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A CASE STUDY ON GROUND REACTION FORCES IN SPRINT HURDLES

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The purpose of this case study was to investigate characteristics of ground reaction forces in sprint hurdles. Four male Japanese hurdlers participated in this study. The 1-cycle motions from 5th to 6th hurdles were videotaped with two high-speed cameras (300Hz) and ground reaction forces were measured (1000Hz). The hurdler who had smaller horizontal velocity of CG during hurdling had large braking time, which increases impulses of both horizontal and vertical components at 1st step. Therefore, maintaining large horizontal velocity during hurdling seems to be one of the important factors in sprint hurdles.

KEY WORDS: support time, flight time, impulse

INTRODUCTION: Sprint hurdlers are required to run from start to finish as fast as possible like sprinters. McDonald (2002) reported that ‘Elite hurdlers must have excellent sprint speed, however hurdling requires adaptations to each of four steps.’ Therefore, it is thought that not only high sprint speed, but also the appropriate technique of the interval running and hurdling motion are required for high performance in sprint hurdles. There are a few studies about sprint hurdlers analyzed from ground reaction forces. McLean (1994) reported on the ground reaction forces occurring in hurdling. He described that ‘the vertical component of the ground reaction force in landing represents a controlled lowering of the body’s centre of gravity.’ Coh (2004) reported that the braking time of the support phase must be as short as possible in order to maintain the horizontal velocity of the CG. However, they mentioned only one phase of sprint hurdles and there was no information about ground reaction forces during four steps in sprint hurdles. The purpose of this case study was to investigate characteristics of ground reaction forces of Japanese top hurdlers.

METHODS: Four male Japanese hurdlers participated in this study (Height: 1.84±0.01m, Mass: 75.4±1.3kg, Age: 20.8±1.0years, Season best: 13.84±0.05s). Figure 1 shows the summary of experimental setup. Each athlete completed two trials from starting block to landing at 6th hurdle. The motions from landing at 5th hurdle to landing at 6th hurdle (1-cycle motions) were videotaped with two high-speed cameras (CASIO EXILIM EX-F1, 300Hz) which were panned. The step length, support time and flight time at each step during 1-cycle motions were calculated from videotaped data. Ground reaction forces at each step during 1-cycle motions were measured with six Kistler force platforms (totally 5.4m-long, 9287A, 1000Hz). The impulses and braking times at each step during the 1-cycle motions were calculated from ground reaction force data. For reasons of experimental settings, the 1st and 2nd steps were analyzed with first trial data, while the 3rd and 4th steps were analyzed with second trial data. And then, there were small differences in 1-cycle time and step length between first trial (1-cycle time: 1.17±0.04s, step length: 1st step 1.33±0.03m; 2nd step 2.06 ±0.06m; 3rd step 1.93±0.05m; 4th step 3.77±0.08m) and second trial (1-cycle time: 1.15± 0.03s, step length: 1st step 1.37±0.08m; 2nd step 2.06±0.08m; 3rd step 1.94±0.06m; 4th step 3.67±0.15m).

RESULTS: Table 1 shows the basic parameters of 1-cycle motion for all participants in this study. The largest values of step length, support time, flight time and braking time were obtained at the 4th step. The second largest values of the above parameters were obtained at the 2nd step.

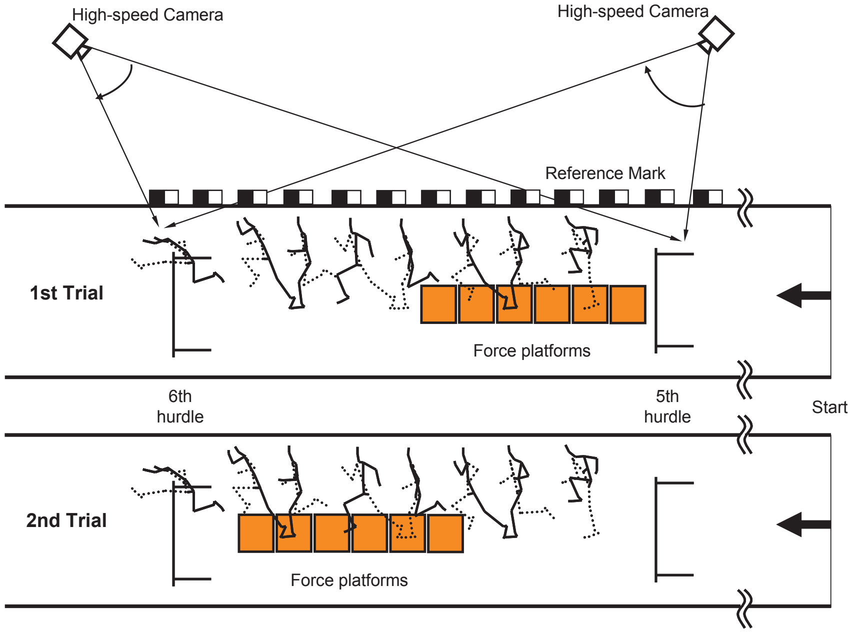

Figure 1: The experimental setup.

