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Mid-phase sprinting movements of Tyson Gay and Asafa Powell in the 100-m race during the 2007 IAAF World Championships in Athletics

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Abstract

In the present study, the running movements of Tyson Gay (9.85 seconds) and Asafa Powell (9.96 seconds) who finished first and third, respectively, in the 2007 IAAF World Championships in Athletics were analyzed. Their data were compared to past data (Ito et al., 1998) in order to determine the characteristics of both sprinters. Maximal sprint running velocity was 11.85 m/s for Gay and 11.88 m/s for Powell. For Gay and Powell, step frequency was 4.90 and 4.96 steps/s, respectively, and step length was 2.42 and 2.40 m, respectively. According to Ito et al. (1998), sprint running velocity is not related to maximum thigh angle "high knee", but the faster the sprint running velocity, the greater the minimum knee angle. The maximum thigh angle for Gay and Powell was comparable at 65° and 70°, and the minimum knee angle for Gay and Powell was 41° and 38°, respectively, and these numbers were similar to the data obtained by Ito et al. (1998). The horizontal distance from the toe at the point of landing to the center of gravity for the two sprinters was 0.31 m, and this number is comparable to that for sprinters who run 100 meters in 11 seconds (Fukuda and Ito, 2004). Therefore, it is not necessarily good to land immediately underneath the center of gravity when landing. In support leg movements, an interesting finding was seen with maximum knee extension velocity for Gay and Powell. During landing, the knee joint of both sprinters always remained bent, and when acceleration force was expressed during the later half of the support phase, the extension velocity had a negative value: -50 degrees/s for Gay and -68 degrees/s for Powell.

Training guidance that attempts to increase sprint running velocity by reducing the deceleration associated with landing must be reexamined because the landing distance for Gay and Powell is comparable to that of sprinters who run 100 m in 11 seconds. What is important here is that Gay and Powell continue to bend the knee of the support leg during the support phase, and training guidance that instructs sprinters to actively extend the knee and ankle joints of the support leg must be reevaluated.

1. Introduction

While the 100-m sprint is a simple sport, it requires athletes to compete by running at top speed, and the winner of the 100-m sprint receives the greatest accolades in track and field. In order to run the 100-m sprint with good results, fast reaction time after the start signal and acceleration after the start are important, but the most important element is maximum sprint running velocity. World-class sprinters reach their maximum sprint running velocity in about 70-80 m (Ae and Ito, 1992), and the maximum sprint running velocity of sprinters who run 100 m in less than 10 seconds is ≥ 11.8 m/s (Ito et al., 1998). Fast sprint running requires a strong body and efficient running movements.

In the present study, the running movements of Tyson Gay (9.85 seconds) and Asafa Powell (9.96 seconds) who finished first and third, respectively, in the 2007 IAAF World Championships in Athletics were analyzed while they were running at top speed in the final race. Their data were compared to past data (Ito et al., 1998) in order to determine the characteristics of both sprinters.

