CONTRIBUTION OF FORWARD AND VERTICAL IMPULSES DURING MAXIMAL 50M SPRINTING TO THE MAXIMUM RUNNING VELOCITY IN SPRINTERS

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The present study developed a 50 m-forceplate system and examined relationships between the impulse calculated from ground reaction force (GRF) from start to 50m and the maximum running velocity (Vfmax). Thirty five male sprinters performed maximal sprint on the system, using starting block. The forward and vertical components of impulses (IMPf and IMPv, respectively) were computed for each support phase by integrating the GRF. The highest correlation coefficients for both IMPf(r=0.736) and IMPv(r=-0.729) were found at the distance of 10 m from the start. These results indicate the ability to keep IMPv low and IMPf high seems to be important for achieving greater Vfmax, notably in the initial stage of acceleration phase.

KEY WORDS; 50m forceplate system, ground reaction forces, sprint

INTRODUCTION: The GRF during sprint running has been extensively studied using force platforms (Cavagna et al., 1971; Fukunaga et al., 1981; Morin et al., 2015). However, the previous studies have used conventional force platforms which were 1-7 m long. Thus, the obtainable data on the GRF have been limited to those for only a few steps. In order to examine GRF during the whole acceleration phase of sprint running, therefore, it has been necessary to repeat the task with changing the distance of starting position from the force platform. The present study developed a 50m-forceplate system in which biomechanical parameters could be continuously obtained at every step of a 50-m sprint run, and aimed to investigate the relationships between impulse of GRF over all step from start to 50m and Vfmax.

METHODS: Thirty five male sprinters (age=19.6±3.4years, body mass=65.0±5.5kg, body height=1.72±0.06m, mean±SD), including 4 Japan National team sprinters participated in this

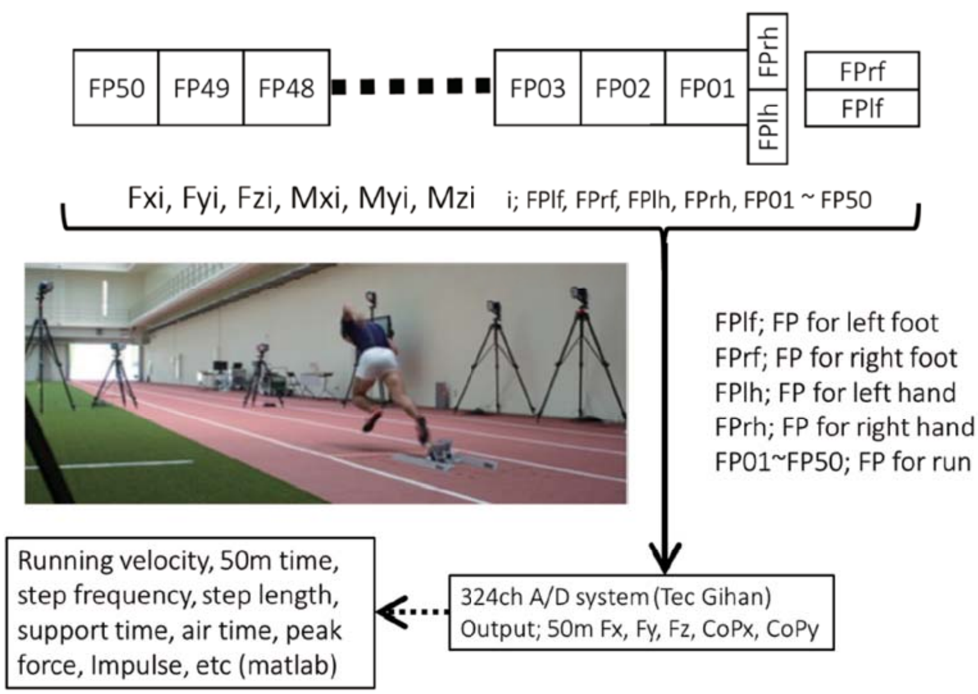

Figure 1: 50mForcePlate analysis system.

