SYNCHRONIZATION OF SPRINTING BETWEEN BLIND AND GUIDE SPRINTERS: A CASE STUDY

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This study aimed to evaluate the magnitude of synchronization between blind and guide sprinters for elite and sub-elite pairs. Two pairs of male blind sprinters and their guide sprinters performed 60-m sprints during which ground reaction force and sprinting motion were recorded. Although flight time and propulsive force in sub-elite pair showed significant and moderate difference between the sprinters, there were trivial and small differences in variables between the sprinters of elite pair. Moreover, the correlation (r = 0.97 and 0.84) in the thigh angle in the sagittal plane between blind and guide sprinters was high with no phase shifting for the elite pair compared to the sub-elite pair during the initial acceleration phase. The results indicate that the magnitude of synchronization is likely high in an elite pair of blind and guide sprinter especially during the initial acceleration phase.

KEYWORDS: para-athlete, kinematics, acceleration, GRF, running.

INTRODUCTION: 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 because their hands are connected during the race by a tether which is shorter than 0.3 m due to the regulation. Based on this fact, differences in spatiotemporal, kinematic and kinetic variables, indicating magnitude of synchronization, during sprinting between 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 synchronization impacting performance. 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 between blind and guide sprinters.

METHODS: The participants were two pairs of male blind sprinters and their guide sprinters (Table 1). The first pair won the gold medals in the 100-m race (T11 class) at the Olympic Games and World Championships, and was the world record holder in the 100-m race at the time of data collection. The second pair were 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.

Table 1: Characteristics of participants.

Participants		Age [y]	Stature [cm]	Body mass [kg]	Personal best time for 100m race [s]
Pair 1	B1	26	169.4	78.3	10.92
	G1	38	173.8	78.0	10.17
Pair 2	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.

The participants wore spiked shoes and performed 60-m sprints from the crouched position using starting blocks. Using a long force platform system which consisted of 54 single force platforms (Nagahara et al., 2019), serial ground reaction force (GRF) data during sprinting for a 50-m distance from the starting spot were recorded (TF-90100, TF-3055, TF-32120, 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 were collected using two motion capture systems (20 and 16 cameras for the initial acceleration and maximal speed phases, respectively). The captured volumes were approximately 9 m × 1.5 m × 2 m and 10 m × 1.5 m × 2 m (length × width × height), respectively.
The GRF signals and marker coordinate data were smoothed using a Butterworth low-pass digital filter with a cut-off frequency at 50 and 20 Hz, respectively. Running speed, step frequency and length, and support and flight times, as well as mean GRFs, were obtained. Moreover, thigh segment angle in the sagittal plane was calculated. For the discrete variables, a paired t-test with effect size of Cohen's d (Cohen, 1988) was used to examine the difference between the blind and guide sprinters in each pair (the data for 30 steps for each sprinter being used for the tests). The significance level was set at $p < 0.05$. Threshold values for the interpretation of effect size were <0.2 (trivial), 0.2– <0.6 (small), 0.6–1.2 (moderate), and >1.2 (large) (Hopkins et al. 2009). 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 correlation coefficient and intra-class correlation coefficient were calculated to evaluate the magnitude of synchronization.

RESULTS and DISCUSSION: Discrete variables during the sprint acceleration are shown in Table 2. For spatiotemporal variables, while there was no significant difference between the sprinters of elite pair, flight time in the sub-elite pair showed significant and moderate difference between the sprinters. For the GRF variables, propulsive and vertical mean forces of the elite pair were significantly different between the sprinters with trivial or small difference, while the difference in propulsive force between the sprinters in the sub-elite pair was significant and moderate. These results indicate that, in general, the differences in spatiotemporal and GRF variables between blind and guide sprinters in the elite pair are likely smaller than the sub-elite pair, and it can be said reduction of difference between the sprinters in terms of spatiotemporal and GRF variables is important to improve blind sprint performance.