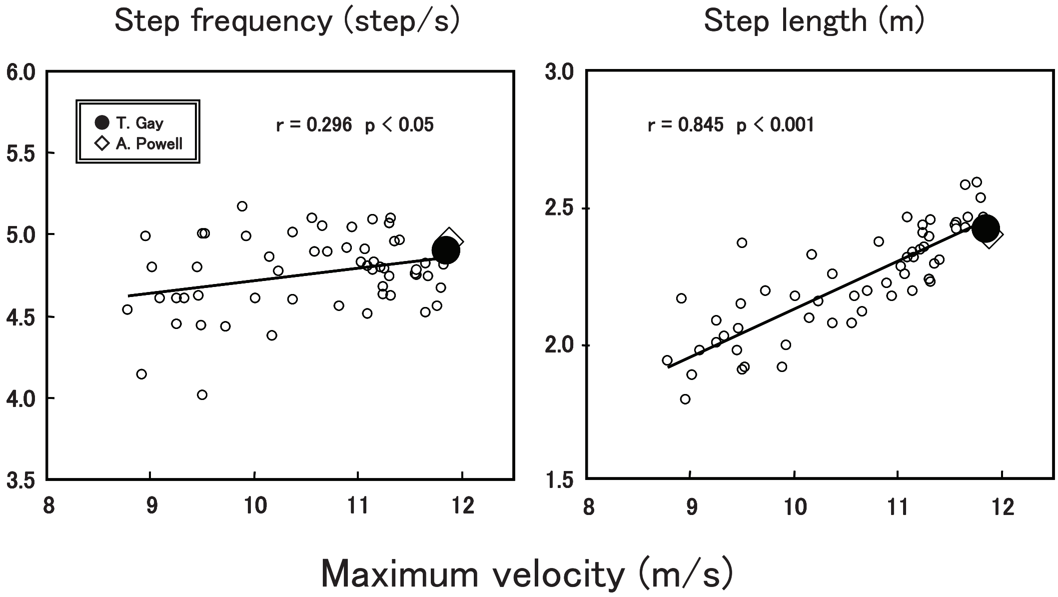

Figure 1. Relationships among sprint running velocity, step frequency and steplength.

2. Methods

During the final race for the men's 100-m sprint event during the 2007 IAAF World Championships in Athletics, two high-speed video cameras (Phantom v4, Vision Research Inc, USA were placed at the highest row of the spectator stands on the start line and on the finish line in order to capture Tyson Gay and Asafa Powell at the 60-m mark. The two cameras were synchronized and captured images at 100 Hz. Using motion analysis software (DKH, Tokyo, Japan), the two-dimensional coordinates of 24 body points were scanned at 100 fps, and the direct linear transformation method (DLT) was used to calculate three-dimensional coordinates where the x-axis was the direction of sprinting, the y-axis the vertical direction perpendicular to the ground, and the z-axis was the horizontal line parallel to the starting line. The error between calculated three-dimensional coordinates and the actual values of the calibration points in the x, y and z-axis directions was 0.005 m, 0.005 m and 0.005 m, respectively. The three-dimensional coordinates were subjected to smoothing at 7 Hz using the Butterworth method.

For comparison, data accumulated from men's 100-m sprint events in international competitions and official Japanese track and field meets were used. Of our previous data, the best sprint record was the 9.86 seconds that Carl Lewis ran at the 1991 IAAF World Championships in Athletics in Tokyo.

3. Results and Discussion

Step frequency and step length

Sprint running velocity was determined based on the distance covered by the center of gravity over two steps, and sprint running velocity at the measurement point was 11.85 m/s for Gay and 11.88 m/s for Powell. Figure 1 shows the relationships among sprint running velocity, step frequency and step length. According to past data (Ito et al., 1998), the faster the sprint running velocity, the greater the step frequency and the larger the step length. For Gay and Powell, step frequency was 4.90 and 4.96 steps/s, respectively, and step length was 2.42 and 2.40 m, respectively, and these numbers mostly agreed with past data. Gay is 1.83 m tall and Powell is 1.90 m tall, and the step length to height ratio for Gay and Powell is 1.32 and 1.26, respectively. Hence, while Gay is a step-length type sprinter, Powell is a step-frequency type sprinter. When Carl Lewis set the world record of 9.86 seconds in 1991, step frequency was 4.67 steps/s, step length 2.53 m and step length-to-height ratio 1.35 (Ito et al., 1994).

Recovery leg movements

Leg movements during the recovery phase when the support leg leaves the ground and then the leg is moved forward were analyzed in terms of maximum thigh angle (maximum angle formed by the thigh and the vertical line), minimum knee angle, and maximum leg angle (maximum angle formed by the vertical line and the line connecting the hip joint and the lateral malleolus) (Figure

