CHANGE OF DIRECTION MOTION DURING THE DEFENSIVE PHASE IN SOCCER PLAYERS

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The purpose of the this study was to the change of direction (COD) movement in the backward direction during the defensive phase. Thirteen male soccer players performed the reactive agility test (RAT) and sprint running. Analysis classified the players to two groups according to the RAT time. There was no significant difference in sprint times, but RAT of the fast group was significantly faster than that of the slow group. Before and after COD of RAT, the fast group had made a deceleration quickly by high-step frequency. In the COD movement, the fast group performed the movement with their body tilted backward while lowering their center of gravity with the hip of the COD foot bent before COD and smaller knee flexion displacement during COD support phase. These findings seem to be a basic knowledge for evaluation and training of COD in soccer.

KEY WORDS: agility, backward, reactive, three-dimensional

INTRODUCTION: In soccer games, players are required to do various movements, such as kicking, sprinting, and change of direction (COD), for offence and defense. A soccer player always moves with the ball or to cover an opponent, and is required to perform many quick COD movements in response to external stimuli. Such COD ability is used as an indicator of physical and talent evaluations (Reilly et al., 2000). Therefore, such COD movement is very important for offence and defense in soccer. Focusing on COD in the defensive phase during the game, defenders reported that COD from 90° to 180° is more compared to other positions (Ade et al., 2016). Thus, there are many COD movements to the backward with a large angle. Quick backward COD will greatly affect the success of the defense. However, in previous studies, cognitive factors are not involved in trials. Moreover, these studies examining COD movements using actual game images did not evaluate the COD movement (Sasaki et al., 2013). On the basis of the above-mentioned findings, the features of quick COD in the defensive phase should be clarified using trials with external stimuli. Therefore, the purpose of this study was to investigate the COD movement in the backward direction in the defensive phase.

METHODS: Participants were 13 male college soccer players (Mean ± SD age 19.75 ± 0.75 years, height, 174.5 ± 5.61 cm, body mass 69.25 ± 4.05 kg). All procedures undertaken in the study were approved by the Ethics Committee for the Institute of Health and Sport Sciences, University of Tsukuba, Japan. Participants performed 13 m sprint and reactive agility test (RAT) with light stimulus. For the 13 m sprint were instructed to sprint with maximal effort from a standing position. In RAT, they moved forward 8 m from the start, turned at 135°, and then moved 5 m further (Fig.1a). The participants passed the timing gate (Fusion Sport, Smartspeed) installed at the 5 m point, which determined the moving direction through the presented light stimulus. Five trials were conducted, and at that time, light stimulus (either to the right or left) was randomly presented. They were instructed to step on the 8 m line at COD and to do RAT as soon as possible. In the RAT, the whole trial was videotaped using a video camera (Panasonic, HC-V300M, 60 Hz), with the range of one step before and after COD was videotaped using two high-speed cameras (Sports-sensing, GC-LJ20B, 300 Hz). The 13 m sprint and RAT times were measured using a photoelectric tube. In the RAT, the data from the trials for rightward movements were analyzed. Based on the average value of the RAT for rightward movements, the top 7 subjects were assigned to the

