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Kinetic and kinematic synchronization between blind and guide sprinters

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ABSTRACT

This study aimed to evaluate the magnitude of synchronization and symmetry between blind and guide sprinters. Elite and sub-elite pairs of male blind sprinters and guide sprinters performed maximal effort 60-m sprints, during which ground reaction force (GRF) for a 50-m distance and sprinting motion during the initial acceleration and maximal speed phases were measured. While there were no significant differences in spatiotemporal and GRF variables between the sprinters of the elite pair, flight time and braking, propulsive and vertical forces in the sub-elite pair showed a significant difference between the sprinters. During the initial acceleration phase, although thigh segment angles in the sagittal plane between the blind and guide sprinters showed obvious phase shifting (lag = −0.078 and −0.088) for the sub-elite pair, the elite pair showed no phase shift and high cross-correlation coefficients (0.96 and 0.83) for the corresponding variable. During the maximal speed phase, for both the elite and sub-elite pairs, there were trivial lags (−0.004 to 0.008) and high cross-correlation coefficients (>0.98) between the thighs of the blind and guide sprinters for both legs. The results demonstrate that a higher magnitude of synchronization between blind and guide sprinters is possibly important for better blind sprint performance.

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KEYWORDS
Running; acceleration; Paralympic; T11

Introduction

A 100-m sprint running race is one of the most attractive sport events in the world. In Paralympic games, there are several categories for 100-m races. Among para-athletes, although amputee sprinters have broadly been studied for multiple biomechanical aspects (Beck & Grabowski, 2018; Strutzenberger et al., 2018), kinematics and kinetics of blind sprinters have never been examined.

A blind sprinter and guide sprinter run at approximately the same running speed with opposite arm and leg actions (symmetric motion between blind and guide sprinters), because their hands are connected during the race by a tether which is no longer than 0.3 m due to the regulation. Based on this fact, differences in spatiotemporal, kinematic and kinetic variables, indicating the magnitude of the synchronization and symmetry, during sprinting between opposite sides of a blind and guide sprinter would be small. However, it is not clear how large the magnitude of differences is. Moreover, it is also unknown whether the differences between a blind and guide sprinter for an elite pair are smaller than those of a sub-elite pair. Thus, it is interesting to investigate the magnitude of synchronization between blind and guide sprinters due to the possibility of the magnitude of the synchronization and asymmetry impacting performance.

A guide sprinter normally can run faster than his/her partner blind sprinter when they freely run at the maximal effort. This indicates that the guide sprinter needs to run at lower speed compared to his/her maximal speed with synchronizing his/her kinematics and kinetics to a blind sprinter for running at the same speed with the same step length (SL) and frequency (SF). An increment of stable running speed towards the maximal speed (from 7 to 9 m/s) is accompanied with a steep increase in SF and roughly maintained SL (Dorn et al., 2012), and thus, in general, lower speed for 1 or 2 m/s compared to the maximal speed will be accompanied with relatively lower SF and almost the same SL. In addition, SF at the maximal speed for a broad range of performance level vary small compared to the variation of SL (Ito et al., 2008). Accordingly, it would be possible that a guide sprinter run at lower speed with shorter SL and the same SF which is not natural sub-maximal speed sprinting for the guide sprinter. Comparing sprinting of a guide sprinter between guide and free conditions could provide knowledge regarding the regulation of sprinting under guide condition which can be considered as specific restrictions.

Given the context shown above, there was a unique opportunity to measure blind sprinters and their guide sprinters, including the world fastest pair, using a long force platform system and motion capture systems. This would allow to answer the aforementioned question regarding blind sprinting. Knowledge gained from such an investigation would be useful for blind sprinters, guide sprinters and their coaches. The purpose of this study was to evaluate the magnitude of synchronization and symmetry between blind and guide sprinters and within a guide sprinter between the guide and free conditions. It was hypothesized that better blind sprint performance would be accompanied with higher magnitude of synchronization between blind and guide sprinters, and a guide sprinter would specifically regulate the sprinting modality rather than naturally running at sub-maximal speed.

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Materials and methods

Participants

The participants were two pairs of male blind sprinters and their guide sprinters (characteristics of the participants being shown in Table 1). The first pair (elite pair) won the gold medals in the 100-m races (T11 class) at the Paralympic Games and World Championships and was the world record holder in the 100-m race at the time of data collection. The second pair was sub-elite sprinters in the same T11 class. The participants were free from injury and gave written informed consent before the experiment. This study was approved by the Ethics Committee of the institute.