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

	B1	G1	P value (t-test)	Effect size	B2	G2	P value (t-test)	Effect size
Running speed [m/s]	7.75 ± 1.87	7.76 ± 1.91	.843	.007	7.51 ± 1.89	7.39 ± 1.89	**.024**	.063
Step length [m]	1.75 ± 0.41	1.75 ± 0.41	.886	.006	1.62 ± 0.36	1.62 ± 0.34	.701	.019
Step frequency [Hz]	4.38 ± 0.61	4.35 ± 0.56	.648	.046	4.52 ± 0.58	4.49 ± 0.61	.582	.048
Support time [s]	.142 ± .091	.139 ± .087	.290	.031	.138 ± .082	.130 ± .094	**.005**	.090
Flight time [s]	.097 ± .025	.099 ± .027	.222	.107	.092 ± .020	.104 ± .019	**<.001**	.615
Braking MF [N/kg]	−3.10 ± 0.96	−2.90 ± 1.02	.423	.198	−2.74 ± 0.78	−3.35 ± 1.31	**.002**	.561
Propulsive MF [N/kg]	4.52 ± 1.15	4.25 ± 1.14	**.003**	.235	4.30 ± 0.89	4.99 ± 0.69	**<.001**	.862
Net AP MF [N/kg]	1.68 ± 1.73	1.87 ± 1.75	.109	.111	1.70 ± 1.47	1.83 ± 1.49	.165	.083
Vertical MF [N/kg]	17.1 ± 3.0	18.3 ± 3.4	**.008**	.377	17.5 ± 2.7	19.1 ± 3.1	**<.001**	.564

B1 and B2, blind sprinters, G1 and G2, guide sprinters, MF, mean force, AP, anteroposterior. Bold text indicates significant difference.

Figure 1 shows the thigh segment angle in the sagittal plane for both legs during the initial acceleration phase. For the sub-elite pair, angle signals showed obvious phase shifting as the blind sprinter changed the angle ahead of the guide sprinter. This aspect was supported by relatively large lag (−0.084 and −0.068) in cross-correlation and low correlation coefficients (r

= 0.49 and 0.42) and intra-class correlation coefficients (ICC = 0.47 and 0.42) of the changes in thigh angles between the sprinters. In contrast, the elite pair showed almost no phase shift and high correlation coefficients (r = 0.97 and 0.84) and intra-class correlation coefficients (ICC = 0.97 and 0.84) of the changes in thigh angles between the blind and guide sprinters. These 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. Thus, it would be important to increase the magnitude of synchronization between the blind and guide sprinters for achieving better performance in a blind sprint race. The lag 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 sub-elite pair during the initial acceleration phase.

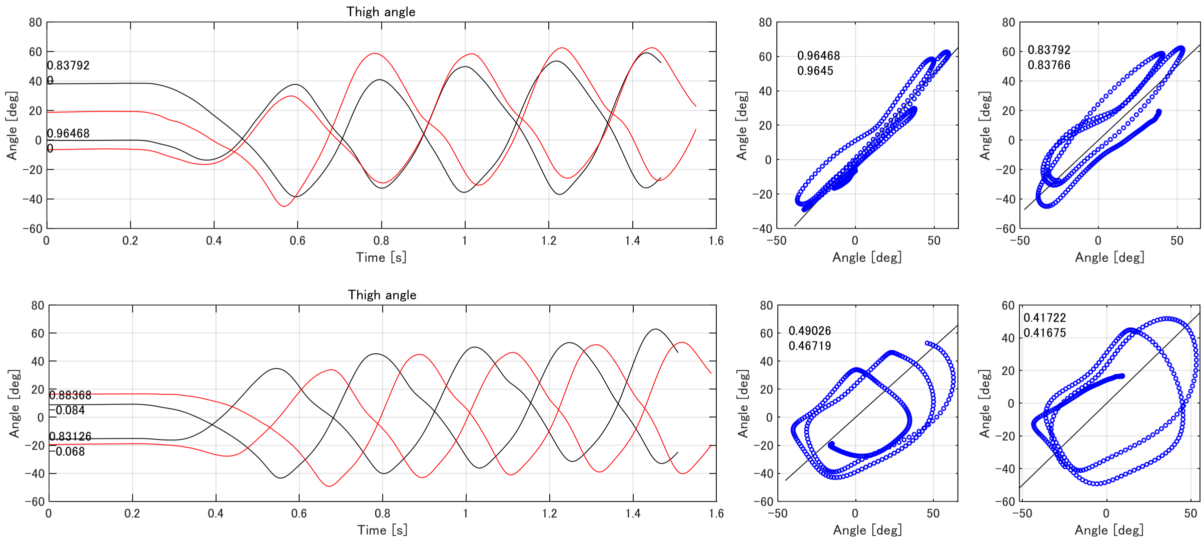

Figure 1: Changes in thigh segment angles for both legs during the initial acceleration phase for elite (top) and sub-elite (bottom) pairs. Black and red lines indicate blind and guide sprinters, respectively. Four panels on the right side show angle-angle relationships between blind and guide sprinters (right thigh on the middle and left thigh on the far right). The numbers in the left panel are results of cross-correlation (correlation and lag coefficients on the top and bottom), and the numbers in the four panels on the right side are correlation coefficient and intra-class correlation coefficient. The black solid lines in the four panels on the right side are the identical lines.