fast group and the bottom 6 were assigned to the slow group. The trials with the fastest time were taken as the analysis target trials. In one step before and after COD of RAT (Fig.1b), the elapsed time, step frequency, step length, contact time, and the cummulative time (the point of time when the COD one step before foot contacted the ground was taken as zero, and the time taken until each event) were calculated as step parameters. For motion description, 23 body landmarks were digitized, and their three-dimensional coordinate data were reconstructed using a DLT method. These data were smoothed by a Butterworth digital filter with cut-off of 7.5 to 15 Hz. The calculation variables, such as the body center of gravity (CG) velocity, body CG height, inclination angle of the body, the hip joint angle, the knee joint angle, the ankle joint angle, and inclination angle of the shank, were calculated from these coordinates. These data were normalized with the time taken by the subject to perform the three steps (from the COD one step before, the COD foot, and the COD one step after) from the ground contact to take-off from 100% as a 100%, and averaged per 1%.
One step before and after COD of RAT was divided into the following phases (Fig.1b): (1) COD foot contact pre-phase: from COD foot one step before at contact to COD foot at contact, (2) COD foot support phase: from COD foot at contact to COD foot at take-off, (3) COD foot take-off post-phase: from COD foot at take-off to COD foot one step after take-off.
The COD foot support phase was divided into the following two periods: the deceleration period is from the COD foot at contact to the lowest point of the CG velocity, and the acceleration phase is from the lowest point of the CG velocity to the COD foot at take-off.
An unpaired t test was conducted to compare each variable between the groups; the significance was $p < 0.05$.

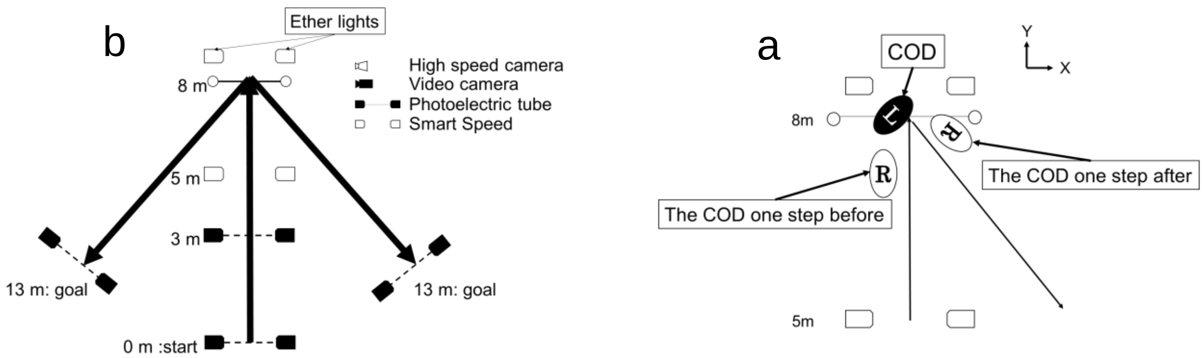

Figure1: The experimental set up.
a: The experimental set-up in RAT. b: The analysis of the target range in the RAT.

RESULTS AND DISCUSSION:

Features of the time, step and CG velocity parameters: Table 1 shows the 13 m sprint and RAT times. In the 13 m sprint times, no significant difference was observed in any section, whereas the RAT times was significantly shorter in the fast group than those of the slow group. Therefore, these results showed that RAT in this study is not affected by sprint ability. Table 2 shows the step parameter. There was no significant difference in the elapsed time, step length, and contact time between the groups. However, the fast group showed a significantly higher step frequency before COD. Furthermore, the time until the COD foot contacted the ground was shown to be significantly shorter in the fast group than in the slow group. Hewit et al. (2013) indicated that that adjustment of step frequency and step length can minimize time loss in COD. Therefore, the fast group increased step frequency while maintaining the appropriate step length and contact time within the same elapsed time, which is considered to have shortened the cumulative time to COD foot at contact. Also, in the CG velocity, no significant difference was observed in the COD foot supporting phase, but the time to the lowest point of the CG velocity was significantly shorter in the fast group (Table 2). Therefore, the fast group finished decelerating early. On the basis of the above-mentioned findings, early deceleration was shown to be important for COD.

Table1: Mean sprint times and RAT times (±SD) for the each group.

	13 m sprint time (s)			RAT time (s)			
	0-3 m	0-5 m	0-13 m	0-3 m	0-5 m	5-8 m	0-13 m
Fast group	0.59 ± 0.04	0.90 ± 0.06	2.02 ± 0.06	0.59 ± 0.03**	0.95 ± 0.03*	1.99 ± 0.06***	2.94 ± 0.07***
Slow group	0.60 ± 0.03	0.93 ± 0.03	2.07 ± 0.05	0.66 ± 0.05**	1.00 ± 0.05*	2.12 ± 0.03***	3.13 ± 0.04***

Table2: Mean Step parameter (±SD) for the each group.