Experiment

The pair of blind and guide sprinters wore spiked shoes and simultaneously performed 60-m sprints from the crouched position using starting blocks. A rest period between the two trials was approximately 10 min. The elite pair performed four trials, while sub-elite pair performed three trials. Moreover, the guide sprinters performed two (elite) or one trials (sub-elite) without blind sprinters. The right hand of the guide sprinter was connected to the left hand of the blind sprinter using a specific tether which was 0.3 m of length. For both pairs, right and left feet were on the front and rear blocks, respectively, for the guide sprinter and on the rear and front blocks, respectively, for the blind sprinter. Using a long force platform system which consisted of 54 single force platforms (Nagahara et al., 2019, 2018), serial ground reaction force (GRF) data during sprinting for a 52-m distance from the starting spot were recorded (TF-90,100, TF-3055, TF-32,120, Tec Gihan, Uji, Japan, 1000 Hz). The GRF of the blind and guide sprinters of each pair were separately collected in two trials because there was one lane of force platform system. Three-dimensional coordinate data from 47 retro-reflective markers affixed to the participant's body during the initial acceleration and maximal speed phases in a single sprint for the pair of blind and guide sprinters were simultaneously collected using two motion capture systems (Motion Analysis Corporation, Santa Rosa, CA; 250 Hz) (15 [Kestrel 4200] and 20 [Raptor-E] cameras for the initial acceleration and maximal speed phases, respectively) (Figure 1). The recording of the force platform system was initiated by the electric starting gun, and the electric starting gum provided the signal for synchronization between force platform system and the motion capture systems. Locations of markers affixed to the participant's body were in accordance with previous studies (Nagahara et al., 2014, 2017). The captured volumes were approximately 8 m × 1.5 m × 2 m for the initial acceleration and 10 m × 1.5 m × 2 m (length × width × height) for the maximal speed phase, respectively.

Table 1. Characteristics of participants.

Participants		Age [y]	Stature [cm]	Body mass [kg]	Personal best time for 100 m race [s]
Elite pair	B1	26	169.4	78.3	10.92
	G1	38	173.8	78.0	10.17
Sub-elite pair	B2	44	171.7	63.0	12.06
	G2	30	165.2	64.3	10.64

B1 and B2, blind sprinters, G1 and G2, guide sprinters.

Data processing

All the analyses including statistical tests were performed using Matlab (R2018a, Mathworks, Natick, MA). The GRF signals were smoothed using the fourth-order Butterworth low-pass digital filter with a cut-off frequency at 50 Hz in accordance with previous studies (Nagahara et al., 2019, 2018). Running speed, SL, SF, and support and flight times, as well as mean GRFs, were obtained at each step using methods described in previous studies (Nagahara et al., 2019, 2018). The three-dimensional marker coordinates from the fastest trial (determined by the average running speed for 52-m distance) for each pair and each guide sprinter in free sprint condition were analysed. Endpoints of 15 segments of the whole body, consisting of head, upper trunk, lower trunk, hands, forearms, upper arms, feet, shanks, and thighs, were determined using the marker coordinates in accordance with previous studies (Nagahara et al., 2014, 2017). The endpoint coordinates were smoothed with a fourth-order Butterworth low-pass digital filter. The cut-off frequency was 20 Hz. Then, thigh segment angles in the sagittal plane were calculated in accordance with a previous study (Nagahara et al., 2017).

For comparisons of spatiotemporal and GRF data during the entire acceleration phase, the fastest trial for each participant in each condition was used for analyses, because only one participant was measured using the long force platform system in each trial. Although the comparisons of spatiotemporal and GRF data between the blind and guide sprinters within a single trial could not be performed, no difference in running speed between the sprinters could allow to virtually examine the symmetry in variables other than running speed during sprinting using two separate trials. Within a guide sprinter, the comparisons of spatiotemporal and GRF data between the guide and free sprint conditions were performed. For

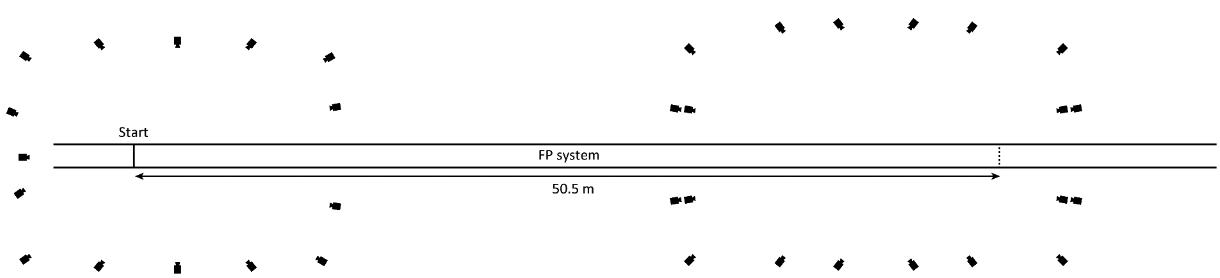

Figure 1. Experimental set-up with 15 and 20 cameras at the initial acceleration and maximal speed phases, respectively.

