Relationship of Step Width with Sprinting Performance and Ground Reaction Forces

Ryu Nagahara, Mirai Mizutani and Akifumi Matsuo
National Institute of Fitness and Sports, 1 Shiromizu-cho, Kanoya, Kagoshima, Japan

Keywords: Running, Foot Placement, Mediolateral, Acceleration.

Abstract: The purpose of this study was to clarify the relationship of step width with sprinting performance and ground reaction forces in order to understand the sprinting mechanism and its relation to better sprinting performance.

1 OBJECTIVES

Relationships between sprinting performance and spatiotemporal variables such as step frequency and length have broadly been investigated (Debaere et al., 2013; Hunter et al., 2004; Nagahara et al., 2014). However, little is known about the relationship of step width, which is the mediolateral distance between two consecutive steps, with sprinting performance. For example, Ito et al. (2006) showed step width at initial acceleration and at maximal speed phase during 100-m race. Although they reported no significant difference in the step width between elite and national level sprinters, the result was obtained with the investigation at initial acceleration and maximal speed phase. Thus, when considering the entire acceleration phase of sprinting, an importance of narrower or wider step width may be able to be found.

While a study has investigated the influence of difference in step width on some kinetic variables during running (Brindle et al., 2014), the influence of step width on ground reaction force (GRF) during sprinting has never been examined. Accordingly, it is still unknown how difference in step width associate with GRFs during sprinting.

The purpose of this study was to clarify the relationship of step width with sprinting performance and GRFs in order to understand the sprinting mechanism and its relation to better sprinting performance.

2 METHODS

2.1 Experiment

Seventeen male athletes (mean ± SD: age, 20.7 ± 1.2 y; stature, 1.73 ± 0.03 m; body mass, 66.5 ± 4.2 kg; personal best 100-m race time, 11.22 ± 0.28 s) participated in this study. After warming-up, the participants performed 60-m maximal effort sprinting from starting blocks. GRF over 52-m distance was sampled with 54 force platforms (1000 Hz) connected to a single computer (TF-90100, TF-3055, TF-32120, Tec Gihan, Uji, Japan).

2.2 Data Processing

Spatiotemporal variables were calculated at every step during 50-m distance with following procedures. Foot strike and toe-off instants were determined with a threshold of vertical GRF as 20 N. Based on the foot strike and toe-off instants, step duration from the foot strike of one leg to the next foot strike of the other leg was calculated. Step frequency was computed as an inverse of step duration. Foot placement was determined as the centre of pressure position at the middle of the support phase. Step length and width were calculated as anterior–posterior and mediolateral distances between two consecutive steps. For the step width, to standardise the value, ratio of step width relative to the corresponding subject stature was calculated. Running speed was calculated as a product of step length and frequency. Step-to-step mediolateral and anterior–posterior impulses during the support phase

Nagahara, R., Mizutani, M. and Matsuo, A.
Relationship of Step Width with Sprinting Performance and Ground Reaction Forces.
In *Extended Abstracts (icSPORTS 2016)*, pages 8-10

over 50-m distance were calculated from GRF signals. Moreover, effective vertical impulse during the support phase was computed (Weyand et al., 2000).

2.3 Statistical Analysis

To examine the relationship among variables during accelerated sprinting with macroscopic perspective, each variable at all steps during 50-m distance was averaged out. Means and standard deviations were calculated for each variable. Pearson's product moment correlation coefficient was calculated to test relationship among the average variables. The significance level was set at 5%. All statistical values were calculated using JMP 12 statistical software (SAS Institute Japan Ltd, Tokyo, Japan).

3 RESULTS

Averaged running speed, step length and step frequency over 50-m distance were 8.20 ± 0.17 m/s, 1.82 ± 0.10 m, 4.45 ± 0.22 Hz, respectively. Figure 1 shows changes in step width during the entire acceleration phase. The step width from the first step after block clearance decreased to the 14th step (3.43 s), and the magnitude of decrease became small afterward during the entire acceleration phase. The averaged step width over 50-m distance and its ratio were 0.15 ± 0.05 m and 8.9 ± 3.0 % of stature.