	Elapsed time (s)	Step frequency (step/s)		Step length (m)		Contact time (s)		
		before COD	after COD	before COD	after COD	before COD foot	COD foot	after COD foot
Fast group	0.32 ± 0.03	17.77 ± 3.33**	6.81 ± 1.12	0.65 ± 0.06	0.73 ± 0.08	0.09 ± 0.03	0.15 ± 0.02	0.12 ± 0.02
Slow group	0.34 ± 0.05	14.01 ± 1.48**	7.11 ± 0.99	0.59 ± 0.08	0.66 ± 0.12	0.09 ± 0.01	0.16 ± 0.04	0.12 ± 0.01

	Comulative time (%)						The time to the lowest point of the center of gravity velocity (s)
	COD foot one step before at contact	COD foot one step before at take-off	COD foot at contact	COD foot at take-off	COD foot one step after at contact	COD foot one step after at take-off	
Fast group	0	27.83 ± 7.91	17.39 ± 3.24**	65.34 ± 3.33	62.55 ± 7.36	100	0.12 ± 0.01***
Slow group	0	27.27 ± 4.56	21.60 ± 2.22**	68.29 ± 4.14	64.46 ± 4.27	100	0.15 ± 0.02***

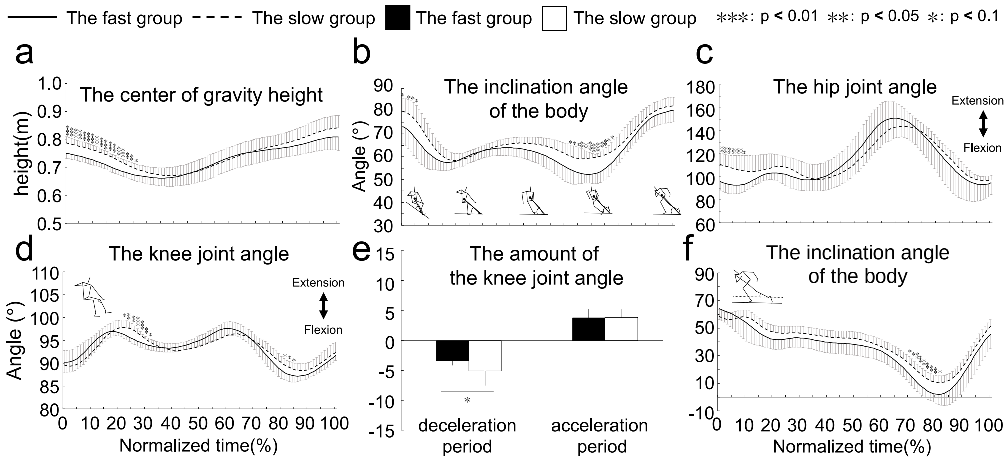

Figure 2: The parameter about COD movement.

Features of COD movement in each phase: To clarify motions affecting the above results, features of movement on each phase are shown for each of the three aspects of COD foot contact pre-phase, COD foot support phase, and COD foot take-off phase.

<u>COD foot contact pre-phase:</u> Fig.2a and Fig.2b shows the CG height and the inclination angle of the body. The fast group had a significantly lower CG height before COD foot contact and tended to be inclined backward compared to the slow group, indicating that the fast group tilted their body while holding a low CG height before COD foot contact. Previous studies have reported that the low CG height and the fact that the CG is located behind the supporting legs during deceleration are necessary for COD (Andrew et al.,1997). Considering that the fast group made deceleration early, it is considered that the low CG height and body tilting backward before COD foot contact enabled early deceleration. Fig.2c shows the hip joint angle on the COD leg. The fast group was in a significantly flexed position compared to the slow group. This flexion is the recovery motion of the swing leg. Moreover, step frequency was high and the cumulative time until the COD foot contact was short in the fast group (Table 2). Thus, it suggested that accelerating the recovery motion of the swing leg shortened the cumulative time and increased the step frequency before foot contact.