comparisons of the thigh segment angles between the blind and guide sprinters, the fastest trial for each pair was used for analyses, because the motion capture system could measure the pair simultaneously. For comparisons of the thigh segment angles within the guide sprinter, the fastest trials from the guide and free sprint conditions were used (the data were synchronized using the start signal for the initial acceleration phase and an instant of foot strike for the maximal speed phase). For the discrete variables, within-participant statistical analysis using model statistics was performed to examine the difference between the blind and guide sprinters in each pair (the data for 29 and 30 steps for the elite and sub-elite pair, respectively, being used for the tests) and between guide and free conditions within the guide sprinters (the data for 27 and 29 steps for the guide sprinters of the elite and sub-elite pairs, respectively, being used for the tests) in reference to previous studies (Bates et al., 1992; Dufek & Bates, 1991). In this analysis, when the mean absolute difference in each variable between sprinters or within a sprinter between two conditions was greater than the corresponding product of the pooled standard deviation and a critical value based on sample size, the difference was considered to be significant (see Dufek & Bates, 1991 for detail). The significance level was set at $p < 0.05$, and the critical values were 0.5572 for 27 and 29 steps comparisons and 0.5097 for 30 steps comparison. For both comparisons (between blind and guide sprinters and within a guide sprinter), it was investigated whether two motions were synchronized and symmetrical. Thus, it was assumed that blind and guide sprinters performed the same sprint motion, and the blind and guide sprinters were treated as within-participant comparison for the model statistics analysis. Moreover, symmetry index (SI) was calculated for discrete variables:

$$SI = \frac{|X_G - X_B|}{(X_G + X_B)/2} \times 100$$

where X_B and X_G are the values obtained from blind and guide sprinters, respectively, at each step and SI is measured in % units. Then, average SI for all the steps were calculated. For the segment angle data, cross-correlation analysis was performed (negative lag value indicating that a blind sprinter's motion is ahead of a guide sprinter's one and that a guide sprinter in the guide condition is ahead of that in the free condition).

Results

Discrete variables of blind and guide sprinters during the sprinting for 52-m distance are shown in Table 2. While there was no significant difference in spatiotemporal and GRF variables between the sprinters of the elite pair, flight time and the braking, propulsive and vertical mean forces in the sub-elite pair showed a significant difference between the sprinters. Moreover, SI of GRF variables was smaller in the elite pair than the sub-elite pair. Discrete variables during sprinting for 52-m distance for guide sprinters in the guide and free conditions are shown in Table 3. There was significant difference in the braking mean force for the elite guide sprinter between the guide and free conditions, while no significant difference was found in the sub-elite guide sprinter. Moreover, SI was generally greater in the elite guide sprinter than the sub-elite guide sprinter.

Table 2. Comparisons of spatiotemporal and GRF variables in a 50-m distance between blind and guide sprinters for elite (29 steps) and sub-elite pairs (30 steps).

	B1	G1	Difference	SI	B2	G2	Difference	SI
Running speed [m/s]	7.75 ± 1.87	7.76 ± 1.91	−0.01 ± 0.35	5.4	7.51 ± 1.89	7.39 ± 1.89	0.12 ± 0.27	5.3
Step length [m]	1.75 ± 0.41	1.75 ± 0.41	>−0.01 ± 0.09	5.4	1.62 ± 0.36	1.62 ± 0.34	0.01 ± 0.10	6.3
Step frequency [Hz]	4.38 ± 0.61	4.35 ± 0.56	0.03 ± 0.31	5.9	4.52 ± 0.58	4.49 ± 0.61	0.03 ± 0.28	4.8
Support time [s]	.142 ± .091	.139 ± .087	.003 ± .013	5.6	.138 ± .082	.130 ± .094	.008 ± .014	8.9
Flight time [s]	.097 ± .025	.099 ± .027	−.003 ± .012	10.9	.092 ± .020	.104 ± .019	**−.012 ± .012**	17.0
Braking MF [N/kg]	−3.10 ± 0.96	−2.90 ± 1.02	−0.20 ± 1.30	26.1	−2.74 ± 0.78	−3.35 ± 1.31	**0.60 ± 1.00**	29.6
Propulsive MF [N/kg]	4.52 ± 1.15	4.25 ± 1.14	0.27 ± 0.45	10.5	4.30 ± 0.89	4.99 ± 0.69	**−0.69 ± 0.56**	17.5
Net AP MF [N/kg]	1.68 ± 1.73	1.87 ± 1.75	−0.19 ± 0.63	1.4	1.70 ± 1.47	1.83 ± 1.49	−0.12 ± 0.48	30.3
Vertical MF [N/kg]	17.1 ± 3.0	18.3 ± 3.4	−1.21 ± 2.29	9.6	17.5 ± 2.7	19.1 ± 3.1	**−1.65 ± 1.28**	9.6

B1 and G1, elite blind and guide sprinters, B2 and G2, sub-elite blind and guide sprinters, SI, average symmetry index, MF, mean force, AP, anteroposterior. Bold text indicates significant difference based on the model statistics.

