A BIOMECHANICAL ANALYSIS OF CUTTING MOVEMENT WHILE RUNNING WITH CHANGE IN DIRECTIONS

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The purpose of this study was to investigate techniques of change of direction during running, and obtain findings to improve cutting movement. Thirty six male university students, who are soccer, basketball, rugby, and handball players, participanted in this study as subjects. In the experimental trials, subjects ran 30m straight and zigzag run with five changes of direction of 30, 60 and 90 degrees using side and cross step. Twenty subject's runs were chosen for further analysis based on the time of 30m straight run and an index of change of direction. There were significant correlations between the time of zigzag running and the index of change of direction. The results suggested that the time of zigzag running was affected not only by the ability to run straight but also by the techniques of changing direction in running.

KEY WORDS: side step cut, cross step cut, change of direction

INTRODUCTION:

In most of the ball games, players must change direction during running at offence and defence. In such case, the ability to quickly change direction could play an important role to control the game as well as running fast. Andrews et al. (1977) described two ways of changing running direction: 1) the side step cut, in which direction is changed by planting one foot to the opposite direction, and 2) the cross step cut, in which after planting one foot the other leg crosses in front of body providing acceleration in the new direction. Numerous studies suggested that the time of running with change of direction was affected by the speed of straight running and the muscular power of the lower limbs. However, Young et al. (2002) showed that techniques of cutting also affected the time of running with change of direction. Tanaka et al. (1999) reported that it was not correlation between the time of straight running and zigzag runs but among time of zigzag runs with different angles of direction change. It seems that there was a certain technique to change running direction quickly regardless of the angle of direction change. Besier et al. (2001) compared planned and unplanned cutting movements and reported that the running speed was significantly slower and the knee joint was significantly more loaded in the unplanned cutting task. Preparatory motion may play a crucial role in changing direction during running. So, to investigate direction change in running, it is advised to include the motions of prior to and after the turning motion in the analysis. Therefore, the purpose of this study was to investigate techniques of change of direction during running, and obtain findings to improve cutting movement.

METHOD:

Data Collection: Thirty-six male university students (age 19.7±1.3yrs, height 1.74±0.05m, body mass 66.2 ± 5.2kg) , who are soccer, basketball, rugby, and handball players, participated as subjects in this study. They performed 30m straight run (SR) and three different zigzag runs (ZR) with side step cut (SS) and cross step cut (CS). Angles of change of direction during zigzag runs were 30, 60 and 90 degrees. The trials of twenty subjects were chosen for further analysis based on the time of 30m straight run and the index of change of direction (explained later). All trials were videotaped at 60 frames/s with two digital video cameras to analyse the motions of three support phases, prior to cutting (SP1), cutting (SP2) and after the cutting (SP3), and the time of the runs were measured using the photocell timer.

Data Analysis: Twenty-five body landmarks were digitized and their three-dimensional coordinate data were reconstructed using a DLT method. The coordinate data were smoothed using a Butterworth digital filter at cut-off frequencies 2.4 to 8.4Hz chosen by a residual analysis. The center of gravity (CG) of each segment was estimated by using Japanese athlete's body segment parameters (Ae, 1996). The velocity of the whole body CG (CGV) was obtained by differentiating the CG coordinates at the foot strike (FS1, 2 and 3), mid-support (MS1, 2 and 3) and toe off (TO1, 2 and 3) for each support phase. The angle of change of direction in running (ACDR) was defined as the angle between the vectors of the horizontal CGV at the foot strike (FS) and toe off (TO). The ground reaction force (GRF) was estimated from the acceleration of the whole body CG. The horizontal component of the GRF was divided into the parallel and normal directions of the CGV.
Index of change of direction: Figure 1 shows the correlations between the mean speeds of ZR by SS and the angles of change of direction for subjects N and H. The regression lines were calculated using the least square method. SR was considered as a ZR with change of direction of 0 degree, so that the mean speed of SR was set as the intercept of the regression line. The index of change of direction (ICD) was calculated by dividing the absolute values of the inclination of the regression line by the y-intercept of that line. Therefore, the values of the ICD indicate the ratio of decrease of the mean running speed caused by the increase in the angle of change of direction.

