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ORIGINAL ARTICLE

Competing against another athlete side-by-side improves 60 m sprint running performance

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ABSTRACT

Purpose: Purpose of this study was to elucidate the differences in sprint performance between two different conditions in the 60 m dash: subjects ran alone (Alone Condition: AC) or two runners competed side-by-side (Competitive Condition: CC). Methods: Subjects were twenty-six male university sprinters. They were asked to perform two 60 m dash, the AC and CC, with maximal effort from crouching start. Running spatiotemporal variables were obtained from video images taken with two digital high-speed cameras. Results: Running speed (AC: 9.34 ± 0.45 $m \cdot s^{-1}$ vs CC: 9.40 ± 0.43 $m \cdot s^{-1}$, p = .011) and step length (AC: 2.04 ± 0.12 m vs CC: 2.06 ± 0.10 m, p = .021) in the maximal speed section (30-60m) were significantly increased in the CC. However, there was no significant difference in step frequency (AC: 4.58 ± 0.26 Hz vs CC: 4.57 ± 0.27 Hz, p = .595). There was no significant difference in any variables in the acceleration section (0-30m). Conclusion: These results indicate that running with a competitor improves running speed with increasing step length in the maximal speed section but does not affect performance in the acceleration section. We concluded that competition improves sprint performances in the maximal speed section.
Keywords: Performance analysis of sport, Competitor, Training.

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INTRODUCTION

All sport events can be classified into open-skill and closed-skill exercises (Poulton, 1957). Open-skill exercises (e.g., tennis, football, or rugby) are performed in an environment with dynamically changing external factors such as opponents and game conditions. On the other hand, closed- skill exercises (e.g., swimming, archery, or gymnastics) are performed with few external factors such as opponents (Knapp, 1963). In general, track and field event is also recognized as a closed-skill exercise, and it is important for athletes to reliably reproduce specific movement patterns (Allard & Starkes, 1991). In the case of the sprint events, the rules stipulate that the sprinters must run on their own lane. However, sprinters have to run with other athletes (i.e., competitors) in a race so that competitors may have an effect on sprint performances. The world record of 9.58 sec set by Usain Bolt in the men's 100 m dash at the 2009 IAAF World Championships may have been achieved through unintentional interpersonal synchronization with Tyson Gay, the second place finisher (9.71 sec) (Varlet & Richardson, 2015). It was demonstrated that Usain Bolt and Tyson Gay who ran side-by-side throughout the race intermittently synchronized their steps. Usain Bolt showed a greater step frequency than semi-final, while Tyson Gay showed a greater step length than semi-final (Varlet & Richardson, 2015). In other words, it is suggested that the running side-by-side (competitive running condition) influences performance.

Triplett (1898) found that competing against other athletes improves cycling performance than when athlete cycle alone. Other study also comparing single condition and competitive condition for bicycle exercise. It was shown that the duration of pedalling time was longer and the power was greater in competitive condition than in the single condition (Corbett, Barwood, Ouzounoglou, Thelwell, & Dicks, 2012; Wilmore, 1968).

Moreover, some studies have compared the running performance of competitive condition and single condition. Tomazini et al. (2015) reported that competitive runners improved their split time in 0-500 m section in the 3000 m run, resulting in the improvement of the finish time. On the other hand, Moore et al. (2007) reported that there was no difference in the 40-yard (36.576 m) running time between the competitive condition and single condition in physically active college students. However, the maximal running speed of sprint appears around 50 m to 60 m (Ae, Ito, & Suzuki, 1992), it is possible that they did not yet reach the maximal running speed in the 40-yard run. In addition, the students in question were not experts in track and field and were not used to running at their maximal speed (Moore et al., 2007).

So far, studies comparing running performances between competitive condition and single condition are limited among the general college students (Moore et al., 2007) . Therefore, how competitive condition affects running performance way is largely unknown. However, there are many situations in daily training. For example, runners are always engaged in competing with training partners as well as running in single condition. Most importantly, they always run with competitors in actual races. The purpose of this study was to elucidate the differences in sprint performance between two different conditions in the 60 m dash; subjects ran alone (Alone Condition: AC) or two runners compete side-by-side (Competitive Condition: CC). We hypothesized that the CC would improve running performance as observed in the race in which Usain Bolt and Tyson Gay competed (Varlet & Richardson, 2015). In particular, step frequency would increase, because step frequency was reported to be greater in a race than the speed in training (Otsuka, Kawahara, & Isaka, 2016).

METHODS

Subjects

The subjects were twenty-six male university track & field athletes (Height:172.2 ± 4.3 cm, Body mass: 63.2 ± 5.7 kg, 100 m dash personal record 11.32 ± 0.42 sec: range 10.65 to 12.01).

