# SPRINT RUNNERS' INTENTIONS DURING ACCELERATION AND CHANGES IN THEIR RUNNING SPEED

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This study investigated the relationship between intention during acceleration and changes in running speed during a sprint. Changes in running speed over each entire sprint were measured using a laser distance meter (100 Hz). Seven male sprinters performed two sprints with different intentions during acceleration: in one sprint, sprinters were instructed to immediately reach their maximum speed ($AC_{inst}$), and in the other, sprinters were instructed to sprint 100 m as in a typical sprint race ($AC_{100}$). $AC_{100}$ showed significantly higher values for the upper limit of the sprinter's top speed compared to the $AC_{inst}$. The $AC_{inst}$ showed significantly higher values for initial acceleration compared to the $AC_{100}$. These results suggest that changes in running speed are affected by the intention in the acceleration.

**KEY WORDS:** sprint running, intention in the acceleration, exponential equation

**INTRODUCTION:** The pattern of speed change is essential to examining sprint running ability. Although maximum speed in the speed change is important factor for the sprint event (Yosuke et al., 2008), maximum speed is reached as a result of acceleration. Therefore, acceleration during sprint running must also be considered. Although the pattern of changes in running speed before reaching maximum speed has been investigated using an exponential equation (Morin et al., 2006; Mendiguchia et al., 2014), these previous studies did not consider the difference in the manner of acceleration. Nagahara et al. (2014a, 2014b) revealed that the entire acceleration phase can be divided into three sections and there are different acceleration strategies in each section for accelerating effectively. From these studies, it can be said that the sprinter has an intention of how to accelerate during acceleration phase. However, it is unclear how the intention during acceleration affects the changes in running speed. The purpose of this study was therefore to investigate the relationship between intention during acceleration and the changes in running speed for the sprint.

**METHODS:** Participants were 7 male sprinters (age [mean ± SD]: 20.7±1.1 years; height: 175.4±1.9 cm; body mass: 69.2±2.7 kg; 100-m sprint personal best, 11.50±0.23 s). The content of the experiment was explained to the participants and consent was obtained. After a normal warm-up, participants performed two sprints with different intended patterns of acceleration. In one sprint, participants were instructed to attempt reach their maximum speed instantly upon starting ($AC_{inst}$), while sprinting at least 70 m. In the other sprint, participants were instructed to sprint 100 m as in a typical sprint race, and to accelerate so that they could aim to set a personal best ($AC_{100}$). The two different sprints were separated by 10 min of passive rest. Each sprint was performed from a crouching start in an outdoor athletic stadium. Participants used their usual spiked shoes and set the starting blocks at their standard block spacing. The participants began running in each trial upon hearing the sound from an electronic starting pistol (JESTAR; NISHI, Japan). Changes in running speed over the entire sprint for each sprint and for each participant were measured using a laser distance meter (LAVEG; LDM301S, Jenoptik, Germany). The device was operated such that the emitted laser would be constantly applied to the participant's back, and was placed on a 1.2-m tripod about 15 m behind the starting point. The sampling frequency for LAVEG was 100 Hz. Because the measured raw data of time-distance change usually includes noise, we smoothed these data using a Butterworth digital filter, cutting off 1.0 Hz (Kintaka, 1999), and the changes in running speed in each sprint were calculated by differentiating the smoothed time-distance changes. In this study, the time of starting sprint was when running speed exceeded 0.2 m/s (Morin et al., 2010). Based on previous research, the time from starting sprint to when maximum speed was reached ($t_{max}$) was considered the acceleration phase (Yosuke et al., 2008). Additionally, the speed changes of the acceleration phase in each sprint were approximated using the following exponential equations.

$$V_{(t)} = A\left(1 - e^{-kt}\right) \quad (1)$$

In Equation (1), $V_a$ is the speed in the acceleration phase, *A* is the upper limit of the sprinter's top speed, *k* is the coefficient of acceleration, *t* is the time elapsed from start, and *e* is the base of natural logarithms (Prendergast, 2001; Yosuke et al., 2008).

