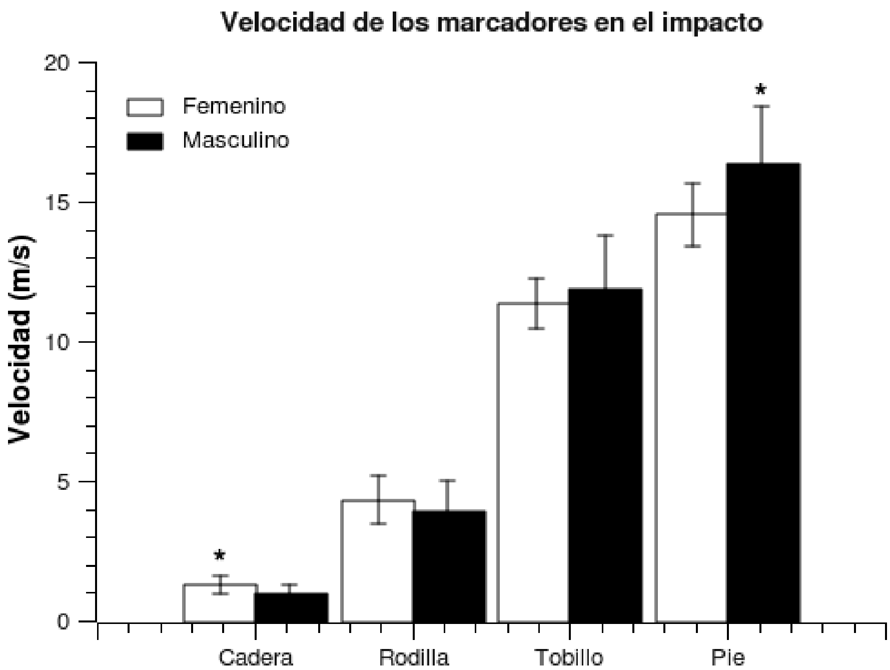

Figure 4. Velocity of the markers at the moment of impact. Male and female comparison. (hip, knee, ankle and foot). **p* < 0,05

Figures 5 and 6 show the sequencing of the velocities of each of the joints (hip, knee, ankle and foot). This shows the evolution velocities during the kick, appreciating as the velocities of the distal segments was achieved later, while more proximal segments decelerated earlier.