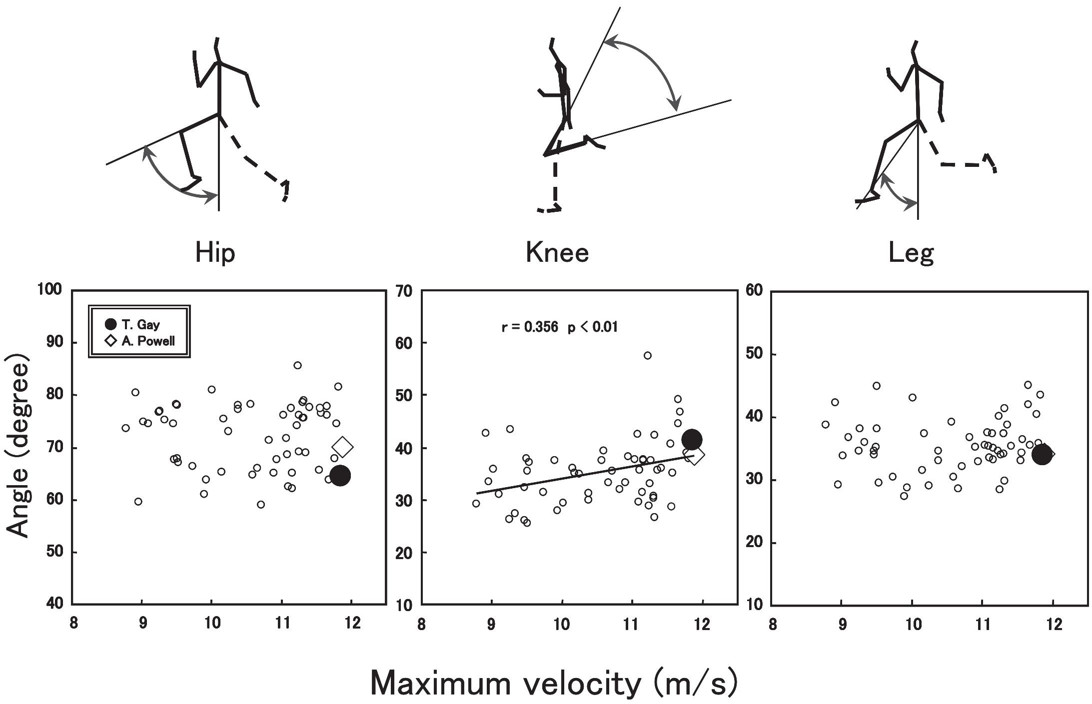

Figure 2 Relationships among sprint running velocity and recovery leg movements

2). According to Ito et al. (1998), sprint running velocity is not related to maximum thigh angle and maximum leg angle, but the faster the sprint running velocity, the greater the minimum knee angle. The maximum thigh angle for Gay and Powell was comparable at 65° and 70°, and these numbers were similar to the data obtained by Ito et al. (1998). The minimum knee angle for Gay and Powell was 41° and 38°, respectively, and these numbers were comparable to past data. The maximum leg angle for both sprinters was 34°, and this number was similar to the data obtained by Ito et al. (1998). Although the technique of the two sprinters appeared different to the naked eye, there were no marked differences in the parameters measured in the present study. In other words, both sprinters moved their legs forward without excessively raising the thigh, thus resulting in relatively low knee height. The horizontal distance from the toe at the point of landing to the center of gravity (this relates to the maximum leg angle) for the two sprinters was 0.31 m, and this number is comparable to that for sprinters who run 100 meters in 11 seconds (Fukuda and Ito, 2004). Therefore, it is not necessarily good to land immediately underneath the center of gravity when landing.

Support leg movements

In the present study, the driving movements of the support leg were analyzed in terms of the maximum extension velocity of the hip, knee and ankle joints of the support leg during landing (Figure 3). Ito et al. (1998) reported that while fast sprinters exhibited fast hip extension and slow knee extension, the maximum ankle extension velocity did not correlate to sprint running velocity. However, an interesting finding was seen with maximum knee extension velocity for Gay and Powell. During landing, the knee joint of both sprinters always remained bent, and when acceleration force was expressed during the later half of the support phase, the extension velocity had a negative value: -50 degrees/s for Gay and -68 degrees/s for Powell. According to our unpublished data, Maurice Greene, the previous world record holder, exhibited the similar movement. The knee extension velocity for Lewis was almost zero (Ito et al., 1998), and the results of the present study suggest that sprint running technology has entered a new era. With regard to knee extension velocity, if the knee joint is fixed like Lewis, then 100% of hip extension can be transferred to drive the leg in the posterior direction, but if the knee joint is bent like Gay and Powell, hip extension velocity is added to the leg, causing the drive velocity of the leg in the posterior direction to exceed 100%. Furthermore, with a driving movement where the knee joint is extended, hip extension velocity is absorbed by knee extension velocity, thus reducing the drive velocity of the leg in the posterior direction.

