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KINEMATIC ANALYSIS ON THE PUNT KICK IN FOOTBALL GOALKEEPER

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The present study aimed to investigate punt kicks by football goalkeepers on the basis of differences in the effort of the kick. Twelve experienced goalkeepers participated in the study. The participants were made aware that for the maximum distance trial (the 100% trial), they should send the ball as far as possible, and for the 80% and 60% trials they should have a more controlled approach. Punt kicks were divided into three phases: the phase of release of the ball from the left hand (BR), the phase of pivot foot ground-contact (LFC), and the phase of the ball impact (IMP). Right hip and knee joint angles were calculated. In comparison to lower intensity punt kicks, the higher effort punt kicks involved increasing the hip joint extension angle for the right foot during the backswing and lowering the knee joint angle of the right leg at the start of the forward swing, thereby producing forward swing velocity for the right foot.

KEY WORDS: motion analysis, goalkeeper, intensity of the punt kick.

INTRODUCTION: Broadly speaking, goalkeepers have 2 ways of passing, either by throwing grounders and liners to teammates on the same side of the field or close to the half line, or by kicking and sending the ball high in the air to a teammate on the opponent's side of the field. The ultimate aim of an attack in football is to breach the opponent's goal, which necessitates techniques for connecting passes that take little time and allow teammates to score with a small number of passes. For this reason, a kicked pass from the goalkeeper is believed to be an ideal means for sending the ball to a teammate who is close to the opponent's goal, provided distance and accuracy are included. Kick accuracy and technique for sending the ball long distances are elements of good goalkeeping in football today.
There has already been a great deal of research attempting to clarify the mechanisms of kicking techniques in football, some of which has studied inside kicks (Levanon & Dapena 1998) and some of which has studied instep kicks (Lees & Nolan 2002; Levanon & Dapena 1998; Robertson & Mosher 1985; Teixeira, 1999). However, there has been virtually no research addressing punt kicking by the goalkeeper. Accordingly, the present study aimed to investigate punt kicks by football goalkeepers on the basis of differences in the effort of the kick, and to obtain basic findings for guidance in improving punt kick accuracy and distance.

METHODS: The participants in the present study were 12 male goalkeepers belonging to a Division 1 college football league, presumed not to have major differences in their punt kicking ability, and all right-footed.
The experimental technique involved first measuring the maximum distance (100%) each kicker's punt kick and then setting up a frame (5.0 m long and 7.0 m wide) at 80% and 60% of the maximum distance and having the goalkeeper accurately send punt kicks aimed at the frames. The participants were made aware that for the maximum distance trial (the 100% trial), they should send the ball as far as possible, and for the 80% and 60% trials they should have a more controlled approach and aim to get the ball in the frame. All punt kicks used in the present study were those normally used in the competitive field. The order of the trials for each intensity following the 100% trial was determined randomly.
For each trial, they were asked to take a moment to formulate a 5-point assessment (5, very good; 3, normal; 1, very bad) that comprehensively took into account the trajectory, rotation, control, and distance of the ball. The trials that received the highest assessment scores for each intensity were subject to further analysis.

An imaging area 3.0 m in the right-left direction (X-axis), 4.0 m in the kicking direction (Y-axis), and 2.5 m high (Z-axis) was established, and 2 high-speed cameras (HSV-500C[3], NAC Inc., Tokyo, Japan) were used for front and side imaging of the trials. The experimental trials were videotaped at a frame rate of 250 Hz and an exposure time of 1/1,000 s. The right lower limb angles were defined as Figure 1.
To assist with the analysis, punt kicks were divided into three phases. These were: the phase of release of the ball from the left hand (BR), the phase of pivot foot ground-contact (LFC), and the phase of the ball impact (IMP).

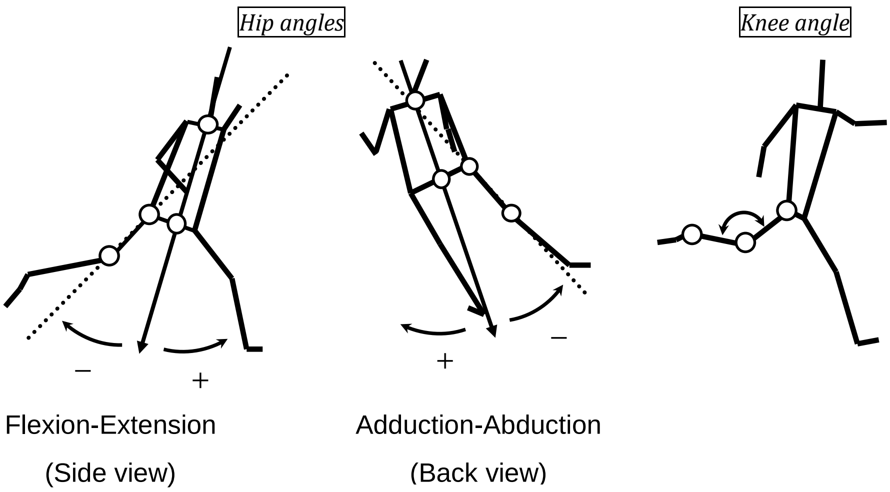

Figure 1 Definitions of the right lower limb angles

RESULTS: Table 1 shows the right hip joint fle-ext (Flexion-Extension) and add-abd (Adduction-Abduction) angle by intensity, for each phase, using the average value and the

