SPRINTING CHARACTERISTICS OF WOMEN'S 100 METER FINALS AT THE IAAF WORLD CHAMPIONSHOPS DAEGU 2011

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This study analyzed the sprinting characteristics of the finalists during the women's 100 m event in the IAAF World Championships Daegu 2011 in order to provide important information to track and field coaches and athletes. Five high speed cameras (Casio, Japan) with a sampling frequency of 300 Hz were used to calculate the number of steps, step length, and stride frequency of the eight sprinters in the women's final event. There was a tendency to show a better performance time with a high number of steps ($p=0.13$) and shorter stride length ($p=0.14$) among the eight sprinters. Furthermore, stride frequency and performance time were negatively correlated as a higher stride frequency had a positive impact on performance time ($p=0.02$). Based on the relationship between COM velocity and lower extremity joint angles, the 4 top ranked sprinters showed the different strategies to maintain a high COM velocity during the mid portion of the race.

KEY WORDS: world championships (WC), sprinting characteristics, centre of mass (COM).

INTRODUCTION: The women's 100 meter world record of 10.49 s was set by Florence Griffith-Joyer (USA) in 1988 and has not been broken for over 20 years. Thus, the aim of the biomechanics project was to analyze the sprinting characteristics of the finalists in the women's 100 meter race during IAAF WC Daegu 2011 in order to provide important scientific information to track and field coaches and athletes.

METHODS: Biomechanical analysis was conducted to capture the movements of eight finalists (26.38 ±2.92 y, 168.75 ±7.05 cm, 56.50 ±5.76 kg) in the women's 100 meter final event. Panning technique (Chow, 1993) was applied to capture the selected sprinting characteristics of the sprinters during the race. Five high speed cameras (Casio EX-F1) operated by each individual from the team were located at the spectator's area on the second floor of the stadium. The video image with a sampling frequency of 300 Hz was synchronized to the sign of the start gun going off near the start line. Once all the images were collected from the five cameras, software (Vegas, Sony, Japan) was used to calculate an average speed (m/s), the number of steps (n), stride length (meter), and stride frequency (n/sec). Also, twelve video cameras (Sony, Japan) with a sampling of 60 Hz and the Kwon 3D program were used for top four ranked sprinters' 3 dimensional analysis of the 40 meter to 70 meter portion of the race (Figure 1).
The correlation coefficients between 1) the performance time and each sprinting variable and 2) COM velocity and lower extremity angles were calculated using the Matlab program (MathWorks, USA) with an alpha level of 0.05.

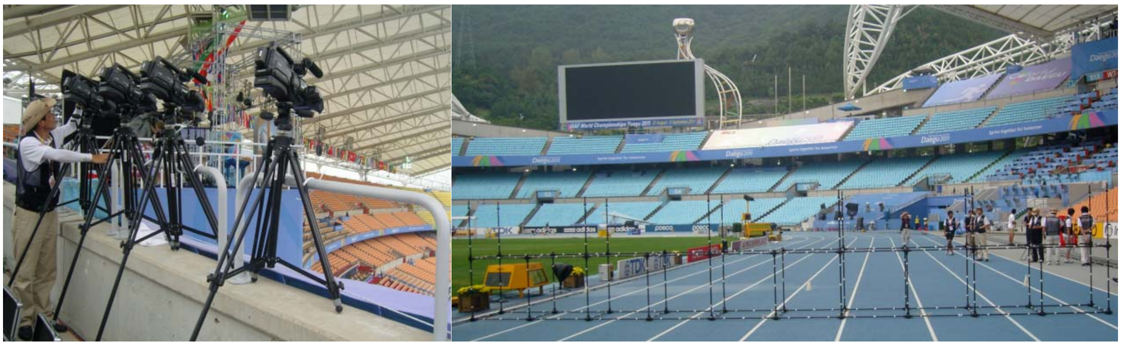

Figure 1: Camera setup on the stadium (left) and DLT calibration process of 40-70 meter capture volume (right).

