THE SUCCESS OF A SOCCER KICK DEPENDS ON RUN UP DECELERATION

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The purpose of the study was to relate the motion of the centre of mass (CoM) during run ups in soccer full insteps kicks with the obtained ball speeds. Nineteen experienced players performed kicks onto the goal and their full body kinematics as well as ball motion were analysed in three dimensions using two high speed video cameras. Higher decelerations of the CoM with the last step are associated with higher ball velocities and higher thigh angular impulses. Those data suggest, that an intensive breaking of the CoM velocity provides a prerequisite to transfer a portion of the CoM impulse into angular impulse of the thigh. High angular impulse of the thigh however can be beneficial for fast instep kicks.

INTRODUCTION: It is widely accepted and quite easy to understand, that the ball speed of a soccer kick depends on the action of the kicking leg (Tsaousidis & Zatsiorsky, 1996; Lees & Nolan, 1998; Sterzing & Hennig, 2008). Both the swing phase prior to ball impact and the collision phase determine the quality of a soccer kick (Tsaousidis & Zatsiorsky, 1996). A high knee muscle moment and a high knee interaction moment at the kicking leg appear to be beneficial to achieve high ball speeds (Nunome et al., 2006a; 2006b). Little attention however has been drawn to the influence of the supporting leg on ball speed. It is reported, that higher ball speeds are associated with higher peak ground reaction force (GRF) values (Barfield, 1998; Orloff et al., 2008) but mechanisms how reaction forces acting on the player's centre of mass (CoM) lead to higher ball speeds are not understood. Findings from throwing disciplines suggest, that an intensive deceleration of the CoM combined with a transfer of momentum and energy from lower body parts to the arm is a prerequisite for successful throws (Morriss et al., 2001; Morriss & Bartlett, 1996). It has been suggested, that the interaction of the supporting leg with the surface has an influence on kicking performance (Potthast & Brüggemann, 2010; Sterzing & Hennig, 2008). Therefore the purpose of this study was to investigate if the deceleration of the player's CoM during the last step is related to ball speed in full instep kicking.

METHODS: 19 experienced male soccer players (highest German amateur level) performed 5 shots from a central position at the end of the penalty box onto the goal. The upper half of the goal was subdivided into three areas. Left footed players had to aim for the upper left corner, right footed players for the upper right corner. The subjects were instructed to perform full instep kicks after self selected run up. The run up and kicking kinematics of the players were recorded by two synchronized digital high-speed cameras (Basler, 100 Hz). The cameras recorded from a posterior and from a lateral view (figure 1). Video footages were analysed (Vicon Motus 9.2) by identifying anatomical landmarks of the player (head, C7, left and right shoulder, elbow, hand, hip, knee, ankle, heel, tiptoes) as well as the centre of the ball. Next to the segmental kinematics the movement of the CoM was calculated. Segment kinetics for the swinging leg were calculated using segmental inertial properties and kinematics. Particularly the angular impulse was calculated by multiplying the moment of inertia and the angular velocity component-by-component. To assess kicking performance the ball speed was used by analysing the ball movement ten frames after foot ball contact. For each player the fastest kick hitting the target area was considered for further analysis. The deceleration impulse during the last step with the supporting leg was calculated by multiplying the players' mass with the change of run up velocity during stance. All kicks were performed on one artificial turf system (pure rubber infill). This pitch did not change the kicking motion of the players in comparison to a well maintained natural grass pitch (Potthast & Brueggemann, 2010).