This study was approved by the Ethics Committees of Waseda University. All subjects were informed of potential risks associated with the experimental procedures. Before the experiments, all subjects gave their written informed consent. All experiments were conducted in accordance with the Declaration of Helsinki.

Experimental protocol and data collection

After a self-selected warm-up activity, subjects asked to perform 60 m dash in two conditions: that is, running alone (Alone Condition: AC) and two runners compete side-by-side (Competitive Condition: CC), with maximal effort from a crouching start with a starting block (NF155B, NISHI, Japan) in the straight lane of an official 400 m track. Each subject started to run when signalled by the sound of a track and field starting pistol (NG5085B, NISHI, Japan). Competitive pairs and order of trials were all randomized by inspector. Subjects took a rest between trials at least 10 minutes to avoid the effects of fatigue.

Reference markers were set every 10 m along the lanes to obtain split time (sec). Two panning high-speed cameras (LUMIX DMC FZ-300, Panasonic, Japan) were set up at 30 m point to determine the moments of foot strike and foot off from the side of the running track at 240 Hz.

Data analysis

Spatiotemporal variables

The length of time it took for a subject's torso to travel 10 m between one and the next reference markers was defined as the split time (sec). Then, running speed ($m \cdot s^{-1}$) was calculated by dividing 10 m by the split time. In addition, the contact time (sec) and flight time (sec) for each step were calculated from the number of frames of the high-speed cameras, and the step frequency (Hz) was calculated for each step. The step length (m) was calculated by dividing the running speed by the step frequency.
Relative performance index of the CC [X (%)] with respect to the AC was calculated by the following equation to quantify the difference in performance between the AC and CC.

$$X\ (\%) = (X_{(CC)}/X_{(AC)}) \times 100$$

Where, X_{CC} and X_{AC} are any spatiotemporal variables (running speed, step frequency, step length, contact time, and flight time) in the CC and AC, respectively. If X (%) is greater than 100 it means the value is greater in the CC than in the AC.

In this study, we defined the first half 30 m as the acceleration section, and the second half 30 m as the maximal speed section. All variables were averaged for each 30 m segment.

Statistical processing

A paired-sampled t-test was used to determine the difference of the spatiotemporal variables between the AC and CC. The Pearson's product–moment correlation coefficient was used to determine the correlation between X_{AC} and X_{CC}. All statistical analyses were performed using statistical processing software (SPSS ver.25, IBM, USA). We set a significance level of .05.

RESULTS

Comparison of spatiotemporal variables between AC and CC

Running time (*p* = .012), running speed (*p* = .011), and step length (*p* = .021) were significantly improved in the CC in the maximal speed section (30-60 m) (Table 1). The running speed was improved by 0.70 %, step length was improved by 0.91 %. However, step frequency, contact time, and flight time had no significant difference between the two conditions. There were no significant differences in any variables during acceleration section (Table 1).

Table.1 Spatiotemporal variables between AC and CC, relative value of the CC.

Acceleration section (0-30m)				
Spatiotemporal variables	**AC**	**CC**	***p*-value**	**Relative value (%)**
Time (sec)	4.40 ± 0.14	4.38 ± 0.14	.102	99.63 ± 1.12
Running speed ($m \cdot s^{-1}$)	6.83 ± 0.22	6.85 ± 0.22	.097	100.38 ± 1.12
Step frequency (Hz)	4.54 ± 0.24	4.55 ± 0.21	.781	100.18 ± 2.10
Step length (m)	1.51 ± 0.08	1.51 ± 0.07	.609	100.24 ± 1.91
Contact time (s)	0.127 ± 0.010	0.125 ± 0.010	.220	98.62 ± 6.23
Flight time (s)	0.094 ± 0.013	0.094 ± 0.010	.884	100.38 ± 8.22
Maximal speed section (30-60m)				
Spatiotemporal variables	**AC**	**CC**	***p*-value**	**Relative value (%)**
Time (sec)	3.22 ± 0.16	3.20 ± 0.15	.012 *	99.32 ± 1.28
Running speed ($m \cdot s^{-1}$)	9.34 ± 0.45	9.40 ± 0.43	.011 *	100.70 ± 1.30
Step frequency (Hz)	4.58 ± 0.26	4.57 ± 0.27	.593	99.81 ± 1.86
Step length (m)	2.04 ± 0.12	2.06 ± 0.10	.021 *	100.91 ± 1.80
Contact time (s)	0.100 ± 0.008	0.102 ± 0.009	.094	101.08 ± 3.20
Flight time (s)	0.119 ± 0.009	0.119 ± 0.008	.970	100.06 ± 3.42