RESULTS: Based on the results, there was a relationship between the sprinters' performance time and their physical characteristics. Lighter weight and shorter height seemed to be positively related with performance time based on the correlation analysis, but it was not statistically significant (Height & Performance time: R=0.583, p=0.129, Weight & Performance time: R=0.655, p=0.078).
Figure 1 shows the linear relationship between performance time and sprinting characteristics. There was a trend that showed a significant correlation between the sprinters' sprinting characteristics and their performance time. Especially, a faster stride frequency has a positive impact on performance time (R=0.790, *p*=0.02). Furthermore, a higher number of steps and shorter stride length seemed to be related with faster performance time but was not significant. The reaction time and performance time of the sprinters were not related.

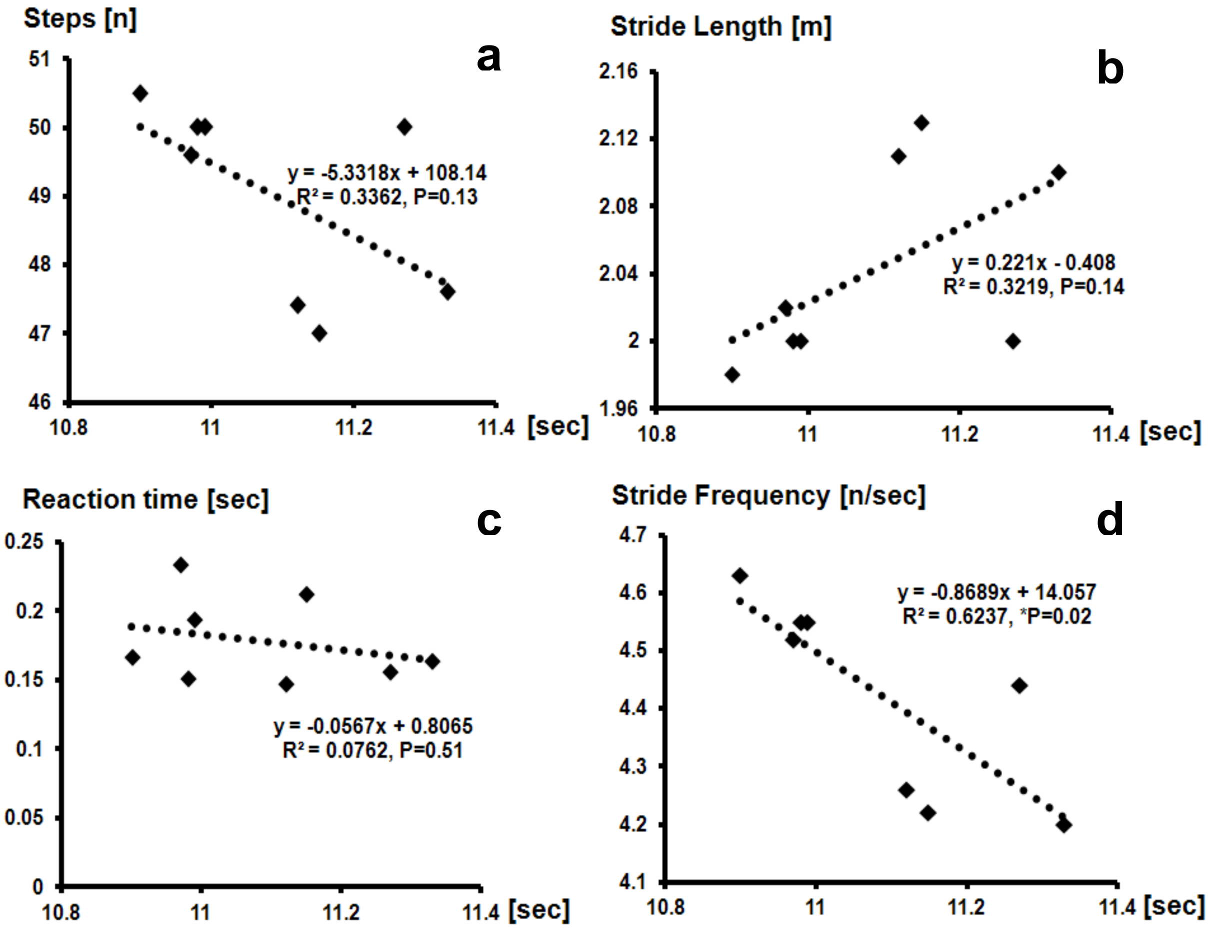

Figure 1: Correlation coefficients between performance time and sprinting characteristics (a: number of steps, b: stride length, c: reaction time, and d: stride frequency), Ryu et al. (2011).

