COMPARISON OF THE ACCELERATION PHASE OF SPRINTING BETWEEN COLLEGE SPRINTERS AND COLLEGE BASEBALL PLAYERS

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The purpose of this study was to examine and compare the sprinting movement of college sprinters and college baseball players, the latter are assumed to be specialized in the acceleration phase. Twenty subjects, 10 sprinters and 10 baseball players, participated in this study. Lower limbs joint angle (hip, knee and ankle), step length, step frequency, contact time and position of the center of mass at the toe-on and the toe-off were calculated. The results indicated that the center of mass of baseball players was located behind that of sprinters at the 3rd step toe on (p 0.008). In addition, the knee joint was significantly extended at the toe-on in the baseball players at the first and the second steps .These observations indicate that baseball players tend to contact with their foot more forward, and with their knees extended, compared to sprinters.

KEY WORDS: kinematics, center of mass, toe-on, toe-off.

INTRODUCTION: Sprint speed is required in various sports. Many biomechanical studies that explored factors for achieving faster sprint speed have mainly examined sprinters as subjects (e.g., Slawinski et al., 2010; Coh et al., 2017). This is probably because sprinters are specialized in sprinting performance itself. However, as far as the early acceleration phase in sprinting is concerned, some other athletes are likely to be superior to the sprinters (Callaghan et al., 2015). Indeed, in many field sports the explosive acceleration is performed more frequently than the near-maximum speed sprinting (Reilly, 1997). Thus, field sports athletes might be particularly adapted to the early acceleration phase and differ from the sprinters in terms of the acceleration movements. The purpose of this study was to examine and compare the sprinting movement of college sprinters and college baseball players, who are assumed to be specialized to the acceleration phase.

METHODS: Ten sprinters and ten baseball players participated in this study (Table 1). These participants were picked out from an athletics club and a baseball club of the same university. Prior to the biomechanical experiment, a preliminary sprint test was conducted using a laser distance measuring device (Trusense S210, Laser Technology, Colorado, USA), to select the ten fastest club members of each club. This preliminary test was conducted on artificial grass. Each participant wore running shoes and was instructed to sprint as fast as possible from a standing posture.

Table 1: Characteristics of subjects

Subject	Age (yr)	Height (m)	Weight (kg)
Sprinters (±SD)	21.0 ± 1.2	1.76 ± 0.06	69.0 ± 5.9
Baseball Players (±SD)	19.8 ± 1.1	1.72 ± 0.05	67.0 ± 8.6

The sprinting action of participants was recorded using a three-dimensional optical-electronic motion capture system (VICON, Oxford Metrics, Oxford, UK) consisting of 12 digital cameras (200Hz). Thirty-three reflective markers (12 mm diameter) were placed on each subject's body (Figure 1). Prior to the biomechanical experiment, each participant was made to warm-up sufficiently. This experiment was conducted on a rubber surface and with running shoes. Each participant was instructed to sprint as fast as possible from a standing posture. As the early acceleration phase, the sprinting movement from the first to the third step were picked out for analysis. The data of 3D coordinates acquired by the motion capture system were smoothed using a fourth-order Butter worth low-pass filter (Winter, 2004) with a cutoff frequency of 8 Hz (Arampatizis et al., 1999). Based on these data, a 2D link-segment model was constructed and kinematic variables were calculated with programming software, MATLAB (MathWorks, Natick, USA). The variables were joint angles of lower-limb (θ_{hip} [deg]: hip extension-flexion angle, θ_{knee} [deg]: knee extension-flexion angle, θ_{ankle} [deg]: ankle plantarflexion-dorsiflexion angle), step length (SL [m]: distance from a toe-maker at toe-off to the opposite toe-maker at the subsequent toe-on), step frequency (SF [Hz]: number of ground contacts per second), contact time (CT [s]:duration of the stance phase), and sagittal angle of the center of mass from the toe (θ_{toe_COM}). The detailed definition of θ_{COM} is shown in Figure 2. For the statistical analysis, unpaired t-tests were performed. Significance level was set at $p < .05$.