*Note. AC: Alone condition. CC: Competitive condition. * (p < .05).*

Relationship between relative performance values of step frequency and step length

Figure 1 shows the relationship between running speeds of the CC and AC in the acceleration section (0-30 m) (Figure 1 A) and in the maximal speed section (30-60 m) (Figure 1 B). We found that eighteen out of twenty-six subjects improved, seven subjects deteriorated, and one subject unchanged the running speed in the CC at the acceleration section (Figure 1 A). Similarly, seventeen out of twenty-six subjects improved, six subjects deteriorated, and three subject unchanged the running speed in the CC at the maximal speed section (Figure 1 B).

Moreover, we illustrated scatter plot of relative values of step frequency and step length both in the acceleration section in Figure 2 A and in the maximal speed section in Figure 2 B. The broken lines indicate an iso-speed line: that is, the running speed was equal between CC and AC. The plots located above and below this line means running speed was faster in the CC and AC, respectively. We found that seventeen subjects who improved running speed were widely distributed in acceleration section (Figure 2 A): that is, five subjects increased both step frequency and step length (Zone 1), six subjects decreased step frequency however increased step length (Zone 2), and seven subjects decreased step length however increased step frequency (Zone 3). Only one subject located in Zone 4. Similarly, five subjects located in Zone 1, seven subjects located in Zone 2, four subjects located in Zone 3, and two subjects located in Zone 4 of maximal speed section (Figure 2 B). The thick black line represents a regression line, it showed a significant negative correlation between the relative values of step frequency and step length in the acceleration section (R = - 0.851, R^2 = 0.724, p < .001) and in the maximal speed section (R = - 0.754, R^2 = 0.569, p < .001).

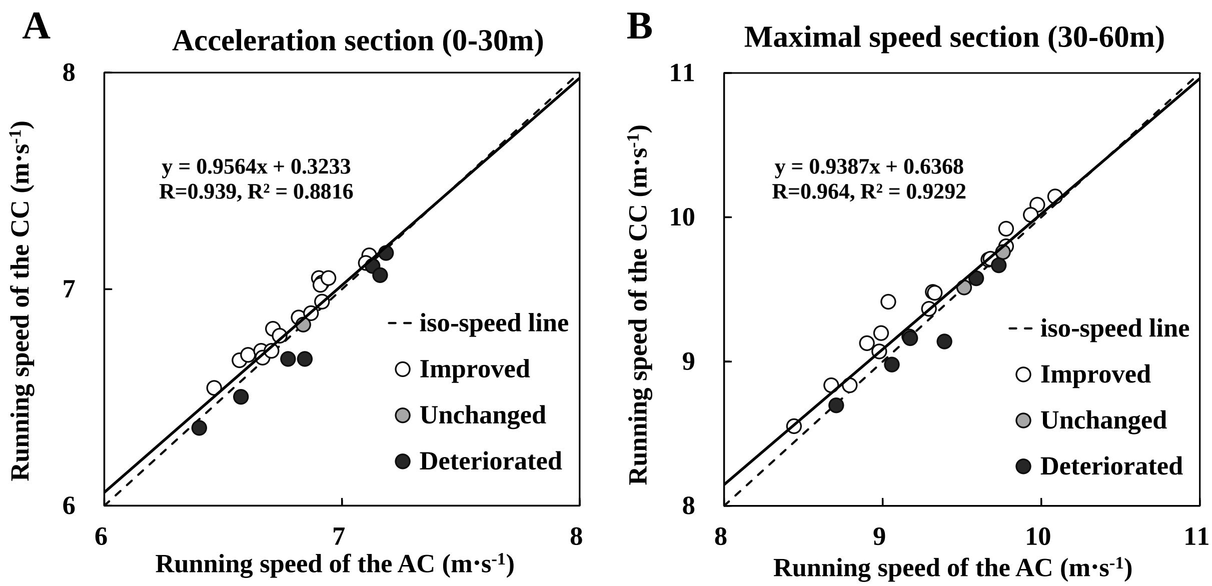

Figure 1. Relationship between running speed of the CC and that of the AC in the acceleration section (0-30 m) (A) as well as in the maximum speed section (30-60 m) (B).