Figure 2 shows the thigh segment angle in the sagittal plane for both legs during the maximal speed phase. For both the elite and sub-elite pairs, there were trivial lags and high correlation coefficients (r = 0.98 and 0.98 for the elite pair and >0.99 and 0.99 for the sub-elite pair) and intra-class correlation coefficients (ICC = 0.98 and 0.97 for the elite pair and 0.96 and 0.99 for the sub-elite pair) between thighs of the blind and guide sprinters for both legs. These results indicate that the magnitudes of synchronization between the blind and guide sprinters during the maximal speed phase for both elite and sub-elite pairs are high, 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 compare the magnitude of difference between the blind and guide sprinters to previous findings, when comparing the difference in thigh segment angles between the intra-individual trials of the blind sprinters, the magnitude of differences between the blind and guide sprinters was comparable. This suggest that the magnitude of the kinematic difference between the blind and guide sprinters seems comparable to the intra-individual variation in movement. Thus, it can be considered that the magnitude of the synchronization in kinematics between the blind and guide sprinters is high.

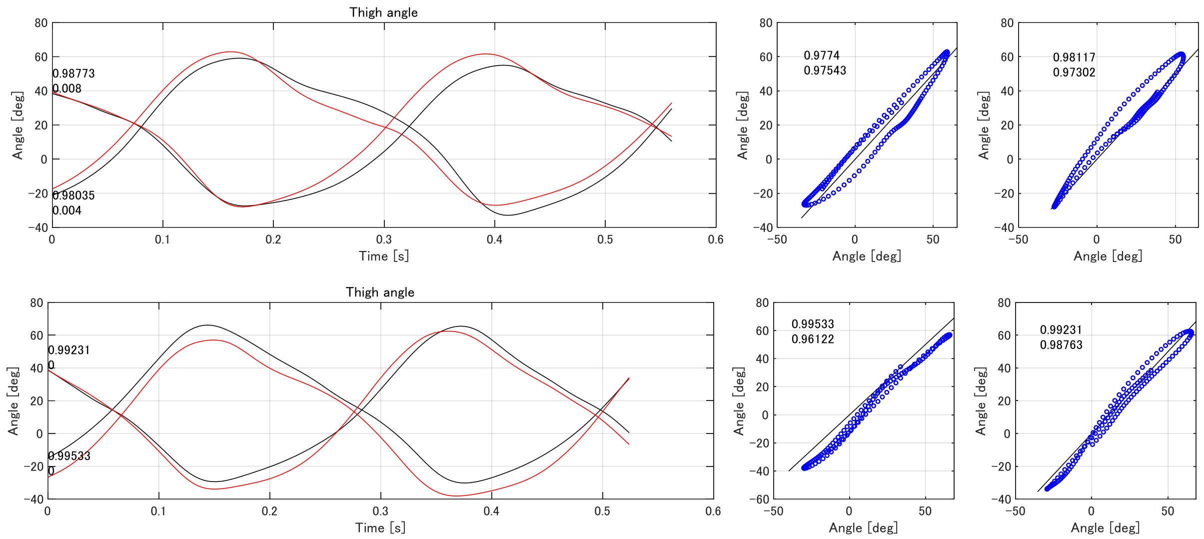

Figure 2: Changes in thigh segment angles for both legs during the maximal speed phase for elite (top) and sub-elite (bottom) pairs. Black and red lines indicate blind and guide sprinters, respectively. Four panels on the right side show angle-angle relationships between blind and guide sprinters (right thigh on the middle and left thigh on the far right). The numbers in the left panel are results of cross-correlation (correlation and lag coefficients on the top and bottom), and the numbers in the four panels on the right side are correlation coefficient and intra-class correlation coefficient. The black solid lines in the four panels on the right side are the identical lines.

CONCLUSION:

The results demonstrate that the magnitude of synchronization is likely high in an elite pair of blind and guide sprinters especially during the initial acceleration phase. Furthermore, the results suggest that the level of expertise may relate to the magnitude of synchronization. It would be important to increase magnitude of synchronization between a blind and guide sprinter for improving sprinting performance in a blind sprint race.

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