Table 3. Comparisons of spatiotemporal and GRF variables in a 50-m distance within guide sprinters between guide and free conditions for elite (27 steps) and sub-elite pairs (29 steps).

	G1 in guide condition	G1 in free condition	Difference	SI	G2 in guide condition	G2 in free condition	Difference	SI
Running speed [m/s]	7.72 ± 1.93	8.56 ± 2.33	−0.85 ± 0.56	10.5	7.35 ± 1.85	7.98 ± 1.94	−0.63 ± 0.31	8.5
Step length [m]	1.74 ± 0.41	1.86 ± 0.46	−0.13 ± 0.07	6.7	1.61 ± 0.34	1.73 ± 0.35	−0.12 ± 0.07	7.6
Step frequency [Hz]	4.36 ± 0.57	4.50 ± 0.61	−0.14 ± 0.22	5.0	4.49 ± 0.62	4.53 ± 0.61	−0.04 ± 0.23	4.1
Support time [s]	.140 ± .088	.129 ± .089	.012 ± .007	11.4	.131 ± .096	.124 ± .089	.007 ± .010	5.5
Flight time [s]	.097 ± .027	.104 ± .025	−.005 ± .008	8.8	.104 ± .020	.107 ± .014	−.004 ± .009	7.5
Braking MF [N/kg]	−2.78 ± 0.80	−3.46 ± 1.00	**0.68 ± 0.85**	31.0	−3.31 ± 1.31	−3.73 ± 1.18	0.42 ± 0.84	23.2
Propulsive MF [N/kg]	4.30 ± 1.13	4.84 ± 1.11	−0.54 ± 0.41	12.8	5.01 ± 0.69	5.25 ± 0.53	−0.24 ± 0.73	9.0
Net AP MF [N/kg]	2.01 ± 1.62	2.53 ± 1.71	−0.52 ± 0.40	30.0	1.88 ± 1.48	2.05 ± 1.78	−0.17 ± 0.58	27.9
Vertical MF [N/kg]	18.2 ± 3.4	19.5 ± 3.9	−1.27 ± 1.17	7.4	19.1 ± 3.2	19.7 ± 3.1	−0.63 ± 1.10	5.4

G1 and G2, elite and sub-elite guide sprinters, SI, average symmetry index, MF, mean force, AP, anteroposterior. Bold text indicates significant difference based on the model statistics.
The cause of different values of in guide condition compared to the results shown in Table 2 is that the numbers of steps used in the two comparisons are different.

Figure 2 shows the comparisons of thigh segment angle in the sagittal plane for both legs during the initial acceleration phase between blind and guide sprinters. For the sub-elite pair, angle signals showed obvious phase shifting as the blind sprinter changed the angle ahead of the guide sprinter (lag = –0.078 and –0.088). In contrast, the elite pair showed no phase shift (lag = 0) and high cross-correlation coefficients (0.96 and 0.83) of the changes in thigh angles between the blind and guide sprinters. Figure 3 shows the comparisons of thigh segment angle in the sagittal plane for both legs during the maximal speed phase between blind and guide sprinters. For both the elite and sub-elite pairs, there were trivial lags (–0.004 to 0.008) and high cross-correlation coefficients (>0.98) between thighs of the blind and guide sprinters for both legs.

Figure 4 shows the comparisons of thigh segment angle in the sagittal plane for both legs during the initial acceleration phase within the guide sprinter between guide and free conditions. For the sub-elite guide sprinter, angle signals showed phase shifting as the free sprint condition changed the angle ahead of the guide condition (lag = 0.056 and 0.048). In contrast, the elite guide sprinter showed trivial phase shift (lag = 0.008 and 0.004) and high cross-correlation coefficients (0.98) of the changes in thigh angles compared to the sub-elite guide sprinter. Figure 5 shows the comparisons of thigh segment angle in the sagittal plane for both legs during the maximal speed phase within the guide sprinter between guide and free conditions. There were lags in thigh segment angles for the elite guide sprinter as the free sprint condition changed the angle ahead of the guide condition, while no lag was found in the sub-elite guide sprinter. For both elite and sub-elite guide sprinters, cross-correlation coefficients were high in thigh angles between the guide and free sprint conditions (>0.98).