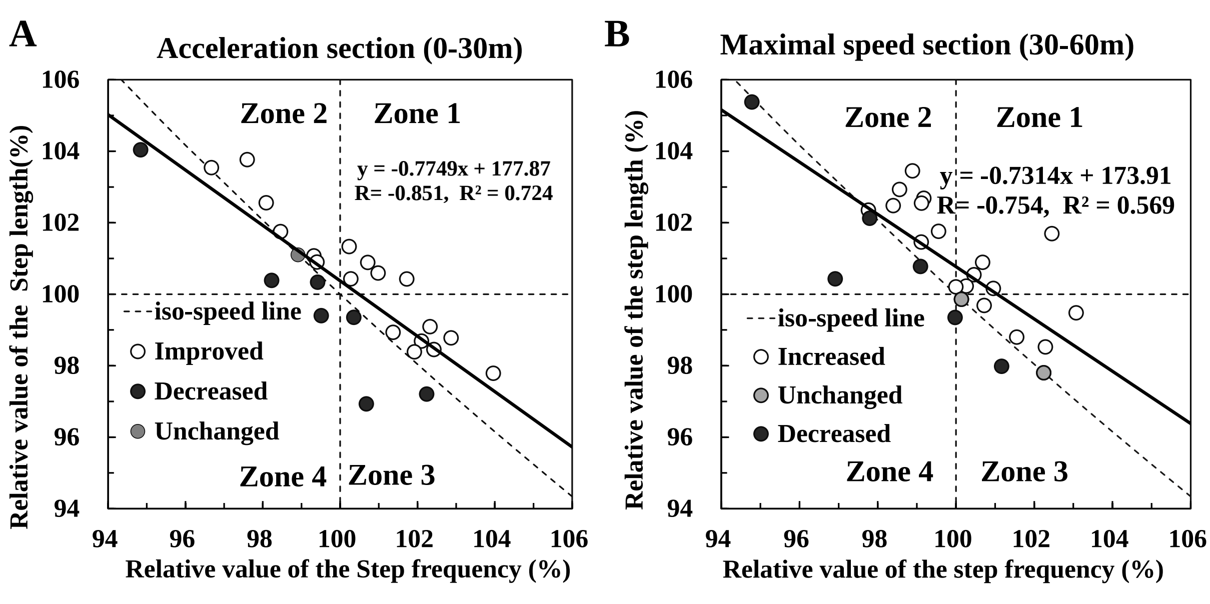

Figure 2. Relationship between relative value of the step frequency and step length in the acceleration section (0-30 m) (A) as well as in the maximum speed section (30-60 m) (B).

DISCUSSION

The purpose of the present study was to clarify difference between two conditions; ran alone (Alone Condition: AC) and two runners competed side-by-side (Competitive Condition: CC) in the 60 m dash. As a result, we found that, running speed was significantly increased (AC: 9.34 ± 0.45 $m \cdot s^{-1}$ vs CC: 9.40 ± 0.43 $m \cdot s^{-1}$, p = .011) with the increase in the step length (AC: 2.04 ± 0.12 m vs CC: 2.06 ± 0.10 m, p = .021) in the CC at the maximal speed section as compared with the AC (Table 1). Then, the relative value of the running speed was 100.70 ± 1.30 %. In other words, the CC could improve running speed about 0.7 %. Improving running speed for 0.7 % is meaningful difference in the sprint events. Therefore, we propose that sprinters should be train with competitor (training partner) to obtain greater running speed even in a usual sprint training.

However, we hypothesized that step frequency would increase in CC, because step frequency was reported to increase in a 100-m race than in an usual speed training (Otsuka et al., 2016). Moreover, it is widely known that high-speed running is mainly accomplished with increasing step frequency (Dorn, Schache, & Pandy, 2012; Goto et al., 2021; Yanai & Hay, 2004). On the contrary, step frequency, contact time, and flight time had no significant difference between the AC and CC neither in the acceleration section nor in the maximal speed section. One possible reason for this is the difference in the experimental design. Otsuka et al. (2016) compared the times in the race and training session, and even in the latter at least two sprinters ran side-by-side. In other words, their reported variables in the speed training had been already affected by the other sprinters (i.e., competitor). On the other hand, our experimental design was to compare the spatiotemporal variables between the two conditions of running alone (AC) and competed running (CC). As a result, we found that running speed improved with the increase in the step length not in step frequency in the maximal speed section in the CC.