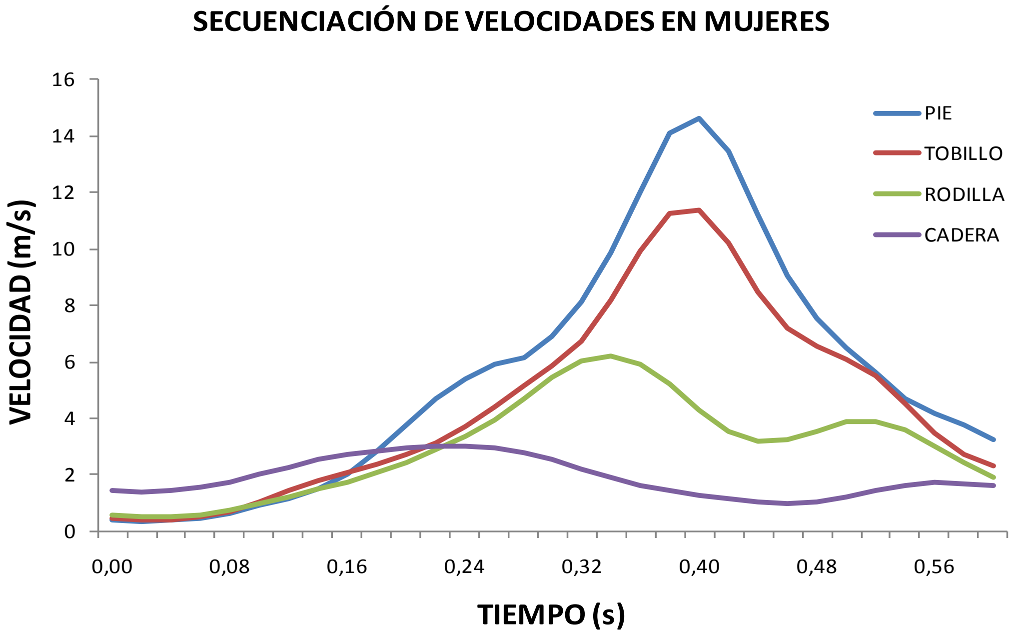

Figure 5. Sequencing of velocities in women's kick. Hip, knee, ankle and foot comparison.

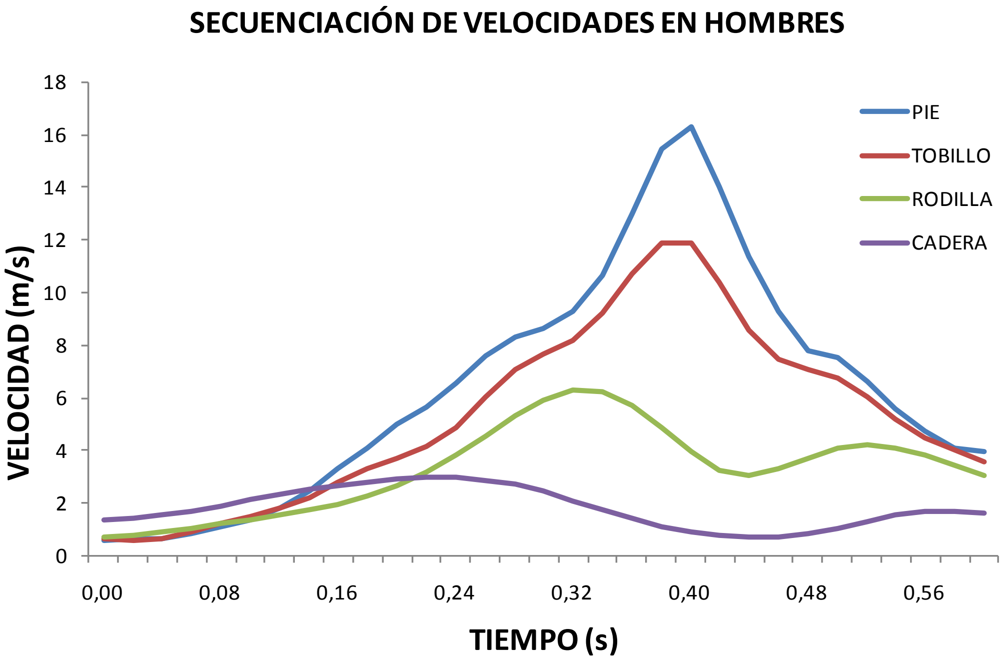

Figure 6. Sequencing of velocities in men's kick. Hip, knee, ankle and foot comparison.

4 DISCUSSION

In the introduction we stated that success in the soccer kick depends on the release velocity of the ball at impact. This parameter is related to maximum velocity of the distal end, which, in our case, is the kicking foot.

The results of this study showed that the maximum speed of the foot in men was significantly higher than in women (Table 1 and Figure 3).

These results were consistent with those reported by Barfield et al. (2002), who examined the kinematic differences in instep kick between male and female professional soccer players. In this study, the eight participants (6 females and 2 males), performed instep kicks from two different approach angles (45° vs. 60°) and kicked a ball placed between two platforms of forces as quickly as possible. The authors concluded that women kicked the ball slower than men, although there was one exception, one of the females kicked the ball with greater velocity than any other man in the group.

The maximum velocity of the kicking foot recorded by Barfield et al. (2002) was 20.4 m/s for males and 18.7 m/s for females. In the present study the values were lower, 16.34 m/s in males and 14.52 m/s in females.