Table 1 shows averaged GRF variables over 50-m distance. The medial (inward) impulse was greater than the lateral (outward) impulse while running on straight line.

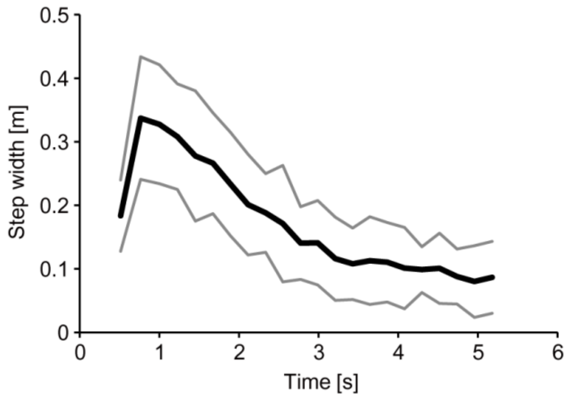

Figure 1: Step-to-step changes in step width during accelerated sprinting for 50-m. Black and grey lines indicate means and standard deviations. The value at the first step was from block clearance to the first foot strike on the ground.

The ratio of step width was significantly positively correlated with running speed (r = .484, P = .049), whereas no significant correlation was found between the ratio of step width and step length or frequency (r = .279 and −.066, P = .279 and .800) (Figure 2). The ratio of step width was significantly correlated positively with medial (r = .816, P < .001), lateral (r = .833, P < .001), net mediolateral (r = .880, P < .001) and propulsive impulses (r = .539, P = .026) (Figure 2). No significant relationship was found between the ratio of step width on the one hand and braking impulse (r = −.447, P = .072), anterior–posterior net impulse (r = .423, P = .091) and effective vertical impulse (r = .015, P = .955) on the other hand.

4 DISCUSSION

This study aimed to clarify the relationships of step width with sprinting performance and GRFs. The results in this study demonstrate the probable importance of relatively wide step width for better accelerated sprinting performance. Because the relationship of step width with both step length and frequency did not show significant relationship, the benefit of wider step width may have no specific effect on longer step length or higher step frequency.

In contrast to the results of this study, Ito et al. (2006) reported no significant difference in the step width between elite and national level sprinters. The reason of this discrepancy may be the difference in methodological approach in addition to the difference in the performance levels between our study and the study by Ito et al. (2006), i.e. sprinting was investigated at initial acceleration and at maximal speed phase in the study of Ito et al. (2006), while it was investigated over the entire 50-m distance in this study.

The wider step width was associated with greater medial impulse and smaller lateral impulse, as well as greater mediolateral net impulse, indicating that the wide step width will be accompanied by large mediolateral velocity of body within a step. Although the mediolateral velocity of body is theoretically disadvantageous for better sprinting performance, the wide step width is interestingly also associated with greater propulsive impulse. This result suggests that wider step width may be feasible to produce greater propulsive force during the support phase of sprinting. While it is difficult to clearly explain the mechanism of how wider step width induces greater propulsive impulse during sprinting, one possible reason is the difference in

Table 1: Averaged GRF variables over 50-m distance. ML and AP mean anterior–posterior and mediolateral, respectively. ML and AP positive values indicate medial and propulsive GRFs. ML and AP negative values indicate lateral and braking GRFs.

	Negative	Positive	Net
ML impulse [Ns/kg]	−0.04 ± 0.03	0.13 ± 0.05	0.09 ± 0.07
AP impulse [Ns/kg]	−0.11 ± 0.02	0.52 ± 0.04	0.40 ± 0.03
Effective Vertical impulse [Ns/kg]		1.02 ± 0.09	