A previous study demonstrated that unintentional interpersonal synchronization occurred between competitors in the world athletics championships in Berlin (2009), most ultimate competitive environment (Varlet & Richardson, 2015), in which Tyson Gay showed a greater step length than the semi-final, while Usain Bolt showed a greater step frequency than the semi-final (Varlet & Richardson, 2015). In general, negative interaction exists between step frequency and step length (Hunter, Marshall, & McNair, 2004). Moreover, optimal combination of the step frequency and step length at the maximal running speed varied among individual (Kakehata, Kobayashi, Matsuo, Kanosue, & Iso, 2020; Salo, Bezodis, Batterham, & Kerwin, 2011). Although present results showed only step length significantly increased (Table 1), however, in fact, we found that combination of the relative value of the step frequency and step length differed among individuals (Figure 2). Therefore, we could not conclude that higher speed in the CC was obtained with increase in step length in any individual. Thus, the effect of CC for step frequency or step length might also depend on the situation; the real competition or usual training. The situation of CC in the present study was similar to that of usual training. In summary, we should be noted that it is necessary to correctly understand whether the CC influences individual parameters positively or negatively.

Previous studies demonstrated that competing against other athletes improves performance than when athlete exercise alone in cycling (Corbett et al., 2012; Triplett, 1898) and distance running (Tomazini et al., 2015). Sasaki and Sekiya (2014) observed performance in the 20 m start dash under pressure trial and non-pressure trial. If subjects could run 0.06 sec faster than the non-pressure trial that had been done in advance, they received a cash reward. If they could not, subjects had to run an additional dash as a penalty. As a result, heart rate and knee joint extension velocity increased at the start under the pressure, and 20 m time was improved. In this way, increased performance under pressure in sport and exercise has been referred to as “*clutch performance*” (Otten, 2009). On the other hand, decreased performance under pressure is called “*choking*” (Baumeister, 1984). For example, Tanaka and Sekiya (2011) compared the performance of a golf putting task in a single condition and a condition with five spectators. Excessive awareness of the pressure of surveillance affected voluntary motor control, resulting in a decrease in the athlete's performance. Thus, pressure in sports have both positive and negative effects. In fact, present study showed that competitive condition significantly improved running speed on averaged, thus having positive effect. However, we found that seven and six of the twenty-six subjects deteriorated running speed in the acceleration section and the maximal speed section, respectively. They would have been affected in a negative fashion in the CC. Therefore, whether competitive running affect the performance on positive or negative depends on an individual.

Moore et al. (2007) reported that there was no difference in the 40-yard (36.576 m) time between the CC and AC. Present results coincides with the previous study in that there was no significant difference in any variable between the AC and CC in the acceleration section (0-30 m) (Table 1). Why there was no significant difference in the acceleration section (0-30 m)? One possible reason might be the difference in visual information. The height of the body's centre of gravity in the crouching start posture is low, it gradually increases with each step after the start, the change becomes almost zero at about the 14th step (Nagahara, Matsubayashi, Matsuo, & Zushi, 2014). Around that time, the visual information would have changed in accordance with the change the posture. The 30 m point after the start in this study corresponds to about the 18th step (Nagahara et al., 2014), and, thus, the visual information is expected to be different between the acceleration section and the maximal speed section. In the maximal speed section, subjects could see the competitor more easily than in the acceleration section. The difference in visual information may be one of the reasons why there was no change in performance in the acceleration section.

Furthermore, previous studies have identified neurological factors such as visual and auditory information as external factors that influence performance (Varlet & Richardson, 2015). For example, Bood, Nijssen, van der Kamp, and Roerdink (2013) suggests that running to motivational music with a very prominent and consistent beat matched to the subject’s cadence improves time to exhaustion (i.e., running economy). Similarly, Simpson and Karageorghis (2006) reported that subjects listen a synchronous music while 400 m running improved time among non-elite sportspersons. What is more, listening to a constant rhythmic sound during walking promoted to stabilize the walking rhythm (Hove, Suzuki, Uchitomi, Orimo, & Miyake, 2012; Hunt, McGrath, & Stergiou, 2014; Roerdink, Lamoth, Kwakkel, van Wieringen, & Beek, 2007). In the same way, it is possible that the visual/auditory information of the footsteps of the competitor, which was not present in the AC, affected the performance of the runners in this study.

CONCLUSION

Purpose of this study was to elucidate the differences in sprint performance of 60 m dash between two conditions, in which subjects ran alone (running alone condition: AC), and two competed side-by-side (competitive running condition: CC). We found that the CC improves running speed with increase in step length in the maximal speed section but does not affect performance in the acceleration section. We conclude that the CC improves sprint performances, however, it should be noted that it is necessary to correctly understand whether the CC affects individual parameters positively or negatively. We propose that sprinters should be trained with competitor (training partner) to obtain greater running speed even in a usual sprint training.

AUTHOR CONTRIBUTIONS

GK, TH, and KK: Idea, Concept, and Design. GK, TH, and YG: Data collection. GK, TH: Data analysis. GK: Writing article. SI and KK: Literature review, Supervision.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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