The differences between both studies could be due to the age of the participants. In the study by Barfield et al. (2002), the participants' ages ranged from 19-22 years, whereas in the present study participant age ranged from 17-19 years. It has been observed that the biomechanical parameters of the kick change with age (Kellis & Katis, 2007). In a previous study (Capranica, Bed, Fanton, Tessitore, & Figure, 1992) concluded that maximum ball velocity increased with age. This increase could be due to increased muscle mass as well as improvements in technique (Kellis & Katis, 2007).

In order to find causes of differences in foot velocity at impact we analysed peak velocity sequencing of the lower limb joints (hip, knee, ankle, and foot) during the kick in both sexes (figures 5 and 6). It was observed that both women and men showed a proximal to distal sequence. This sequence has been described as optimal for achieving maximum foot velocity, and consequently for increasing the release velocity of the ball (Kellis, Katis, & Vrabas, 2006, Lees & Nolan, 1998).

There was no difference in the peak velocity sequencing between the sexes, which could indicate that differences in foot velocity at impact were not due to using a different motor pattern.

Another aspect which could influence peak foot velocity is the transfer velocity between the segments of the kicking leg (Clagg, Warnock, & Thomas, 2009). In order for there to be transfer velocity between segments, there must be a sequence of accelerations and decelerations of the segments proximal to the distal.

In this study the amount of deceleration was studied by analysing the velocities of the markers at the instant of impact. In a correctly performed kick, the velocity of the proximal segments at the time of impact should be close to zero.

For this reason, in the present study we analyzed the velocities of the different markers (hip, knee, ankle and foot) at the impact for both males and females.

The velocity scores of the hip at impact were significantly different between groups. Females achieved a higher velocity than males (1.27 ± 0.31 m/s vs 0.94 ± 0.33 m/s; $P < 0.05$). In contrast, as mentioned above, the maximum speeds reached by both groups were similar (3.00 ± 0.31 m/s vs 3.05 ± 0.32 m/s; $P > 0.05$).

Similarly, in the knee joint differences were found between both groups, although these were not significant (4.31 ± 0.88 m/s vs. 3.94 ± 1.07 m/s, $P > 0.05$). This data suggests that the lower foot velocity at impact of females compared to males could be a result of reduced deceleration of the hip and knee. This lower deceleration could make the velocity transfer rate between distal to proximal segments most difficult, and consequently decrease foot velocity at impact.

Barfield et al. (2002) also analyzed the velocity of the knee at the moment of impact. The authors found that females reached higher knee angular velocity than males at the instant of impact (19,79 rad/s and 19,42 rad/s, respectively). The authors suggested that this difference was due to a protection mechanism which decelerates the knee before kicking in order to reduce potential injuries.

Barfield et al. (2002) also reported a higher ankle velocity at impact in males compared to females (13,8 m/s and 11,9 m/s, respectively). In this study, although ankle velocity was higher in males than in females, both scores were slightly lower than those reported by Barfield et al. (2002) (11.86 m / s and 11.37, respectively).

As stated above, the differences between the two studies could be due to age of the participants.

5 CONCLUSIONS

The present study showed that there were differences in the mechanics of the kick between men and women, the most important being the higher velocity of the foot at impact in males than females.

These differences were not due to different motor patterns. There were no differences between groups either in the peak velocity sequence or at instants when peak velocity was achieved.

The possible causes could be both a less effective deceleration of proximal segments (hip and knee) in women, as well as the protection mechanism of the knee in men, which decelerates the knee before reaching maximum extension.

6 REFERENCES

Andersen, T. B., Doerge, H. C., & Thomsen, F. I. (1999). Collisions in soccer kicking. *Sports Engineering, 2*(2), 121-125.

Asai, T., Carré, M. J., Akatsuka, T., & Haake, S. J. (2002). The curve kick of a football I: impact with the foot. *Sports Engineering, 5*(4), 183-192.