RESULTS AND DISCUSSION:
Figure 2 presents the times of 30m straight and the zigzag running. In both zigzag runnings (SS and CS), the times were longer when direction changes were 90 degrees than when they were 60 ($p<0.001$) and 30 degrees ($p<0.001$), and when longer in 60 degrees were used compared to 30 degrees ($p<0.001$). No significant differences between SS and CS were found in any of the 3 degrees used. There was also no significant differences in the ICD between SS (0.30 ± 0.02) and CS (0.31 ± 0.02) and neither significant correlations between thse ICDs and the times of SR. Because of decrease of mean running speed the angle of change of direction, that is ICD was larger in subject N (0.35) than subject H (0.27), the mean speed of SS of 90 degrees was smaller in subject N than subject H, despite a larger mean speed of SR of subject N (Figure 1). Figure 3 shows the correlation coeficients between the time of the zigzag runs and ICD. There were positive correlations between ICD and the time of ZR in all SS and CS runs, which suggests that the time of ZR was affected not only by the speeds of straight running, but also by the techniques of change of direction in running.

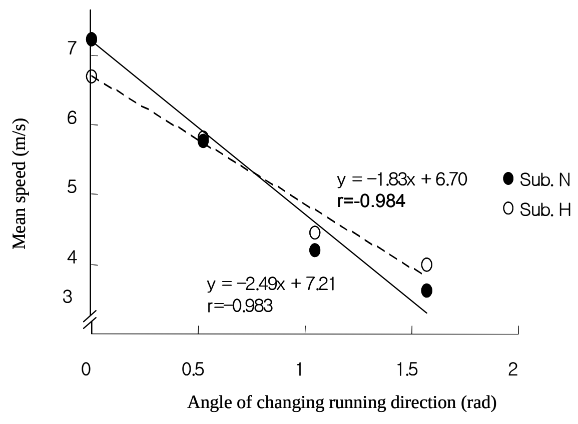

Fig.1 Relationship between mean speed and angle of changing running direction.

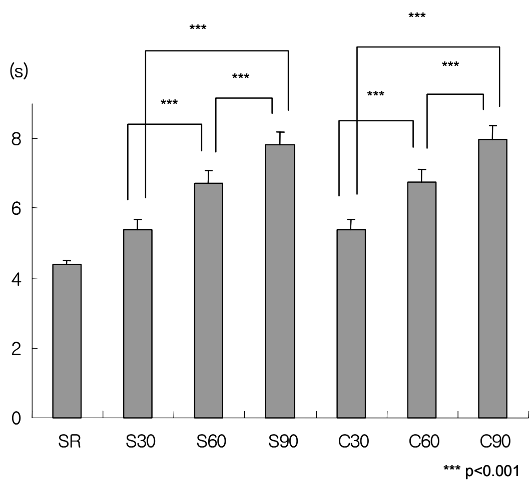

Figure 2 The time of the 30m straight running and the zigzag running.

Figure 4 shows the horizontal component of the CGV at the foot strike (FS), mid-support (MS) and toe off (TO) and figure 5 shows the CG horizontal displacement with the FS and TO instants in SS of 60 degrees for subject T and K, who respectively had the low (0.29) and high ICD (0.33). Figure 4 shows that subject T had smaller CGV in support phase1, but greatly accelerated from MS2 to TO3 compared to subject K, who showed small changes of CGV from SP1 to SP3. In figure 5, the maximum CG displacements in the x direction for subjects T and K were 2.15m and 2.51m, respectively. Chang and Kram (2007) suggested that a reduction in peak ground reaction forces plays a siginificant role in limiting speed during curve sprinting. That is, this suggestions indicates that the angle of direction change was affected not only by the ground reaction forces but also by the running speeds. From these results, subject T covered less distance than subject K by decelerating his CGV in SP1 and accelerating quickly after the change of direction. As a result, the time of zigzag running of subject T was shorter than that of subject K.