*A* and *k* in Equation (1) were calculated using a least-square regression from the smoothed speed data of the acceleration phase.
Acceleration was obtained by differentiating Equation (1).

$$a_{(t)} = Ake^{-kt} \quad (2)$$

Using Equation (2), initial acceleration immediately after starting was calculated.
The data of two different sprints were compared by using the paired t-test. The significance level was set at $p < 0.05$.

**RESULTS:** Figure 1 shows an example of the smoothed changes in running speed and the approximated speed changes. The approximated speed change was very close to the smoothed speed change in both $AC_{inst}$ and $AC_{100}$. Table 1 compares the values of $AC_{inst}$ and $AC_{100}$. There was no significant difference in maximum speed and $t_{max}$ between $AC_{inst}$ and $AC_{100}$. *A* was significantly higher in $AC_{100}$ than in $AC_{inst}$ ($p<0.05$); however, *k* and initial acceleration were significantly higher in $AC_{inst}$ than in $AC_{100}$ ($p<0.05$). Figure 2 presents the average patterns of the approximated speed change and the approximated acceleration change in $AC_{inst}$ and $AC_{100}$. The speed approximated by $AC_{inst}$ was faster than that by $AC_{100}$ in the first half of the acceleration phase, but slower in the second half. Furthermore, the $AC_{inst}$-approximated acceleration was higher than that in $AC_{100}$ after starting the sprint, but if starting sprint occurred later, the $AC_{100}$-approximated acceleration for the rest of the acceleration phase was higher than that approximated by $AC_{inst}$. Figure 3 shows the relationships between $\Delta k$ of $AC_{inst}$-$AC_{100}$ (obtained by subtracting the *k* of $AC_{100}$ from the *k* of $AC_{inst}$) and 100 m time in $AC_{100}$, and $\Delta A$ of $AC_{inst}$-$AC_{100}$ (obtained by subtracting the *A* in $AC_{100}$ from the *A* in $AC_{inst}$). There was no significant relationship between $\Delta k$ of $AC_{inst}$-$AC_{100}$ and 100 m time in $AC_{100}$, and $\Delta A$ of $AC_{inst}$-$AC_{100}$.

**DISCUSSION:** Figure 1 indicates that the approximated speed change represents the smoothed speed change well. Therefore, we consider that the variables can be used to examine the difference between $AC_{inst}$ and $AC_{100}$.

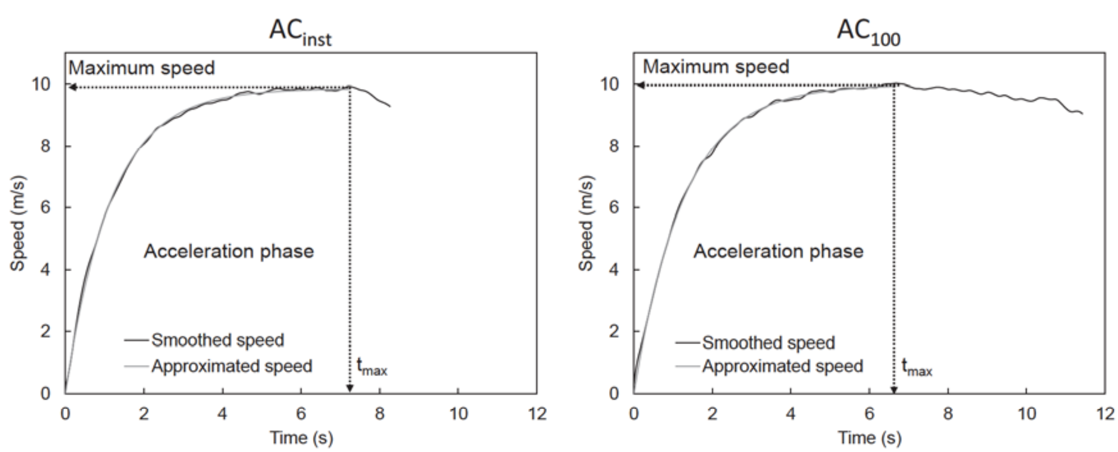


**Figure 1: Example of the smoothed running speed changes and the approximated speed changes (Left: $AC_{inst}$, Right: $AC_{100}$)**