Discussion

To the best of our knowledge, this study firstly investigated biomechanical aspects of blind sprinters and their guide sprinters. Although this study only included two pairs of blind and guide sprinters, the number of athletes competing in T11 class is small, which made it difficult to gather many athletes. While there is no previous study focused on biomechanics of blind sprinting, other Paralympic sprint events such as amputee sprinting have broadly been studied from multiple biomechanical aspects (Beck & Grabowski, 2018; Strutzenberger et al., 2018). This fact highlights the difficulty of gathering many blind sprinters as participants of a study and the importance of this case study. Moreover, one of the participants in this study was the fastest blind sprinter ever, and focusing on the features of the individual pair, rather than grouping many blind and guide sprinters together, would provide deeper understanding of them (Bates et al., 1992; Heale & Twycross, 2018). With this in mind, it is believed that the knowledge gained in this study

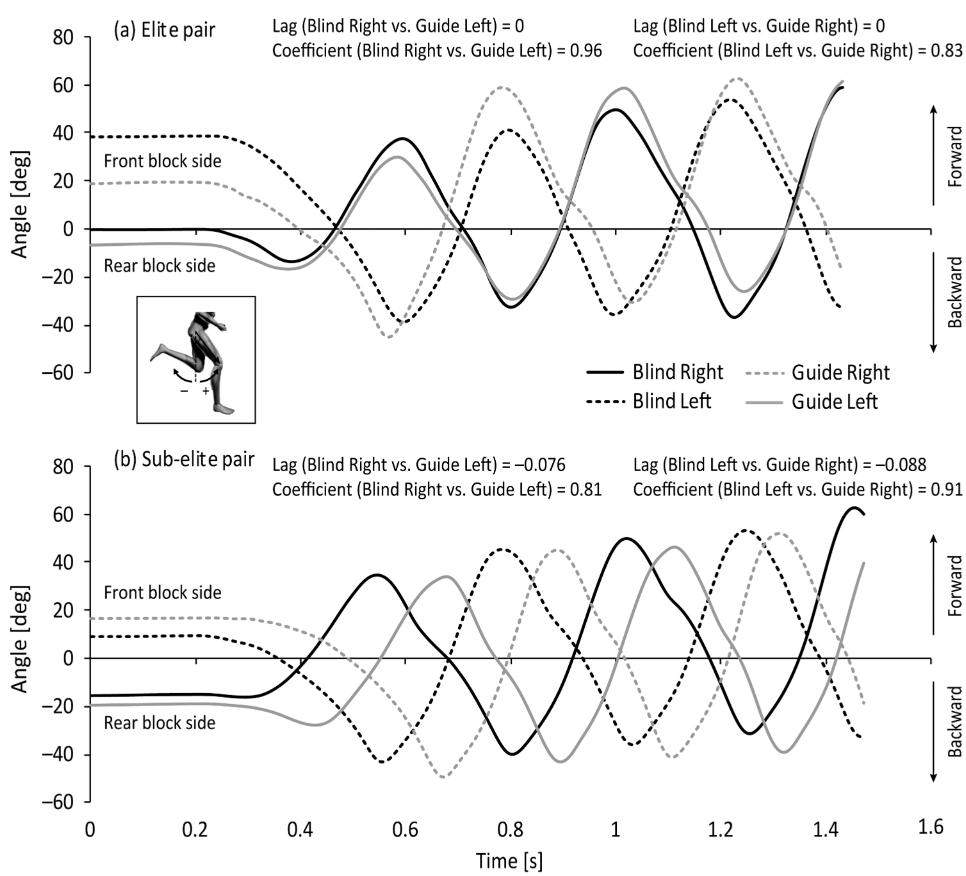

Figure 2. Changes in thigh segment angles for both legs during the initial acceleration phase (from the start signal to the toe-off of the 4th step) for elite (top) and sub-elite (bottom) pairs. Lag and coefficient are results of cross-correlation.

