KICKING IN SOCCER

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Kicking as the defining action of soccer has gained huge interest within the scientific community with respect to practice, coaching, science and technology. This paper focuses on current knowledge of soccer kicking, including its biomechanical description, skill execution, kicking techniques, performance criteria, and measurement technology. Additionally, it refers to a fairly new research aspect, the influence of soccer footwear on the kicking movement and consequently on kicking success as it has been shown that soccer footwear alters the biomechanics of kicking. Finally, future directions of research are suggested that are helpful to enhance the fundamental understanding of kicking.

KEY WORDS: kicking technique, velocity, accuracy, measurement technology, footwear

INTRODUCTION

Soccer kicking is described as a complex motor movement consisting of six important stages: Approach angle, plant foot forces, swing limb loading, flexion at the hip and extension at the knee, foot contact with the ball, and follow-through (Barfield, 1998). The kicking procedure may also be divided into five essential aspects: Approach, support leg, kicking leg, foot to ball interaction, and ball flight (Lees et al., 2010). The resultant ball movement of soccer kicking is finally determined by its core phase characteristics, the foot to ball interaction, which only lasts about 10 ms (various authors). Thereby, the impact phase of soccer kicking is characterized as a mixture of impact-like and throwing-like mechanisms (Tsaousidis & Zatsiorsky, 1996). Shinkai et al. (2009) elaborated on these considerations and identified the four following specific phases of foot to ball interaction: phase I – centre of ball gravity (CBG) moves without ball movement (pure ball deformation), phase II – start of ball movement until ball velocity exceeds foot velocity, phase III – start of ball decompression with continuing decrease of foot velocity and further increase of CGB velocity, phase IV – foot loses ball contact while foot deceleration and ball acceleration stops (Figure 1). For powerful kicking Kellis & Katis (2007) have identified key aspects in the literature: Technique, optimum transfer of energy between segments, approach speed and angle, skill level, gender, age, limb dominance, maturity, the characteristics of foot to ball impact, muscle strength and power of the players, and type of kick. Accurate kicking has received less attention, important aspects are: Approach speed, kicking velocity reduction, foot to ball contact point, and ball spin (Kellis & Katis, 2007).

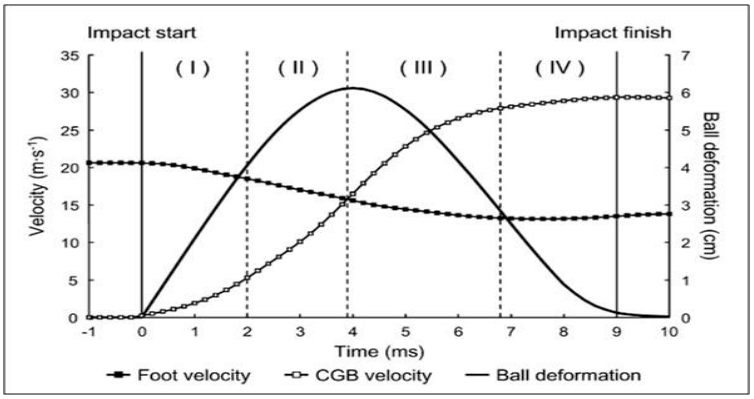

Figure 1: Foot-ball interaction (Shinkai et al., 2009)

KICKING TECHNIQUES

There is a selection of kicking techniques in order to cope with the demands of various specific game situations. The most obvious differentiation refers to kicking stationary or non-stationary balls. Thereby, non-stationary ball kicking situations are characterized by rolling or bouncing balls, the latter require volley or drop kick techniques. Player's kicking technique selection should be based on the specific necessity of ball speed, accuracy, spin, and ball flight and should be analyzed in relation to the player's position to the ball and on the field.

Kicking techniques may be divided into instep, side foot, and toe kicks. Thereby, the inner and outer instep kick aim to rotate the ball by the tradeoff of some velocity (Neilson & Jones, 2005).