**Table 1**
**Comparison of the variables of $AC_{inst}$ and $AC_{100}$**

| | Maximum speed (m/s) | | $t_{max}$ (s) | | *A* | | *k* | | Initial acceleration (m/s²) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $AC_{inst}$ | $AC_{100}$ | $AC_{inst}$ | $AC_{100}$ | $AC_{inst}$ | $AC_{100}$ | $AC_{inst}$ | $AC_{100}$ | $AC_{inst}$ | $AC_{100}$ |
| Participant 1 | 9.87 | 9.98 | 6.29 | 6.43 | 9.78 | 9.87 | 0.88 | 0.86 | 8.65 | 8.46 |
| Participant 2 | 9.93 | 10.02 | 7.21 | 6.67 | 9.86 | 9.99 | 0.87 | 0.79 | 8.54 | 7.85 |
| Participant 3 | 9.82 | 9.80 | 6.57 | 6.72 | 9.58 | 9.74 | 0.92 | 0.79 | 8.84 | 7.70 |
| Participant 4 | 9.57 | 9.64 | 6.65 | 6.62 | 9.45 | 9.60 | 0.92 | 0.79 | 8.05 | 7.33 |
| Participant 5 | 9.33 | 9.42 | 6.55 | 6.88 | 9.18 | 9.25 | 0.85 | 0.76 | 9.65 | 9.16 |
| Participant 6 | 9.60 | 9.55 | 6.70 | 6.95 | 9.49 | 9.48 | 1.05 | 0.99 | 7.96 | 7.36 |
| Participant 7 | 9.06 | 9.29 | 6.83 | 7.04 | 8.95 | 9.06 | 0.84 | 0.78 | 8.94 | 8.33 |
| Mean | 9.60 | 9.67 | 6.69 | 6.76 | 9.47 | 9.57 | 0.92 | 0.84 | 8.66 | 8.02 |
| SD | 0.31 | 0.28 | 0.28 | 0.21 | 0.32 | 0.33 | 0.08 | 0.09 | 0.57 | 0.66 |
| comparison | n.s. | | n.s. | | $AC_{inst} < AC_{100}$ * | | $AC_{inst} > AC_{100}$ * | | $AC_{inst} > AC_{100}$ * | |

*: $p<0.05$, n.s.: no significant

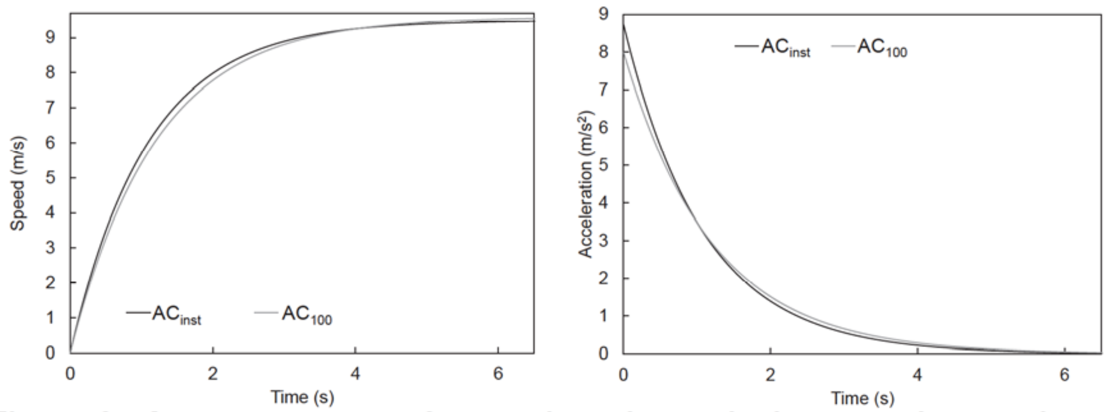


**Figure 2: Average patterns of approximated speed change and approximated acceleration change in $AC_{inst}$ and $AC_{100}$**