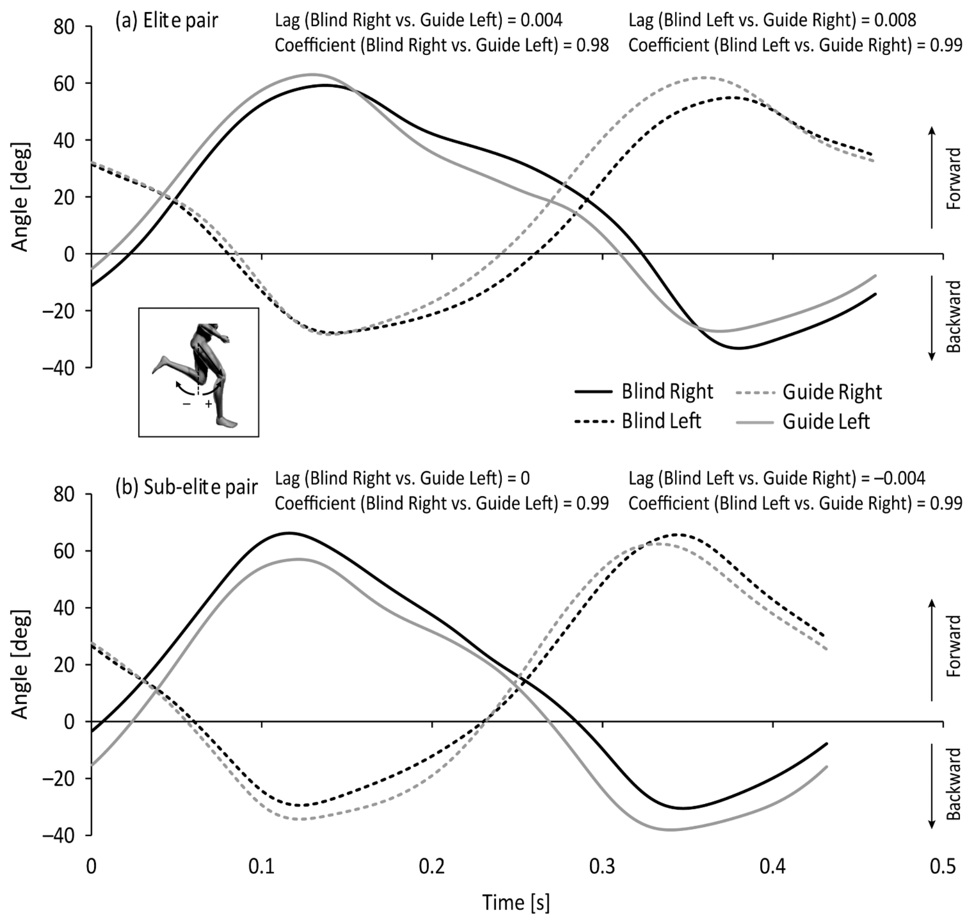

Figure 3. Changes in thigh segment angles for both legs during the maximal speed phase (from the left foot strike of the blind sprinter to the next left foot strike of the blind sprinter) for elite (top) and sub-elite (bottom) pairs. Lag and coefficient are results of cross-correlation.

with a small cohort will be useful for blind athletes and their coaches. Moreover, the regulation of locomotion for a guide sprinter would provide an insight of human locomotor function. Only the thigh segment angle was used in this study because including other kinematic and kinetic variables make this study too descriptive and all of the variables showed the same trend with the thigh segment angle. In addition, attention should be paid to the multiple trials (data being not obtained within a single trial) for comparison of the spatiotemporal and GRF data between the blind and guide sprinters. That said, as there were no significant differences in running speed and net anteroposterior mean force between the blind and guide sprinters for both pairs, the used trials for the comparisons between the sprinters can be useful to verify the symmetry in variables during sprinting.

The current results indicate that, in general, the differences in spatiotemporal and GRF variables during the entire acceleration phase between blind and guide sprinters in the elite pair are likely smaller than those in the sub-elite pair (Table 2). Regarding the thigh segment angle, the results demonstrate that the magnitude of synchronization between the blind and guide sprinters during the initial acceleration phase could be higher in the elite pair compared with the sub-elite pair (Figure 2). Because blind and guide sprinters' hands are connected using a 0.3 m tether, lower magnitude of synchronization will encumber arm motions of both blind and guide sprinters, possibly resulting in lower running speed. Thus, it would be important to increase the magnitude of synchronization between the blind and guide sprinters, particularly during the initial acceleration phase, for achieving better performance in a blind sprint race. The lag of thigh segment angles between blind and guide sprinters for the sub-elite pair was the largest at the first step and decreased step to step, indicating that the difference in timing to produce force at the block clearance is possibly the source of the low synchronization magnitude between the sprinters in the sub-elite pair during the initial acceleration phase. During the maximal speed phase, the results of thigh segment angles indicate that the magnitudes of synchronization between the blind and guide sprinters for both elite and sub-elite pairs were high (Figure 3), suggesting that the magnitude of synchronization of thigh segment motion would not distinguish the difference in performance levels between the elite and sub-elite pairs. Although it is difficult to explain the reason of smaller differences in faster pair, higher synchronization level would be accompanied with natural and comfortable sprinting of the blind sprinter, which in turn unleash the potential of a blind sprinter. Although it is difficult to compare the magnitude of synchronization between the blind and guide sprinters to previous findings, when compared to SI of bilateral differences in GRF variables during running (2.6 to 49.8) (Zifchock et al., 2006), the magnitude of synchronization between the blind and guide sprinters in the current study (1.4 to 30.3) was within the magnitude of bilateral