study.
The sprinters were tested on the 110m running track (70m indoor, 40m outdoor) of the Sports Performance Laboratory in the National Institute of Fitness and Sports in Kanoya. The sprinters were asked to perform 2 or 3 times of 50m sprints. For each sprinter, the fastest trial was used for analysis.
These mediolateral, forward, vertical components of GRF were measured by 50m force platform system (Tec Gihan, Uji, JAPAN) in Figure 1. This system consisted of 54 individual force plates (FP01~FP50, 1.0m length x 0.9m wide for sprinting; FPlf and FPrf, 1.2m length x 0.32m wide for foot and FPlh and FPrh; 0.3m length x 0.55m wide for hand at block clearance, natural frequency >145Hz), and was able to measure GRF with strain gauges in three axes, i.e., horizontal transverse force (Fx), horizontal forward-backward force (Fy), and vertical force (Fz). GRF signals were digitized at a sampling frequency 1 kHz. The data were analyzed using a low-pass filter of cutoff frequency of 100 Hz. Fx, Fy, Fz were expressed in BW of N per body mass. Forward and vertical impulses of GRF (IMPf, and IMPv, respectively) were computed for each support phase (50N threshold) by integrating GRF at each step from block clearance to 50m. The forward running velocity (Vf) in each step and lap time in every 10m was calculated from the location of center of pressure (CoPx, and CoPy) in each support phase.

RESULTS AND DISCUSSION: 50m lap time and Vfmax were 6.48 ± 0.28 sec and 9.73 ± 0.46 m/s, respectively. Figure 2 indicates a sample of GRF and CoP as a function of time. As the running time increased, the Fz increased from 1.7 BW at block clearance to 4 BW at 50m, positive Fy decreased 2 BW to 0.8 BW, and negative Fy increased from zero to over 1.5 BW. CoPy was almost constant value at support phase and was zero at air phase. Thus, the developed forceplate system enabled to quantify the changes in GRF and CoP at each step during a 50-m sprint run.
Figure 3 shows the changes of IMPf and Vf over the distance of 50 m. With repeated decrease and increase during support phase, IMPf increased rapidly after the start and reached almost steady state near 50m. Vf increased with the same pattern as IMPf after the start. After 3 s from the start, the difference between IMPf and Vf was increased gradually, and it reached about 1 m/s at 50 m. This difference may be due to the influence of air