<u>COD foot support phase:</u> Fig.2d and Fig.2e shows the knee joint angle and its degree on the COD leg. The fast group was in a significant flexion position and tended to have a smaller degree of flexion in the deceleration period compared to the slow group. A previous study reported that a quick COD reduces bending of the hip and knee joints after COD foot contact (Kameda et al., 2017). Considering that the time to the lowest point of the CG velocity is short in the fast group, reducing the flexion degree with the knee joint in the flexion position had an effect on the early termination of the deceleration.

COD foot take-off post-phase: Fig.2b and Fig.2f shows the inclination angle of the body and shank. In the fast group, the body and shank were significantly inclined forward compared to the slow group. In the sprinter, it is considered reasonable to tilt forward the shank (Ito et al.,1998). Therefore, inclining the body and shank to forward may influenced the acceleration of COD.

Features of ankle joint motion of COD foot: Figure 3 shows the ankle joint angle. The fast group had a tendency to have a dorsi-flexion of the ankle before the COD foot contact, and the dorsiflexion of the ankle tended to be large immediately after the COD foot contact compared to the slow group. The ankle of sub.A in the fast group was dorsiflexed after the COD foot contact (c), whereas that of sub.B in the slow group was dorsiflexed after bottom-lexing once after COD foot contact (d). This is because the ankle joint of sub.A was dorsiflexed as it is grounded at the bottom flexion level when the COD foot contacted. It has been reported that the ankle joint of the support foot in the elite sprinter is dorsiflexed just after the contact (Ito et al., 1998). Therefore, it may that sub.A was able to decelerate with a similar grounding method as the elite sprinter's.

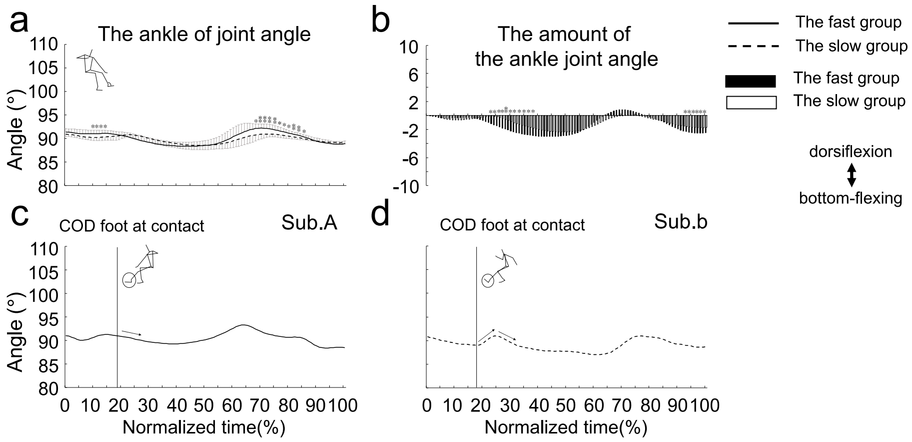

Figure 3: The parameter about the ankle joint angle.

CONCLUSION: The main results of this study were: (1) There was no significant difference in sprint times in any groups in terms of RAT; (2) In the RAT, the fast group had a significantly high-step frequency and shorter cummulative time to COD foot at contact, the time to the lowest point of CG velocity; (3) The fast group had a low CG height and tilted backwards before COD foot contact, had a hip flexion recovery motion of the swing leg, and reduced the flexion amount of the knee joint during the deceleration period. From these movements, the COD foot contact became faster, and deceleration appeared early. These findings provide basic knowledge for evaluation and training of COD in soccer.

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