PERFORMANCE CRITERIA

Important performance variables are ball velocity and accuracy, and also ball flight. A curved ball flight is achieved by imparting spin to the ball due to eccentric foot-ball contact. Maximum ball speed has been widely accepted to be the main biomechanical indicator of kicking success. However, there are good reasons to reconsider this notion as kicking accuracy might be much more important, as it applies to almost all passing and kicking throughout the game regardless of technique and power applied. When shooting on goal, players often want to maximize both, ball velocity and accuracy, to reduce reaction time of the goal keeper and to increase his distance to the ball. Obviously, this combination is difficult to achieve. It also occurs in various other sports like tennis, volleyball, or handball. Commonly it is referred to as the speed-accuracy-trade-off which has been quantified for the three most frequently used techniques in soccer (Figure 2; Sterzing et al., 2009).

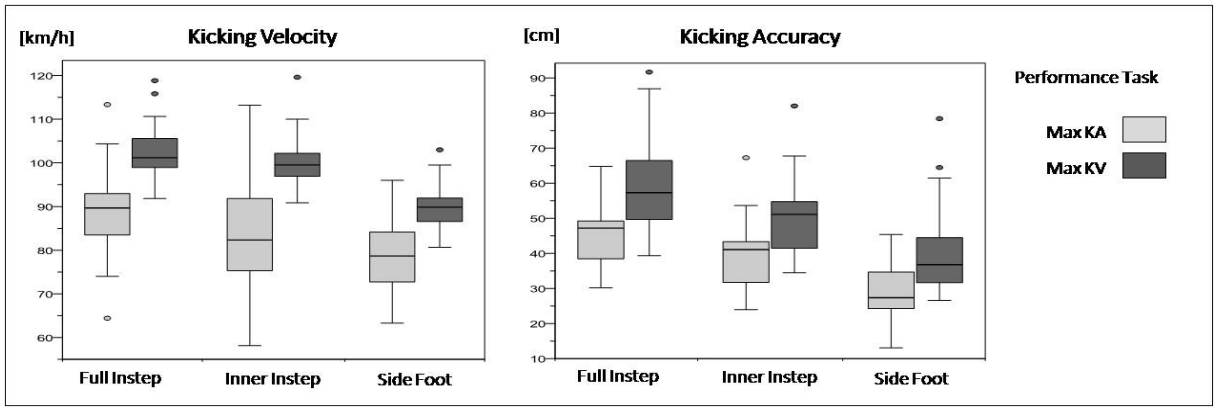

Figure 2: Max KA/ KV: Maximization of accuracy/ velocity (Sterzing et al., 2009)

Players kicked slower when trying to maximize kicking accuracy. Thereby, reduction of velocity was fairly similar across the three kicking techniques. Kicking accuracy was reduced when players kicked as fast as possible. Looking at kicking variability, players used a relatively stable velocity within each technique and performance task. In contrast, accuracy outcome appeared relatively variable. It was concluded that players can better tune their input velocity variable than controlling their accuracy output. Further performance criteria like ball flight and ball spin are more difficult to measure. For curved balls an important variable is the lateral deflection of its flight. This allows players to kick the ball around a defensive wall during a free kick more easily. For analysis of irregular and unsystematic ball flight curves, objective performance criteria are difficult to obtain.

MEASUREMENT TECHNOLOGY

Measurement technology is an essential aspect for the analysis of kicking. For testing kicking accuracy of players' motor performance in practice sessions, discrete target areas are commonly used. However, for obtaining more precise and metric data, advanced measurement technology is needed. For precise measurements of ball accuracy different measurement procedures have been introduced: Ball prints produced by carbon paper on a wooden wall (Finnoff et al., 2002), a custom made circular electronic target (Hennig et al., 2009), and high-speed video capturing (Sterzing et al., 2009). All these provide precise ball accuracy data with high resolution, however the latter two needing a certain amount of technical instrumentation. For kicking velocity measurements commonly high-speed video capturing or radar guns are used by various researchers. Ball spin can be measured by motion analysis of an instrumented ball with retroreflective markers attached. An

extraordinary way of showing ball flight was presented by Asai et al. (2007) visualizing the knuckle effect of a ball that was kicked with no rotation by use of titanium tetrachloride.