Table 1. Angle of the right hip joint (Mean±SD)

	60%		80%		100%	
	Fle-ext	Add-abd	Fle-ext	Add-abd	Fle-ext	Add-abd
BR	29.5±15.2	1.7±3.3	30.2±14.2	3.5±4.6	30.8±11.6	3.6±5.2
LFC	-22.5±10.8	-14.2±4.8 ※	-24.1±8.7	-10.2±6.1	-26.3±9.2	-9.5±4.1
IMP	36.3±9.1	-54.2±4.8 ※	38.9±11.7	-48.2±6.1 †	40.4±8.5	-39.1±7.4

Unit : deg
※ : Significant difference : 60% vs. 80%, 100% ($P<0.05$)
† : Significant difference : 80% vs. 100% ($P<0.05$)
Fle-ext : Flexion (+) - extension (-), Add-abd : Adduction (+) - abduction (-)

standard deviation. The right hip joint fle-ext angle showed no significant difference between the degrees of effort at any phase. However, there was a significant difference in the right hip joint add-abd angle between the 60% trial and the 80% and 100% trials at the LFC, and the lower intensity, the greater the angle of abduction. There was also a significant difference between the IMP in the 60% trial and the 80% and 100% trials as well as between the 80% trial and the 100% trial, such that the lower intensity, the greater the angle of abduction was.

Table 2 shows the right knee joint angle, by intensity, using the average value and the standard deviation. At the BR, no significant difference was observed in any of the degrees of effort. At the LFC, a significant difference was found between the 60% trial and the 80% and 100% trials, and between the 80% trial and the 100% trials, and the lower intensity, the greater the right knee joint angle. Similarly, at the IMP, a significant difference was found between the 60% trial and the 80% and 100% trials as well as between the 80% trial and the 100% trial, such that the higher intensity, the greater the right knee joint angle was.

DISCUSSION: The right hip joint fle-ext angle (Table 1) showed no significant difference at any phase between the degrees of effort. However, at the LFC, the 100% trial had the greatest extension, followed by the 80% trial and then the 60% trial. This shows that at the LFC, the movement of the right leg occurs during back swing and seems to represent an action whereby extension of the right hip joint was adjusted depending on the kick distance, since a greater right hip joint extension during back swing yields a greater distance for forward swinging the right leg. The right hip joint add-abd angle (Table 1) showed a significant difference at the LFC between the 60% trial and the 80% and 100% trials, and the 60% trial had a greater angle of abduction than either of the others. A significant difference between the 60% trial and the 80% and 100% trials and between the 80% trial and the 100% trial was also found at the IMP, with the 60% trial having the greatest abduction angle and the 100% trial having the smallest abduction angle. This indicates that a smaller abduction angle of the right hip joint means the leg impacts the ball more vertically, while a greater abduction angle means the leg impacts the ball more horizontally. When the abduction angle is small, because the ball can be kicked up from below, the ball-kicking angle in the YZ plane can be increased, and when the abduction angle is high, because the ball will be kicked from the side, it becomes difficult to increase the ball kicking angle in the YZ plane, which indicates that adjusting the abduction angle will also adjust the ball kicking angle in the YZ plane.

Table 2. Angle of the right knee joint (Mean±SD)

	60%	80%	100%
BR	132.3±4.2	130.8±5.1	131.2±6.4
LFC	88.7±3.6 ※	84.1±2.6 †	80.2±3.1
IMP	154.3±5.5 ※	158.8±4.2 †	161.6±4.4

Unit : deg

※: Significant difference : 60% vs. 80%, 100% (P<0.05)

†: Significant difference : 80% vs. 100% (P<0.05)

There were significant differences between the 60% trial and the 80% and 100% trials and between the 80% trial and the 100% trials in the right knee joint angles at the LFC (Table 2), with the kickers exhibiting greater right knee joint angles during the 60% trial than during the other trials. At the IMP, significant differences were also found between the 60% trial and the 80% and 100% trials and between the 80% trial and the 100% trial, with the 100% trial having the greatest right knee joint angle in comparison to the others. This may mean that, as is the case with right hip joint fle-ext, the movement of right leg at the LFC occurs during backswing, and a smaller right knee joint angle toward the forward swing after the back swing makes it possible to lower the moment arm and can be expected to yield swing velocity for the foot, so that trials with a higher intensity had greater flexion of the right knee joint.

CONCLUSION: In comparison to lower effort punt kicks, the higher effort punt kicks involved increasing the hip joint extension angle for the right leg during the backswing and lowering the knee joint angle of the right leg at the start of the forward swing, thereby producing forward swing velocity for the right foot. Further, in the trials where the intensity of the punt kick was controlled, in addition to the hip joint abduction angle of the right leg was adjusted to control the ball kicking angle in the YZ plane. Our findings show that when the football goalkeeper adjusts the intensity in punt kicking, this adjustment is dealt with by adjusting the hip joint abduction and knee joint angle of the right leg.

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