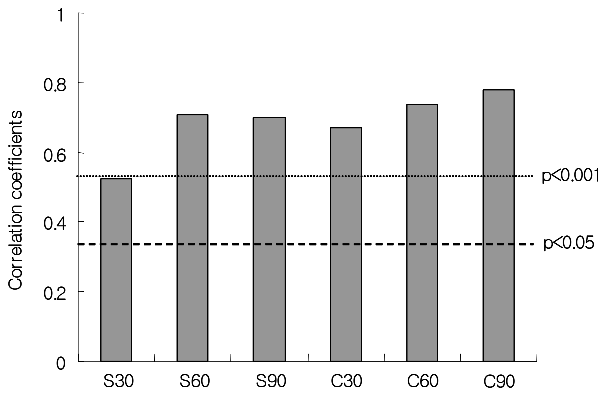

Figure 3 Correlation coefficients between the time of zigzag running and the index of change of direction(ICD).

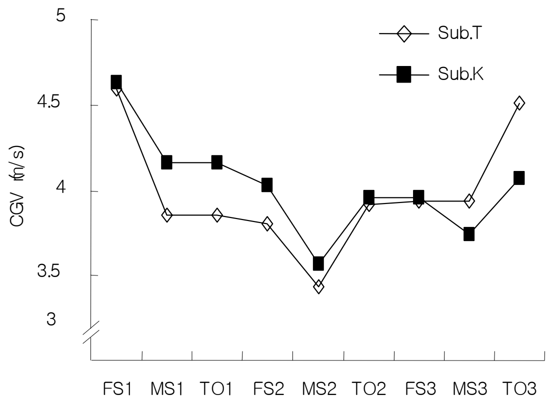

Figure 4 The horizontal velocity of the center of gravity (CGV) at foot strike(FS), mid-support(MS) and toe off(TO) for subject T and subject K.

Figure 6 shows the mean force normal to the CGV (MFnv) in SP1, SP2 and SP3 for subject S and M in C60. Subject S had low ICD (0.28) and subject M had high ICD (0.34). MFnv of subject S was larger in all three support phases, particularly in SP1 and SP2. The horizontal displacement of CG, both hips and the support foot for subject S and M are ploted in figure 7. While the subject S planted his foot in a nearly constant distance from the CG in the three support phases, subject M planted his foot closer to the CG at FS2.

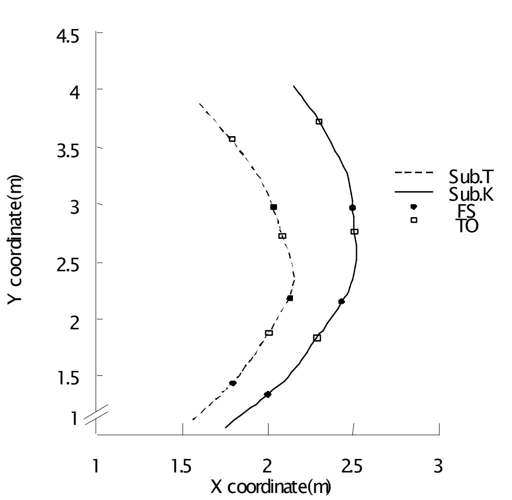

Figure 5 The X and Y coordinates of the center of gravity for subject T and subject K.

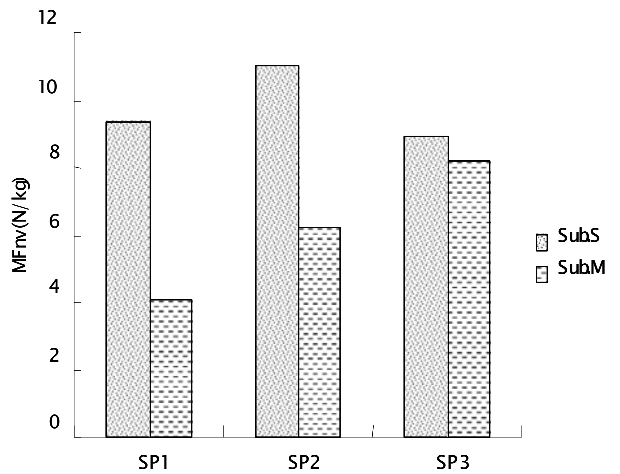

Figure 6 The mean force normal to velocity of the center of gravity (MFnv) in 3 support phases for subject S and subject M.