Figure 2 shows changes in Carmelita Jeter's joint angles of the right leg and trunk over time during 40 meter to 70 meter of the race. Once the velocity of COM and the angles of flexion and extension of each sprinter were calculated, correlation coefficients between COM velocity and joint angles were also calculated. Based on the results, each sprinter showed own sprinting strategy to maintain a high velocity of COM during the mid race (Table 1). Carmelita Jeter (USA) showed more flexed knee and hip motion at heel contact (HC) to maintain a high COM velocity while S.A. Fraser-Pryce (JAM) showed more extended knee and hip motion at HC. On the other hands, Veronica Campbell-Brown (JAM) and Kelly-Ann Baptiste (TRI) showed a tendency to have high knee lifts during the swing phase to maintain the high COM velocity during the race.

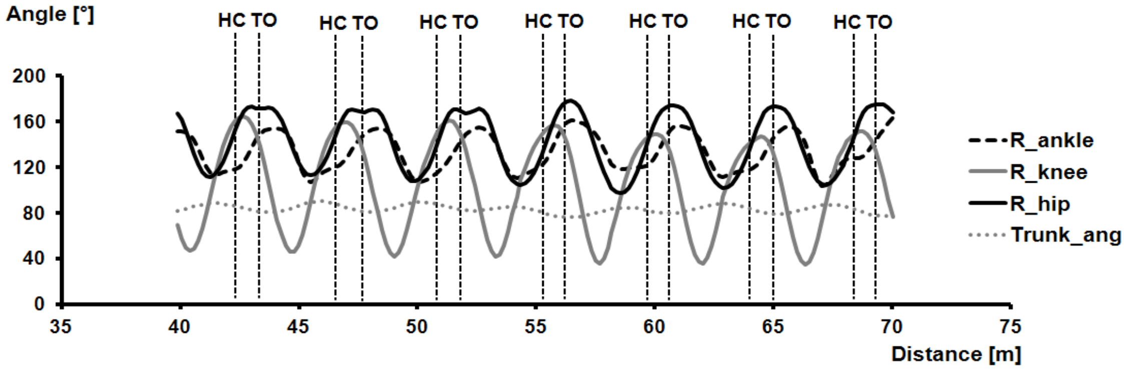

Figure 2: Changes in Carmelita Jeter's flexion and extension angles of the right leg and trunk over time during 40 m- 70 m race(HC: Heel Contact, TO: Toe Off), Ryu et al. (2011).

Table 1: Correlation coefficients (R) between velocity of COM and the angles of sprinters during 40 m to 70 m (HC: heel contact, TO: toe off), Ryu et al. (2011).

Angles		Jeter	Campbell	Baptiste	Fraser
Ankle Flex-Extension	Maximum	0.6158	-0.4165	-0.7952*	-0.2513
	Minimum	-0.1446	-0.3602	0.8916*	0.6864
	HC	0.3111	0.2407	0.5135	-0.2277
	TO	-0.1670	0.6663	0.6353	-0.5226
Knee Flex-Extension	Maximum	0.7025	-0.7105	-0.0125	0.5010
	Minimum	0.5767	-0.4525	0.1327	0.5708
	HC	-0.8763*	-0.4094	-0.3373	0.8079*
	TO	-0.4436	-0.7276	-0.2317	-0.3711
Hip Flex-Extension	Maximum	-0.6796	0.5347	0.0956	-0.2301
	Minimum	0.2324	-0.8608*	-0.8916*	0.5407
	HC	-0.7883*	-0.5204	-0.8260*	0.9030*
	TO	0.6887	-0.4014	0.7666*	-0.5850

* $P<0.05$

DISCUSSION:

Biomechanics analysis was conducted to understand sprinting characteristics of the finalists during the women's 100 meter event in the IAAF World Championships Daegu 2011. Five high speed cameras were used to calculate sprinting characteristics such as the number of steps, step length, and stride frequency of the eight sprinters in the women's final event. Then, twelve video cameras with a program were used to calculate 3 dimensional angles of the top four ranked sprinters during the 40 meter to 70 meter portion of the race. Therefore, the relationship between the sprinting performance and biomechanical variables of the sprinters was investigated.