Barfield, W. R., Kirkendall, D. T., & Yu, B. (2002). Kinematic instep kicking differences between elite female and male soccer players. *Journal of Sports Science & Medicine, 1*(3), 72-79.

Capranica, L., Cama, G., Fanton, F., Tessitore, A., & Figura, F. (1992). Force and power of preferred and non-preferred leg in young soccer players. *Journal of Sports Medicine & Physical Fitness, 32*(4), 358-363.

Carré, M. J., Asai, T., Akatsuka, T., & Haake, S. J. (2002). The curve kick of a football II: flight through the air. *Sports Engineering, 5*(4), 193-200.

Clagg, S. E., Warnock, A., & Thomas, J. S. (2009). Kinetic analyses of maximal effort soccer kicks in female collegiate athletes. *Sports Biomechanics, 8*(2), 141-153.

Chu, Y., Fleisig, G. S., Simpson, K. J., & Andrews, J. R. (2009). Biomechanical comparison between elite female and male baseball pitchers. *Journal of Applied Biomechanics, 25*(1), 22-31.

Dorge, H. C., Bull Andersen, T., Sorensen, H., & Simonsen, E. B. (2002). Biomechanical differences in soccer kicking with the preferred and the non-preferred leg. *Journal of Sports Sciences, 20*(4), 293-299.

Elliott, B. C., Bloomfield, J., & Davies, C. M. (1980). Development of the punt kick: A cinematographic analysis. *Journal of Human Movement Studies, 6*(2), 142-150.

Kellis, E., & Katis, A. (2007). Biomechanical characteristics and determinants of instep soccer kick. *Journal of Sports Science & Medicine, 6*(2), 154-165.

Kellis, E., Katis, A., & Vrabas, I. S. (2006). Effects of an intermittent exercise fatigue protocol on biomechanics of soccer kick performance. *Scandinavian Journal of Medicine & Science in Sports, 16*(5), 334-344.

Lees, A. (1996). Biomechanics applied to soccer skills. In *In, Reilly, T. (ed.), Science and soccer, London, E & FN Spon, c1996, p. 123-133.* United Kingdom.

Lees, A., & Nolan, L. (1998). The biomechanics of soccer: a review. *Journal of Sports Sciences, 16*(3), 211-234.

Levanon, J., & Dapena, J. (1998). Comparison of the kinematics of the full-instep and pass kicks in soccer. *Medicine and Science in Sports and Exercise, 30*(6), 917-927.

Nunome, H., Asai, T., Ikegami, Y., & Sakurai, S. (2002). Three-dimensional kinetic analysis of side-foot and instep soccer kicks. *Medicine and Science in Sports and Exercise, 34*(12), 2028-2036.

Nunome, H., Lake, M., Georgakis, A., & Stergioulas, L. K. (2006). Impact phase kinematics of instep kicking in soccer. *Journal of Sports Sciences, 24*(1), 11-22.

Putnam, C. A. (1991). A segment interaction analysis of proximal-to-distal sequential segment motion patterns. *Medicine and Science in Sports and Exercise, 23*(1), 130-144.

Shan, G. (2009). Influence of gender and experience on the maximal instep soccer kick. *European Journal of Sport Science, 9*(2), 107-114.

Shinkai, H., Nunome, H., Isokawa, M., & Ikegami, Y. (2009). Ball impact dynamics of instep soccer kicking. *Medicine and Science in Sports and Exercise, 41*(4), 889-897.

Tsaousidis, N., & Zatsiorsky, V. (1996). Two types of ball-effector interaction and their relative contribution to soccer kicking. *Human Movement Science, 15*(6), 861-876.

Wickstrom, R. L. (1975). Developmental kinesiology: maturation on basic motor patterns. *Exercise & Sport Sciences Reviews, 3*, 163-192.

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Referencias propias de la revista / Journal's own references: 0