The angle between the vector connecting the hips and the CGV of subjects S and M at FS2 were 54.5 and 97.5 degrees, respectively. The distance from the CG to support foot of subjects S and M at FS2 were 0.47m and 0.21m, respectively. Mcclay and Cavanagh (1994) reported significant positive correlations between the mediolateral component of GRF and the distance from the CG to the support foot in the frontal plane. In our study, subject S positioned his left hip more forward than subject M at FS2 increasing the distance between the CG and the support foot. Becasuse of this, MFnv also increased and subject S could keep greater CGV during the change of direction. Although the left hip was positioned foward at FS2, subject S positioned the right hip forward at the TO2, which increased the horizontal distance between the CG and the support foot at FS3. Therefore, to keep great CGV during the change of direction, it is important to plant the support foot widely and rotate the hip from FS2 to TO2.

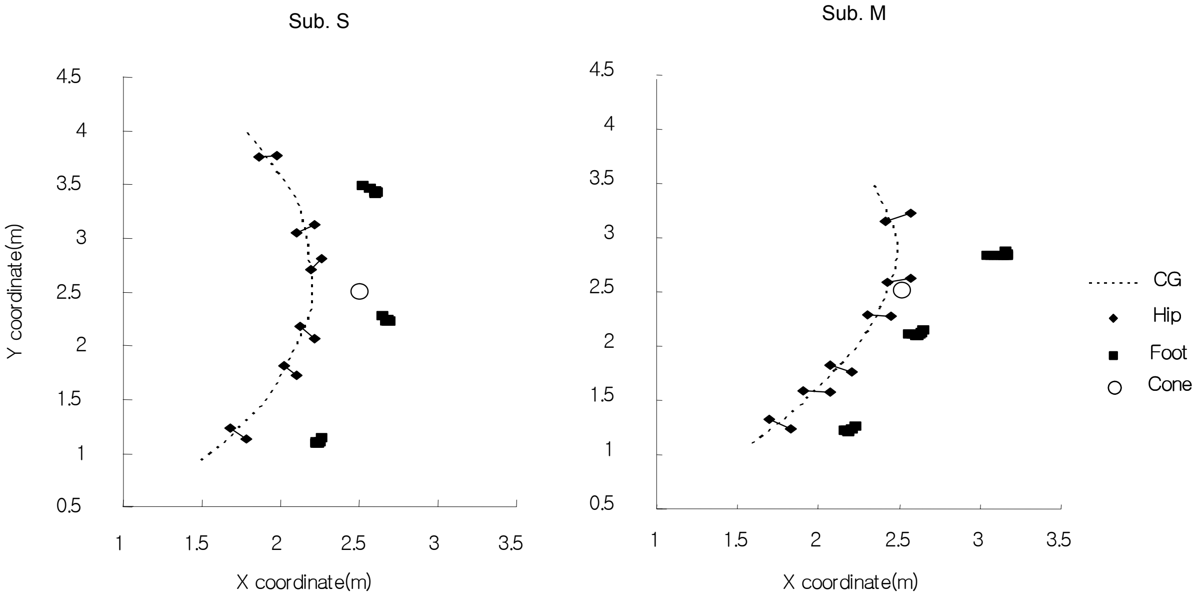

Figure 7 The X and Y coordinates of the center of gravity, the hip and the foot of support leg for subject S and subject M.

CONCLUSION:

The time of zigzag running was affected not only by the ability to run straight but also by the techniques of change of direction. Different techniques were used in SS and CS to improve the time of running in zigzag. In SS, to change direction quickly, it is important that the CGV be decelerated at SP1, so that strong support at SP2 enabling great acceleration at SP3. In CS, it was important to plant the support foot widely and rotate the hip to change of direction quickly during running.

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