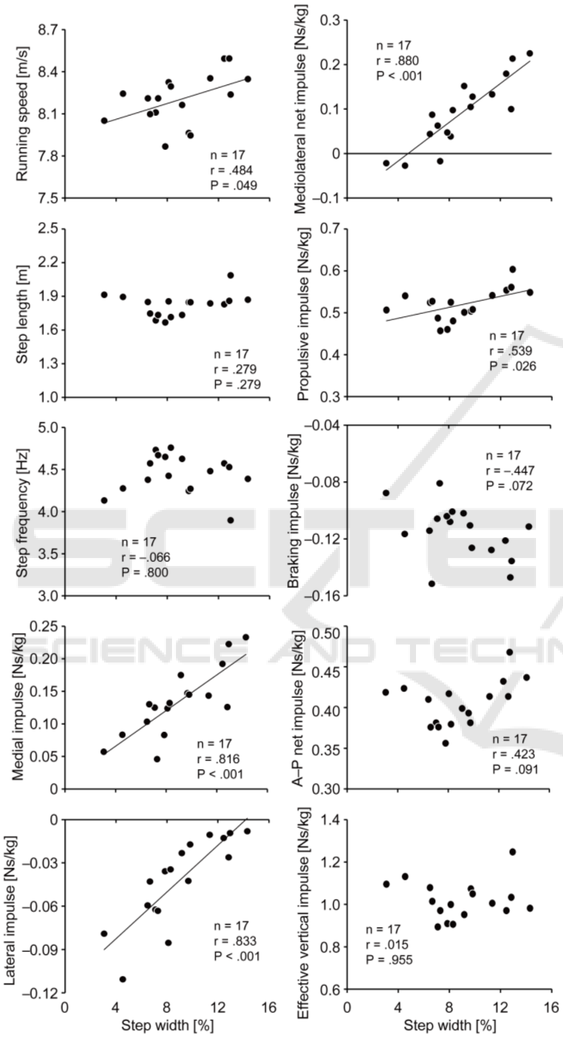

Figure 2: Relationship of step width with spatiotemporal and GRF variables.

adductor muscle activations during hip extension between wide or narrow stances. In the study with squat exercise (McCaw and Melrose, 1999), the integrated electromyography values of adductor muscle for the ascent phase of squat with use of a wide stance were approximately 20% greater than that with use of narrow stance. Wiemann and Tidow (1995) indicated the importance of adductor muscles to generate propulsive force together with major hip extensor muscles. Consequently, relatively wide step width during sprinting possibly induces greater activity of adductor muscles and better sprinting performance through greater propulsive force.

In conclusion, the wider step width may be beneficial for better accelerated sprinting performance. This finding may deepen the understanding of sprinting performance and be beneficial for athletes and coaches, trying to improve accelerated sprinting performance.

REFERENCES

Brindle, R.A., Milner, C.E., Zhang, S., Fitzhugh, E.C. 2014. Changing step width alters lower extremity biomechanics during running. *Gait Posture* 39:124–128.

Debaere, S., Jonkers, I., Delecluse, C. 2013. The contribution of step characteristics to sprint running performance in high-level male and female athletes. *J Strength Cond Res* 27:116–124.

Hunter, J.P., Marshall, R.N., McNair, P.J. 2004. Interaction of step length and step rate during sprint running. *Med Sci Sports Exerc* 36:261–271.

Ito, A., Ishikawa, M., Isolehto, J., Komi, P.V. 2006. Changes in the step width, step length, and step frequency of the world's top sprinters during the 100 metres. *New Studies in Athletics* 21:35–39.

McCaw, S.T., Melrose, D.R. 1999. Stance width and bar load effects on leg muscle activity during the parallel squat. *Med Sci Sports Exerc* 31:428–436.

Nagahara, R., Naito, H., Morin, J.B., Zushi, K. 2014. Association of acceleration with spatiotemporal variables in maximal sprinting. *Int J Sports Med* 35:755–761.

Weyand, P.G., Sternlight, D.B., Bellizzi, M.J., Wright, S. 2000. Faster top running speeds are achieved with greater ground forces not more rapid leg movements. *J Appl Physiol* 89:1991–1999.

Wiemann, K., Tidow, G. 1995. Relative activity of hip and knee extensors in sprinting - implications for training. *New Studies in Athletics* 10:29–49.