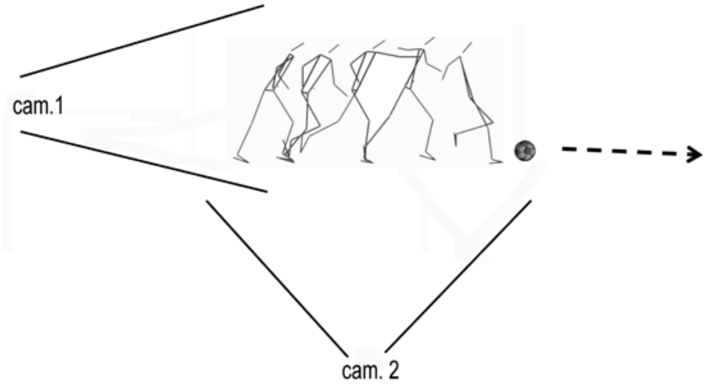

Figure 1. Schematic drawing of the camera positions (cam. 1 and cam 2) in respect to the players' run up and kicking action. The dashed arrow indicates the kicking direction.

RESULTS: The average kicking velocity was 100.1 km/h ± 7.3, the average deceleration impulse was 144.5 kg*m/s ± 32.5, the average increase of thigh angular impulse was 3.2 kg*m^2/s ± 1.1. Figure 2 shows the relationship between kicking velocity and deceleration impulse. The correlation coefficient was r=0.6 (p=0.006, n=19), indicating that 36% of the variance of the kicking velocity is explained by the deceleration impulse of the CoM. More intensive reduction of the velocity of the CoM is correlated with higher ball speeds.

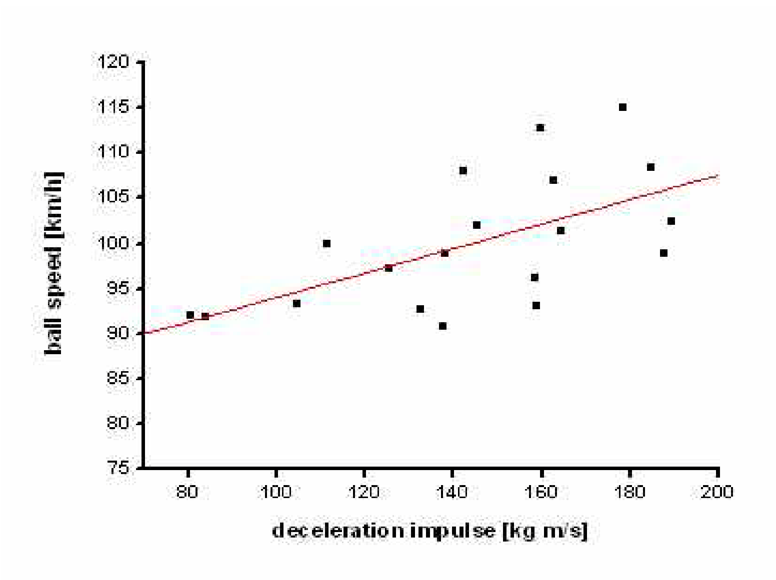

Figure 2.Relationship between CoM deceleration impulse with the last step of the supporting leg and ball speed (r=0.6; p=0.006; n=19). A more intensive breaking is associated with higher kicking velocities.

Figure 3 indicates, that a bigger portion of the CoM deceleration impulse is transferred into angular impulse of the thigh in kicks with high ball speed than in kicks with low ball speed.