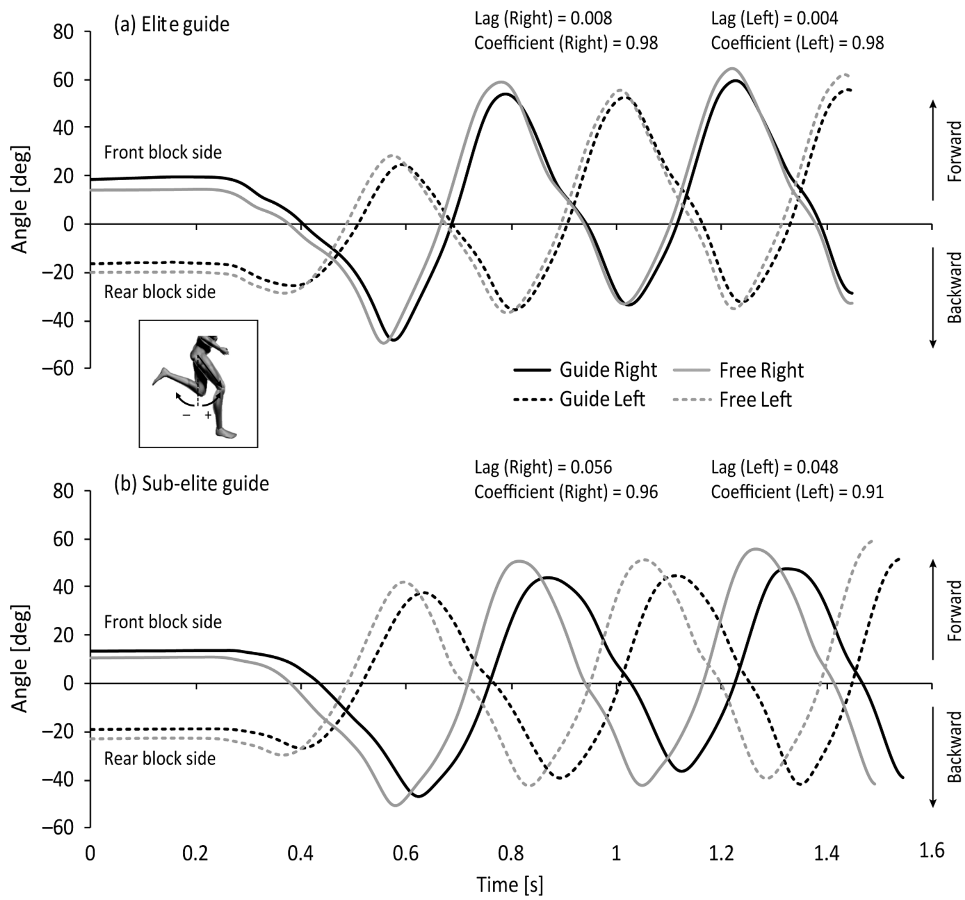

Figure 4. Changes in thigh segment angles for both legs during the initial acceleration phase (from the start signal to the toe-off of the 4th step) for elite (top) and sub-elite (bottom) guide sprinters in the guide and free sprint conditions. Lag and coefficient are the results of cross-correlation.

symmetry. This suggest that the magnitude of the differences between the blind and guide sprinters seems to be comparable to the intra-individual bilateral variation in running. Thus, it can be considered that the magnitude of the synchronization between the blind and guide sprinters is high.

The difference in kinematic and kinetic variables within a guide sprinter between the guide and free sprint conditions demonstrates one of the regulation strategies of the fastest human locomotion. Magnitudes of differences in discrete variables during the entire sprinting between guide and free sprint conditions were greater in the elite guide sprinter compared to sub-elite guide sprinter (Table 3), although the significant difference was only found in the braking mean force in the elite guide sprinter. These results suggest that the elite guide sprinter was necessary to change his sprinting modality with greater extent. This can partially be explained by the fact that there was greater difference in sprint performance between guide and free conditions in the elite guide sprinter (0.84 m/s) than the sub-elite guide sprinter (0.63 m/s). However, the difference in spatiotemporal variables during the entire sprinting between guide and free conditions showed specific features, demonstrating that the sprinting under the guide condition is not simply the sub-maximal effort sprinting. The current results showed the greater magnitude of decrease in SL compared to corresponding changes in SF comparing the free to guide conditions which is not consistent to magnitudes of changes in SL and SF with a natural decrement of running speed around the comparable running speed (Dorn et al., 2012; Luhtanen & Komi, 1978). Thus, the guide sprinter probably intentionally changed their sprinting modality in order to synchronize to the blind sprinter. To accomplish the specific sprinting modality with relatively short SL with high SF, the elite guide sprinter in the guide condition increased support time, decreased flight time, and suppressed the range of thigh motion in the sagittal plane (Figures 4 and 5). These features of difference in sprinting within the guide sprinter between guide and free sprint conditions demonstrate the difference between guide sprinting and natural sub-maximal sprinting (Dorn et al., 2012; Luhtanen & Komi, 1978; Williams, 2000). The shorter flight time in guide sprinting is opposite to the corresponding changes in accompanied with a natural decrease in speed (Luhtanen & Komi, 1978), emphasizing the particularity of guide sprinting. During the initial acceleration phase, between the guide and free conditions, there was greater lag in the changes in thigh segment angle in the sagittal plane for the sub-elite guide sprinter compared to the elite guide sprinter. This suggests that the elite guide sprinter could start naturally in the guide condition, while sub-elite guide sprinter did not start naturally and delayed the timing of initiation of motion at the start. Taken into account the fact that the sub-elite guide sprinter delayed to start compared to his partner blind