SOCCER FOOTWEAR

Soccer footwear has to be regarded as an artificial and beneficial interface between the athlete's foot and the environment as shown for a variety of aspects like comfort, protection, traction, and stability (Hennig & Sterzing, 2010). However, its performance influence during kicking is unique. Soccer shoes seem to be rather generally obstructive than supportive during maximum full instep kicks. Players, who were able to neglect pain when performing maximum full instep kicks barefoot, achieved slightly higher ball velocity compared to kicking shod (Sterzing & Hennig, 2008). The mechanism to support this finding was first referred to as "forceful plantarflexion of the *foot"* (Lees, 1993) and elaborated on by Shinkai et al. (2009). The bare foot is already fully plantarflexed at initial ball contact, in contrast to the shod foot (Figure 3). At final ball contact both conditions show full plantarflexion. This indicates increased energy dissipation in the shod condition and also suggests reduced effective mass due to a less rigid ankle structure consequently leading to decreased ball velocity. A systematic analysis of the influence of isolated shoe features on ball velocity was carried out (Sterzing & Hennig, 2008).

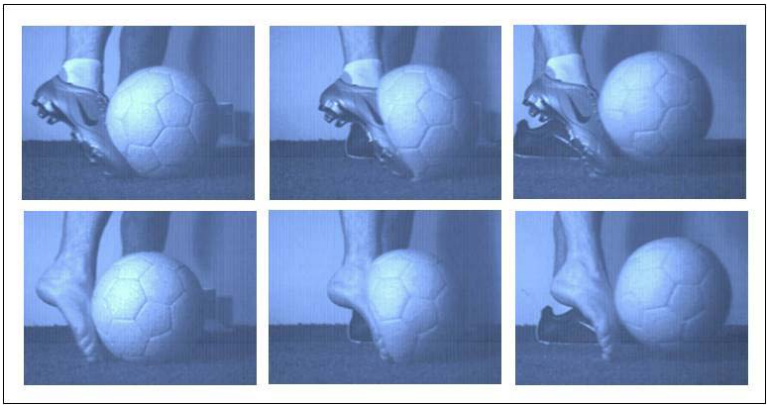

Figure 3: Ball contact plantarflexion (Sterzing & Hennig, 2008)