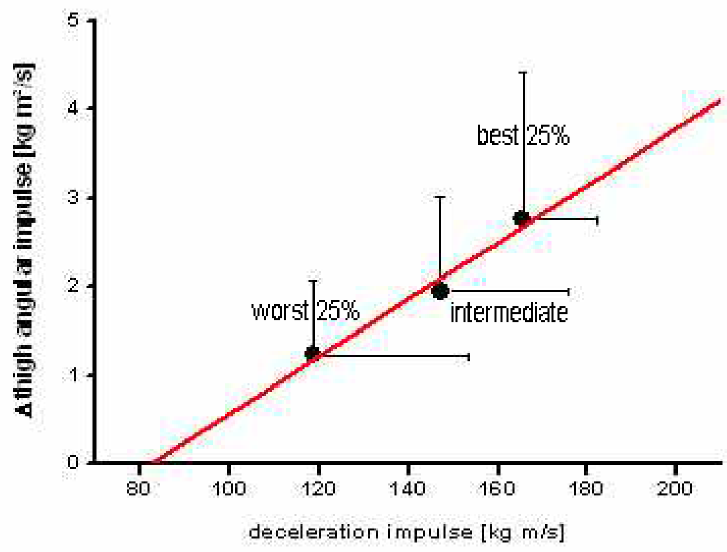

Figure 3. Mean values and standard deviations of the angular impulse (vertical axis) and decelereation impulse of the CoM (horizontal axis) for kicks with high ball speeds (best 25%), low ball speeds (worst 25%) and intermediate ball speeds (n=19).

DISCUSSION: The purpose of the study was generally to investigate if a momentum transfer to leg segments due to the deceleration of the run up velocity of the CoM could influence ball speed. Using video footages three-dimensional run up and kicking kinematics were analysed as well as ball speed. The ball speed parameters were similar to those reported in other studies. Slight differences (Sterzing & Hennig, 2008) can be explained by different measuring techniques and skill level of subjects. The results show, that intensive deceleration of the run up within the last step of the stance leg is correlated (r=0.6) to higher ball speeds. In addition kicks with the highest ball speeds coincide with high CoM decelerations and high increases of angular impulses of the thigh. On the other side, the slowest kicks coincide with smaller CoM decelerations and smaller changes of thigh angular impulses. Those facts indicate, that an intensive breaking of the CoM velocity provides a prerequisite to transfer a portion of the CoM impulse into angular impulse of the thigh. High angular impulse of the thigh can be beneficial for fast instep kicks (Nunome et al., 2006a, 2006b). This information should be valuable in different fields of application. The results indicate that the deceleration of the run up and the behaviour of the stance leg in general have to be considered when teaching instep kicks. In the field of sports technology an un-disturbed deceleration has to be ensured e.g. by surfaces or shoes. It should be sated that this study needs confirmation by future research.

REFERENCES:

Barfield, W.R. (1998). The biomechanics of kicking in soccer. *Clinical Sports Medicine,* 17.

Lees, A, and L Nolan (1998). The biomechanics of soccer: a review. *Journal of Sports Sciences,* 16, 211-34

Morriss, C., Bartlett, R. (1996). Biomechanical factors critical for performance in the men's javelin throw. *Journal of Sports Medicine*, 21, 438-446

Morriss, C., Bartlett, R., Navarro, E. (2001). The function of blocking in elite javelin throws: A re-evaluation. *Journal of Human Movement Studies*, 41, 175-190

Nunome, H, Y Ikegami, R Kozakai, T Apriantono, and S Sano (2006a). Segmental dynamics of soccer instep kicking with the preferred and non-preffered leg. *Journal of Sport Science* 24, 529-541.
Nunome, Hiroyuki, Mark Lake, Apostolos Georgakis, and Lampros Stergioulas (2006b). Impact phase kinematics of instep kicking in soccer. *Journal of Sports Sciences* 24, 11-22.
Orloff, Heidi, Bryce Sumida, Janna Chow, Lalae Habibi, Aaron Fujino, and Brian Kramer (2008). “Ground reaction forces and kinematics of plant leg position during instep kicking in male and female collegiate soccer players.” *Sports biomechanics* 7, 238-47.
Potthast W, Brüggemann G-P (2010): Motion differences in goal kicking on natural and artificial soccer turf systems. *Footwear Science 2*, in press
Sterzing, Thorsten, and Ewald M Hennig (2008). “The influence of soccer shoes on kicking velocity in full-instep kicks.” *Exercise and sport sciences reviews* 36, 91-7.
Tsaousidis, N, and V Zatsiorsky (1996). Two types of ball-effector interaction and their relative contribution to soccer kicking. *Human movement science* 15, 861-876.