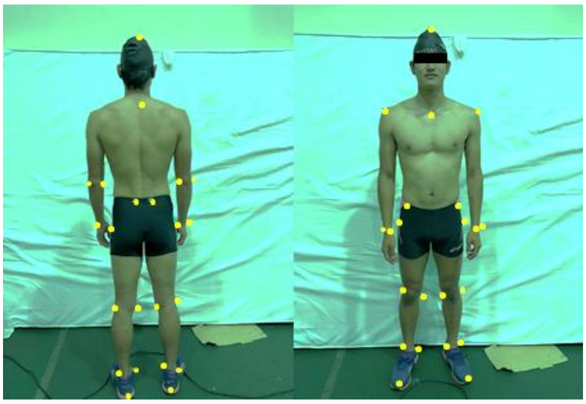

Figure 1: Location of the markers.

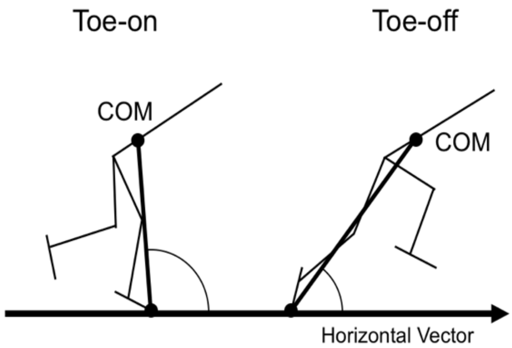

Figure 2: Definition of the θ_{toe_COM}.

RESULTS: For SL, SF and CT, no significant differences were observed between the groups regardless of the step (Table 2). Table 3 shows the results of the joint angles at the first step. At the moment of the toe-off, θ_{knee} (p=0.013) and θ_{ankle} (p=0.005) of swing leg were significantly larger in baseball players than in sprinters. The results of the joint angles at the second step are shown in Table 4. At the toe-off, θ_{knee} (p=0.010) of swing leg was significantly larger in baseball players than in sprinters. Besides, Table 5 shows the results of the joint angles at the third step. At the toe-on, significantly larger θ_{hip} (p=0.006) of swing leg was observed in baseball players than in sprinters. At the toe-on of third step, θ_{toe_COM} was significantly larger in baseball players (p =.008) than in sprinters (Figure 3a), whereas at the toe-off no significant differences were observed between the groups regardless of the all steps (Figure 3b). This result indicates that the baseball players contacted with their toes more forward compared to the sprinters.

Table 2. Group values of SL, SF and CT

Variable		Sprinters (n=10)	Baseball players (n=10)
	SL (m)	1.03 ± 0.11	0.99 ± 0.14
first step	SF (Hz)	3.62 ± 0.45	3.70 ± 0.32
	CT (s)	0.18 ± 0.02	0.18 ± 0.01
	SL (m)	1.20 ± 0.12	1.23 ± 0.17
second step	SF (Hz)	3.89 ± 0.49	3.97 ± 0.39
	CT (s)	0.15 ± 0.02	0.16 ± 0.01
	SL (m)	1.34 ± 0.15	1.31 ± 0.17
third step	SF (Hz)	4.11 ± 0.38	4.10 ± 0.58
	CT (s)	0.13 ± 0.01	0.14 ± 0.01

† p<0.05

Table 3. Joint angles at the first step.

Variable			Sprinters (n=10)	Baseball players (n=10)
Support leg	θ_{hip}	Toe-on	111.1 ± 10.7	114.2 ± 8.1
		Toe-off	173.5 ± 5.7	172.9 ± 6.8
	θ_{knee}	Toe-on	121.2 ± 11.5	124.5 ± 5.3
		Toe-off	160.0 ± 8.0	162.5 ± 4.0
	θ_{ankle}	Toe-on	70.4 ± 6.6	70.9 ± 4.9
		Toe-off	115.5 ± 4.5	117.1 ± 6.6
Swing leg	θ_{hip}	Toe-on	158.6 ± 9.1	164.0 ± 6.6
		Toe-off	86.0 ± 5.0	84.5 ± 6.7
	θ_{knee}	Toe-on	121.0 ± 13.7	121.9 ± 10.3
		Toe-off	98.1 ± 4.6	110.1 ± 11.0 †
	θ_{ankle}	Toe-on	114.1 ± 5.8	114.9 ± 10.3
		Toe-off	70.8 ± 3.9	76.1 ± 4.7 †

† $p<0.05$

Table 4. Joint angles at the second step.