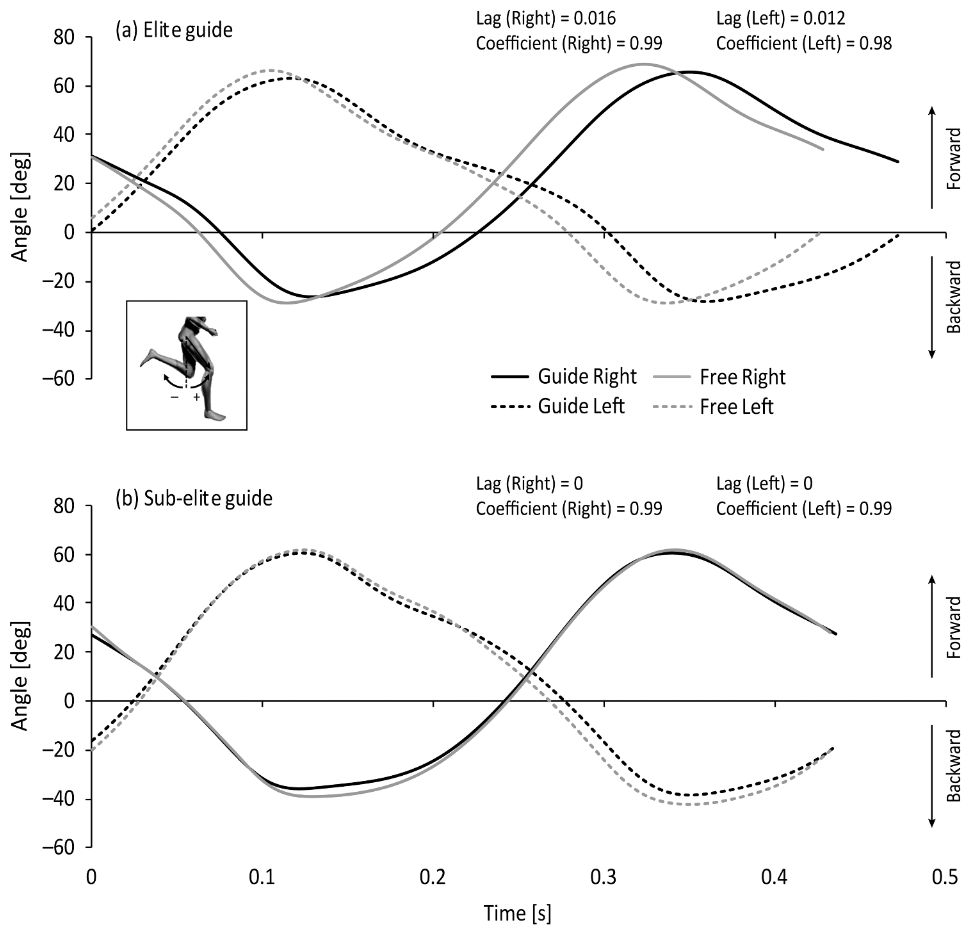

Figure 5. Changes in thigh segment angles for both legs during the maximal speed phase (from the right foot strike to the next right foot strike) for elite (top) and sub-elite (bottom) guide sprinters in the guide and free sprint conditions. Lag and coefficient are the results of cross-correlation.

sprinter by visually checking the initiation of motion of the blind sprinter (visual determination by the examiner), this aspect is possibly a training task for improving the performance of sub-elite guide sprinter in a guide sprint condition. Comparison of thigh segment angles within guide sprinters during the maximal speed phase showed greater lag in the elite guide sprinter compared to the sub-elite guide sprinter, supporting the fact that the elite guide sprinter regulates his sprinting modality with greater extent. Thus, although the magnitude of synchronization of thigh segment motion would not distinguish the difference in performance levels between the elite and sub-elite blind sprint pairs during the maximal speed phase, an ability to greatly regulate sprinting modality to synchronize the motion with a blind sprinter is likely required for being better guide sprinter.

In conclusion, the results from two pairs of blind and guide sprinters demonstrate that the magnitude of synchronization is likely high in an elite pair of blind and guide sprinters, especially during the initial acceleration phase. Moreover, for a guide sprinter, the magnitude of regulation to synchronize the motion to a blind sprinter may need to be high for better sprint performance of a pair of blind and guide sprinters. These suggest that the level of expertise may possibly relate to the magnitude of synchronization. Although it should be kept in mind that this study only compared two pairs, it would be important to increase the magnitude of synchronization between a blind and guide sprinter for improving sprint performance in a blind sprint race.

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Disclosure statement

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