A quicker reaction time to start the 100 meter sprint is critical to perform the best race. When Veronica Campbell-Brown (JAM) won the race with a record of 11.01 s in Osaka WC 2007, her reaction time was 0.167 s and second place, Williams (USA)'s reaction time, was 0.145 s (JAAF, 2007). On the other hand, Fraser Shelly-Ann (JAM) won her race with a record of 10.73 s and with a reaction time of 0.146 s in Berlin WC 2009. Finally, in Daegu WC 2011, the reaction time of the top three sprinters was 0.167 s, 0.234 s, and 0.151 s, respectively. Carmelita Jeter (USA), who won the women's 100 meter final race with a record of 10.90 s, showed a reaction time of 0.167 s. This was slower than her reaction time of 0.160 s in Berlin WC 2009. However, there was no direct relationship found between reaction time at the start and the final performance time of the race.

Based on the relationship between performance time and the sprinters' physical characteristics, the lighter and shorter sprinters seem to perform better among the eight finalists. It was found that the top four sprinters' physical characteristics ranged from 160 cm to 167 cm in height and 52 kg to 54 kg in weight. On the other hand, heavier sprinters seem to perform better but the height of the sprinters does not seem to be related to performance time when analyzing the men's 100-m final event at Daegu WC 2011. There would be an existing gender difference between men and women but further investigation would be required to find the exact relationship between performance and physical characteristics based on the higher number of the top sprinters in the analysis.

The results showed a better performance time with a higher number of steps and a shorter stride length among the eight sprinters. Furthermore, stride frequency and performance time were negatively correlated, as a higher stride frequency had a positive impact on performance time. Thus, female sprinters using a shorter step length and a faster stride cycle strategy during their sprints should see a positive impact on their performance. Furthermore, the unpublished data of men's sprinting characteristics in the 100-m in Daegu 2011 also shows a similar trend between sprinting characteristics and performance time, but the relationship was weaker than female sprinters (KSSB, 2011).

A previous study investigated the sprinting strategies of male sprinters who have an average record of 11.09 ±0.15 s (Mackala, 2007). The study suggested that an appropriate adjustment of step frequency and step length in the first 10 to 20 meters of a race is important to perform the best in a 100 meter race. Therefore, how the sprinters change sprinting characteristics such as stride length and frequency during acceleration, mid-race, and finish phases would be required to understand the sprinting strategy of today's top-class sprinters in the women's 100-m (KSSB, 2011). Furthermore, 3 dimensional analysis of the top ranked sprinters indicated that each sprinter has the different strategies to maintain a high COM velocity during the mid portion of the race. A previous study suggested that greater magnitudes of propulsive impulse during stance phase is important for reaching a high velocity during the race (Hunter et al., 2005). Also, they suggested that the magnitude of propulsive impulse and hip extension velocity of the stance leg is positively associated during the race. Therefore, further investigation about the relationship between sprinting velocity and angular kinematics (e.g. angular velocity and acceleration) of the lower extremity during stance phase would be necessary.

CONCLUSION: It has been predicted that the ultimate performance time of a 100 meter sprint would be 9.37 s for men and 10.15 s for women (Peronnet & Thibault, 1989). Usain Bolt (JAM) in the men's 100-m event broke the world record with a record of 9.58 s at the Berlin WC in 2009. However, no strong female sprinters have stepped up to break Florence Griffith-Joyner (USA)'s current record, 10.49 s for over 20 years. This research was conducted during the 100-m women's event in the IAAF Daegu 2011 and aimed to provide useful biomechanical information to track and field coaches and athletes through the analysis of sprinting strategies used by today's top female sprinters.

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