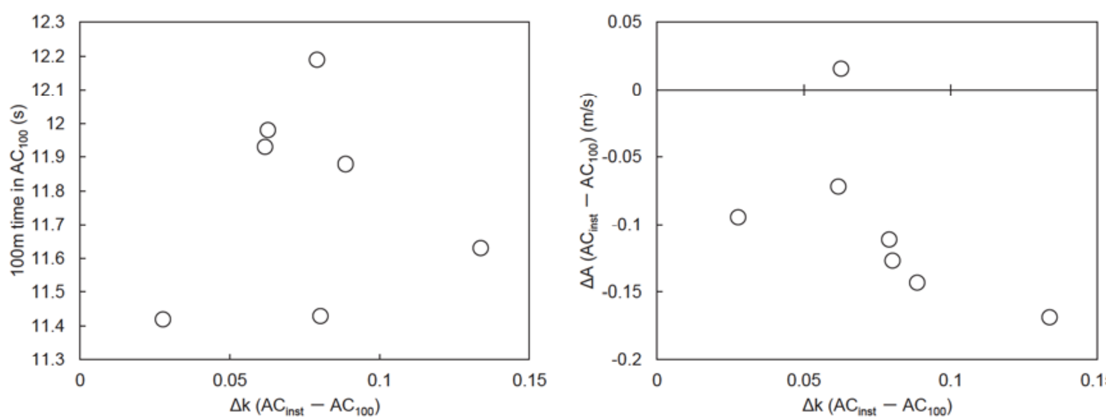


**Figure 3: Relation between Δ*k* of $AC_{inst}$-$AC_{100}$ and 100 m time in $AC_{100}$ and Δ*A* of $AC_{inst}$-$AC_{100}$**

As shown in Table 1, the variables of the exponential equations in speed change between $AC_{inst}$ and $AC_{100}$ were significantly different. As shown in Figure 2, the average speed change patterns in the $AC_{inst}$ and $AC_{100}$ were different. Therefore, we can infer that differences in speed change patterns were due to the different intentions of acceleration. Prendergast (2001) reported that acceleration increases as the value of $k$ increases larger. From the previous study and the results of the present study, it is thought that, if a sprinter strives to accelerate with the intention of instantly reaching maximum speed, the speed change pattern will change so that there is high acceleration in the initial acceleration phase. Also, it is inferred that if a sprinter strives to accelerate so that he could aim to set a personal best in the 100 m sprint, the speed change pattern will alter so that final maximum speed is higher.
However, the $\Delta k$ of $AC_{inst}$-$AC_{100}$ had no significant relationship with 100 m performance (Figure 3). In other words, even when $k$ was dramatically changed, indicating an altered method of acceleration, performance was not necessarily improved. This can also be considered from the results of relationship between the $\Delta k$ of $AC_{inst}$-$AC_{100}$ and $\Delta A$ of $AC_{inst}$-$AC_{100}$ (Figure 3). There was no significant relationship between $\Delta k$ of $AC_{inst}$-$AC_{100}$ and $\Delta A$ of $AC_{inst}$-$AC_{100}$. Therefore, we speculate that the effect of changes in $k$ may vary based on individual characteristics. In addition, there were two participants (Participant 3 and 6) whose maximum speed in $AC_{100}$ slightly decreased compared with in $AC_{inst}$ although the maximum speed in $AC_{100}$ increased compared with in $AC_{inst}$ in most participants. Hence, it is necessary to further examine the relationship between the intention during acceleration and changes in running speed during a sprint based on the individual characteristics.

**CONCLUSION:** This study investigated the relationship between the intention during acceleration and changes in running speed during a sprint. The results suggested that changes in running speed are affected by runners' intentions during acceleration. This finding indicates that there is an element of strategy regarding acceleration in sprint racing. Therefore, measuring the changes in running speed might be useful for coaches to assess athletes' acceleration skill. Hence, more studies are required to examine the influence of individual characteristics on the relationship between runners' intention during acceleration and running speed changes in the sprint.

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