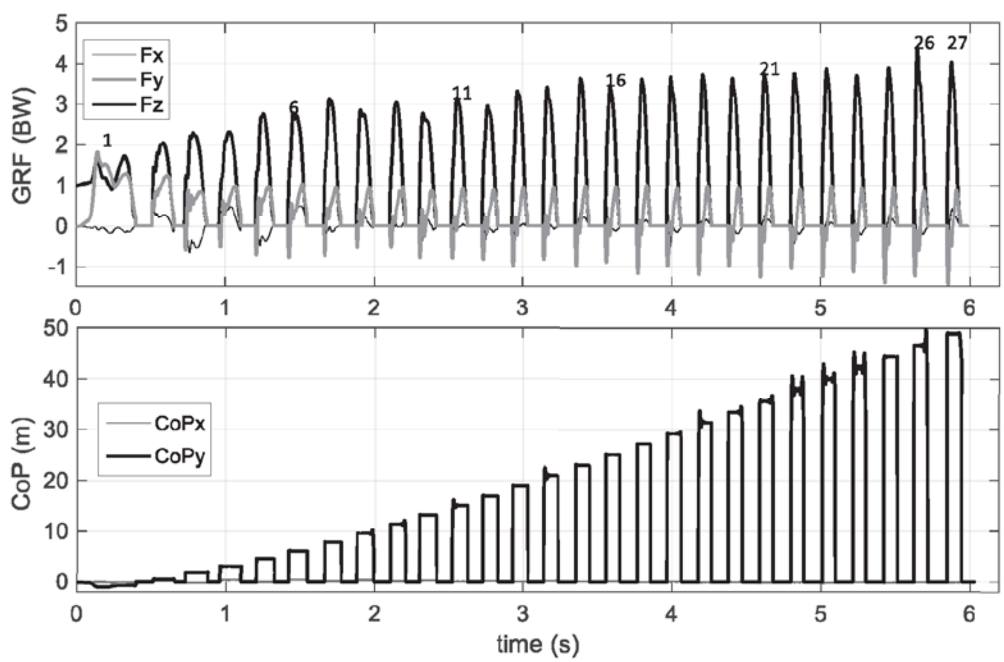

Figure 2: Typical sample of GRF and CoP entirely block clearance to 50m

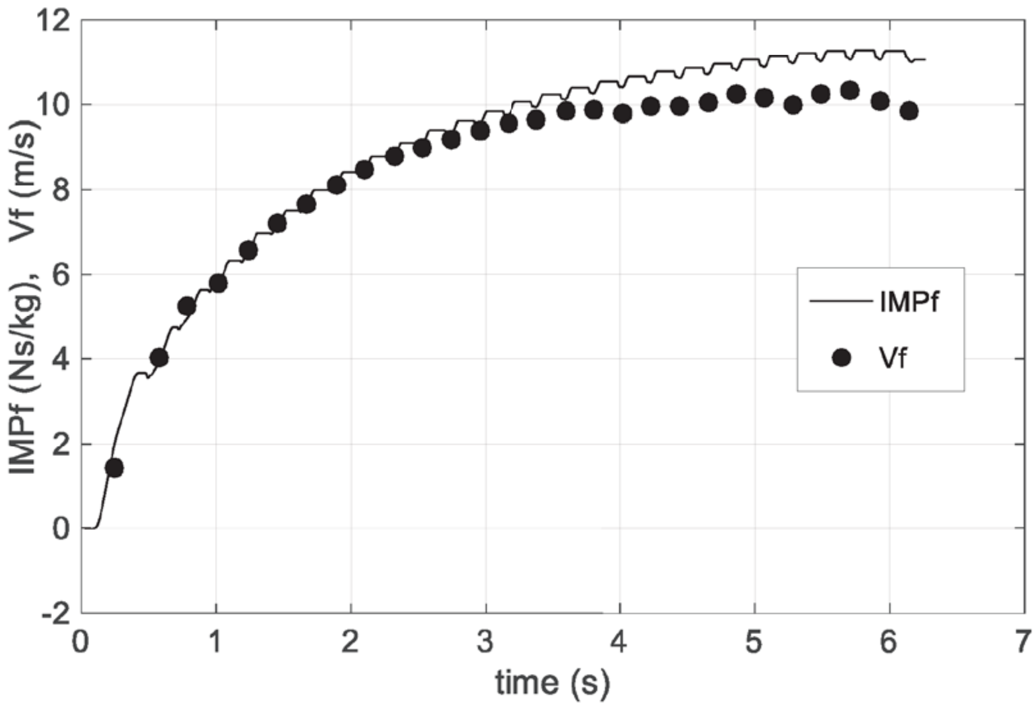

Figure 3: The changes of IMPf and Vf from start to 50m.

resistance.

Table 1 summarizes descriptive data on IMPf and IMPy and their correlation coefficients with Vfmax. In every 10m phase, IMPf and IMPv were decreased with increasing distance. The total IMPf and IMPv over the 50m were positively (r=0.828, p<0.001) and negatively (r=-0.814, p<0.001) with Vfmax, respectively. The correlation coefficients between Vfmax and two variables varied with the running distance. Namely, the significant association for IMPf was limited to the distance from the start to 30 m, and the corresponding distance for IMPy was from the start to 40 m. The highest correlation coefficients for both IMPf and IMPv were found at the distance of 10 m from the start. These results indicate the ability to keep IMPv low and IMPf high seems to be important for achieving greater Vfmax, notably in the initial stage of acceleration phase.

Table 1: The impulse values of mean, sd and the correlation coefficients between impulse and Vfmax.

n=35	IMPf (Ns/kg)				IMPv (Ns/kg)			
section	mean	sd	r	p	mean	sd	r	p
bc-10m	8.04	0.33	0.736	***	19.93	0.98	-0.729	***
10m-20m	1.44	0.20	0.457	**	11.34	0.67	-0.464	**
20m-30m	0.77	0.11	0.399	*	10.47	0.67	-0.726	***
30m-40m	0.44	0.15	0.331	ns	10.34	0.83	-0.668	***
40m-50m	0.17	0.23	0.088	ns	9.65	1.35	-0.141	ns
bc - 50m	10.86	0.54	0.828	***	61.73	2.89	-0.814	***

CONCLUSION; These results indicate that (1) the force-platform system developed here is useful for quantifying changes in ground reaction force at each step during a 50-m sprint run, and (2) the ability to vertical component of GRF low and forward component of GRF high can be an important factor for achieving greater Vfmax, especially in the initial stage of the acceleration phase.

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