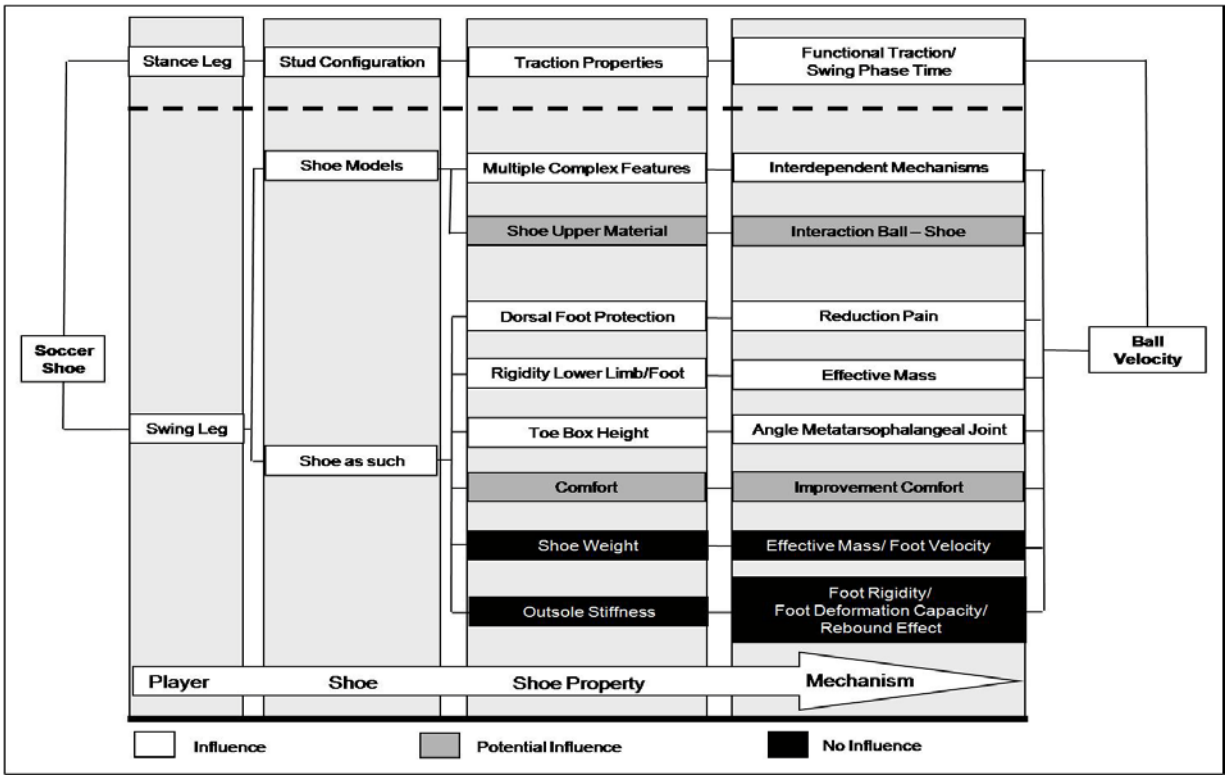

Figure 4: Shoe features and ball velocity during full instep kicks (Sterzing & Hennig, 2008)

Figure 4 provides an overview of the influencing potential of various shoe features as well as pointing out the multiple mechanisms. Finally, it needs to be acknowledged that increasing

ball velocity by soccer footwear is a complex challenge, surely influenced by stance leg traction, dorsal foot protection, the rigidity of the ankle joint and the toe box height.
The influence of the shoe on kicking accuracy has been underestimated for long. Six potential mechanisms were proposed to influence kicking accuracy: Interface pressure distribution, interface friction, spin production, foot skin sensation, functional stance leg traction, and shoe mass (Hennig & Sterzing, 2010). In contrast to kicking velocity, barefoot kicks were shown to be less accurate than shod kicks. It was speculated that the uneven, bony barefoot surface reduced accuracy of kicks compared to shod conditions, which provide a more even interface between the foot and the ball. It was concluded that avoidance of high pressure gradients across the foot is an important factor in achieving better kicking precision by footwear. However, many of the proposed mechanisms have not yet been examined.

PERSPECTIVE:

Kicking was and still is a fascinating research topic and is currently undergoing multiple new and innovative research initiatives. Interestingly, most studies have investigated kicks of stationary balls so far. Although these kicks are important and in many cases game decisive (free-kicks, penalties), the majority of passing and kicking actions take play with the ball not being stationary but rather rolling, bouncing or flying towards or away from the player in various speeds and angles, thereby increasing variability of the various kicking movements. Here, there are a lot of unsolved research issues especially with regard to timing of the kicking action that have not been examined, yet. Also, as the impact phase of the kick determines the final success of the kick, more research should focus on relating the mechanisms observed during the impact phase to the outcome with respect to speed, accuracy, spin and flight path of the ball. Thereby, whole body posture as well as specific kinematics and kinetics of the lower leg foot complex should be considered. Results of these studies should be helpful to better understand what determines the success of kicks and should be useful to give adequate advice to coaches.

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