Table 1
Calculated parameters at each step.

Parameters	Step	Subject A	Subject B	Subject C	Subject D
1-cycle time (s)		1.19	1.16	1.12	1.10
Step length (m)	1st	1.35	1.36	1.29	1.33
	2nd	2.04	2.07	1.99	2.12
	3rd	2.02	1.95	1.88	1.89
	4th	3.81	3.61	3.75	3.47
Step frequency (step/s)	1st	6.12	6.00	7.50	6.38
	2nd	3.61	3.66	4.17	3.85
	3rd	4.48	4.69	4.69	5.08
	4th	1.88	1.97	1.88	2.08
Support time (s)	1st	0.10	0.10	0.09	0.09
	2nd	0.13	0.13	0.14	0.12
	3rd	0.13	0.13	0.13	0.11
	4th	0.14	0.13	0.14	0.13
Flight time (s)	1st	0.06	0.07	0.04	0.07
	2nd	0.15	0.14	0.10	0.14
	3rd	0.10	0.09	0.08	0.09
	4th	0.39	0.38	0.39	0.35
Braking time (s)	1st	0.05	0.04	0.03	0.03
	2nd	0.06	0.05	0.06	0.05
	3rd	0.05	0.05	0.05	0.04
	4th	0.08	0.08	0.08	0.08

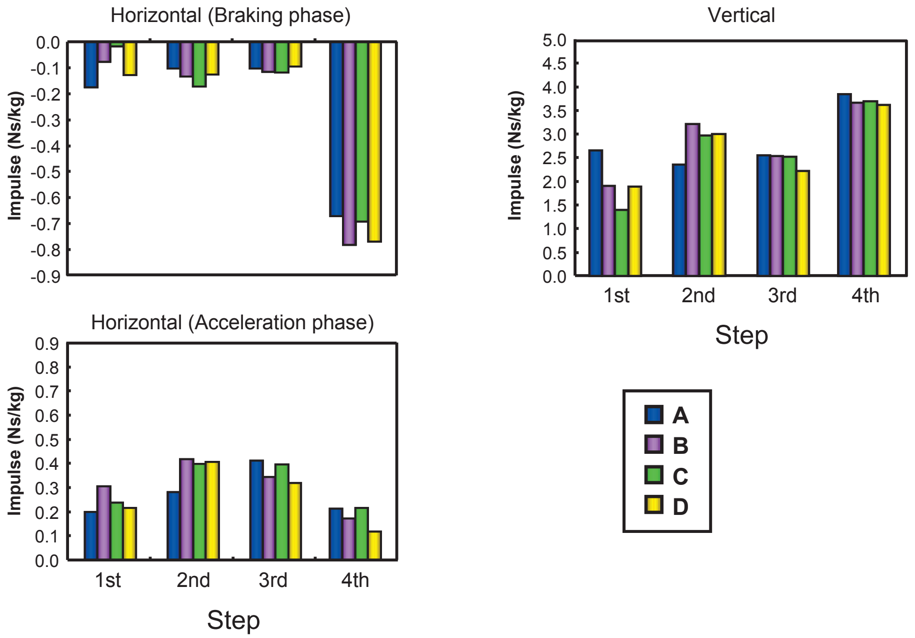

Figure 2: The impulse of ground reaction forces.

Figure 2 shows the impulses of ground reaction forces. The largest positive value of vertical component and negative value of horizontal component in braking phase were obtained at the 4th step. The second largest values were obtained at the 2nd step.

DISCUSSION: The vertical component of impulse at 2nd step was larger than that of 1st step. The hurdler has to raise their body CG to clear the barriers, and the body CG has been dropping until the support phase at 2nd step. These results indicated that the hurdlers have to recover horizontal and vertical velocities of CG during the support phase at 2nd step. Supposing the hurdler has smaller horizontal velocity of CG at landing of 1st step (in present study, correspond to Subject A), it is assumed that the landing angle of CG comes closer to perpendicular axis. In this case, the hurdler might have to generate the larger vertical component of impulse at 1st step. Mann and Herman (1985) reported that faster hurdlers achieved shorter support time at 1st step. There are two ways of increase impulses: increasing forces or increasing times. In this study, Subject A increased support time, especially braking time, to increase impulses at 1st step. As a result, Subject A had large impulses of both horizontal and vertical components. Coh (2004) described the braking time of the contact phase at 1st step must be as short as possible in order to maintain the horizontal velocity of the CG. Therefore, the small horizontal velocity of CG during hurdling might cause large deceleration at 1st step.

CONCLUSION: The results of this case study revealed that small horizontal velocity of CG during hurdling increased braking time, which increases impulses of both horizontal and vertical components at 1st step. Therefore, maintaining large horizontal velocity during hurdling seems to be one of the important factors in sprint hurdles.

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