Variable			Sprinters (n=10)	Baseball players (n=10)
Support leg	θ_{hip}	Toe-on	111.7 ± 7.2	108.1 ± 6.2
		Toe-off	174.1 ± 3.5	173.3 ± 6.5
	θ_{knee}	Toe-on	125.8 ± 8.5	129.4 ± 5.9
		Toe-off	160.8 ±6.6	159.3 ± 6.0
	θ_{ankle}	Toe-on	67.7 ± 7.9	72.0 ± 5.1
		Toe-off	115.7 ±5.6	111.7 ± 6.4
Swing leg	θ_{hip}	Toe-on	150.6 ± 7.5	156.1 ± 8.9
		Toe-off	86.8 ± 6.6	87.9 ± 7.6
	θ_{knee}	Toe-on	101.5 ± 14.5	107.1 ± 13.9
		Toe-off	93.7 ± 10.6	106.7 ± 9.4 †
	θ_{ankle}	Toe-on	110.0 ± 6.8	114.2 ± 7.2
		Toe-off	74.9 ± 5.0	77.7 ± 3.8

† $p<0.05$

Table 5. Joint angles at the third step.

Variable			Sprinters (n=10)	Baseball players (n=10)
Support leg	θ_{hip}	Toe-on	115.9 ± 7.3	113.6 ± 5.2
		Toe-off	173.8 ± 2.3	175.7 ± 3.5
	θ_{knee}	Toe-on	130.5 ± 10.1	132.5 ± 5.8
		Toe-off	159.4 ± 4.6	163.1 ± 4.8
	θ_{ankle}	Toe-on	69.5 ± 7.7	71.7 ± 5.8
		Toe-off	104.0 ± 10.5	105.5 ± 5.6
Swing leg	θ_{hip}	Toe-on	147.5 ± 12.8	161.5 ± 6.2 †
		Toe-off	89.0 ± 6.7	96.4 ± 7.4
	θ_{knee}	Toe-on	85.4 ± 15.7	96.1 ± 13.6
		Toe-off	82.6 ± 5.9	90.2 ± 18.3
	θ_{ankle}	Toe-on	106.8 ± 7.6	108.8 ± 7.9
		Toe-off	78.4 ± 5.4	81.8 ± 6.0

† $p<0.05$

DISCUSSION: For the support leg, there were no significant differences in the joint angles between the groups regardless of the all steps. This suggests that the movement to kick the ground were similar between the sprinters and baseball players. The result obtained in this study differs from those in the preceding studies that investigated the biomechanics of sprint acceleration and found that the joint kinematics of the drive leg were related to the subject's attributes (Lockie et al., 2012; Lockie et al., 2014). Contrary to the previous studies results on support leg, θ_{toe_COM} was significantly larger in the baseball players than in the sprinters ($p = 0.008$) at the toe-on of the third step (Figure 3a). In addition, the knee joint was significantly extended at the toe-on in the baseball players at the first and the second steps (Table 3 and 4). These observations indicate that baseball players tend to contact with their foot more forward, with their knees extended, compared to sprinters. Overviewing the previous research on the sprint acceleration (e.g., Slawinski et al., 2010), there have been few studies showing results related to the contact position of the swing leg. Nevertheless, the limitations of this study are that the subjects of this study were college athletes and that only baseball players were examined as field sports athletes. Therefore, further research on various backgrounds of field sports athletes is needed to clarify the adaptation to the sprint acceleration.

CONCLUSION: This study compared kinematics of the acceleration in sprinting between ten college sprinters and ten college baseball players. The results indicate that baseball players tend to contact their foot more forward, with their knees extended, compared to sprinters. These observation are considered to be a characteristic difference between sprinters and field sports athlete.

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