The maximum hip extension velocity for Gay and Powell was 774 and 693 degrees/s, and the maximum

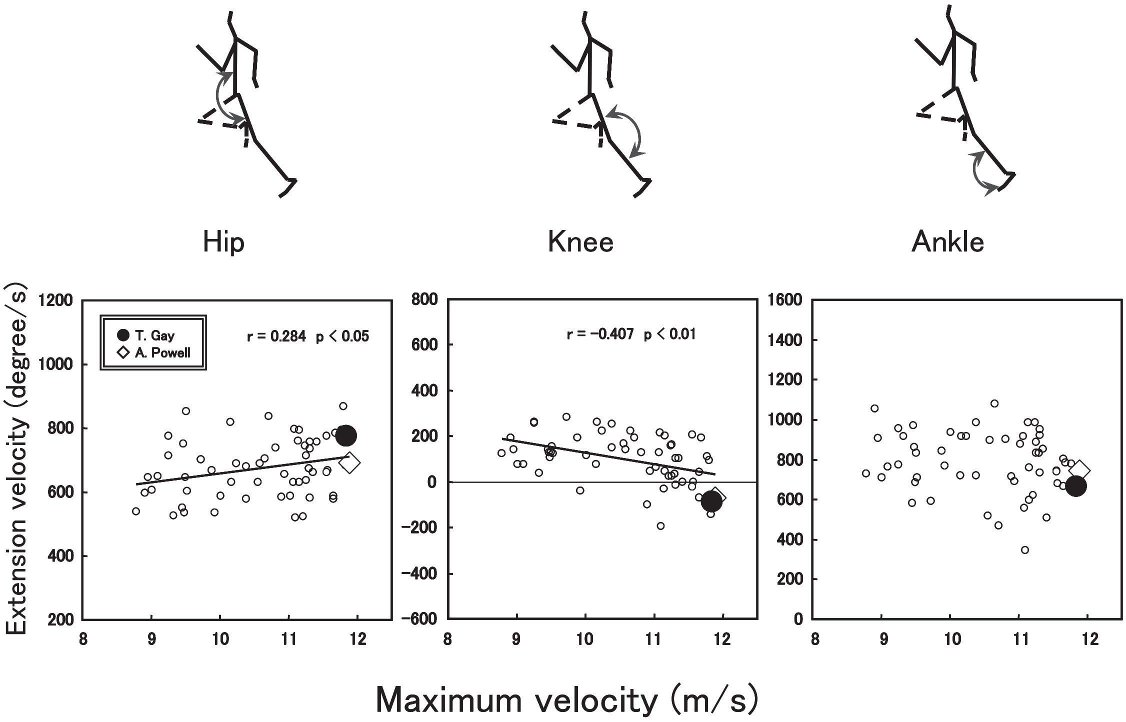

Figure 3 Relationships among sprint running velocity and support leg movements

ankle extension velocity 664 and 743 degrees/s, respectively, and these values were mostly comparable to the data obtained by Ito et al. (1998).

4. Guidance recommendations

The results of the present study show that Gay and Powell are world-class sprinters with different characteristics in terms of step length and step frequency, and suggest that caution must be exercised when strongly correcting step frequency and length.

Past studies have shown that the maximum ankle extension velocity is constant and is not related to sprint running velocity, and this suggests that so-called "snapping" movements are due to the spring-like properties of the muscle-tendon complex involving the triceps muscle of the calf and the Achilles tendon. In other words, athletes do not consciously extend the ankle, and guidance should take into account this point.

Training guidance that attempts to increase sprint running velocity by reducing the deceleration associated with landing must be reexamined because the landing distance for Gay and Powell is comparable to that of sprinters who run 100 m in 11 seconds. What is important here is that Gay and Powell continue to bend the knee of the support leg during the support phase, and training guidance that instructs sprinters to actively extend the knee and ankle joints of the support leg must be reevaluated.

References

Ae, M and Ito, A. (1992). The men's 100 meters. New Studies in Athletics, 7(1), 47-52.

Fukuda, K. and Ito, A. (2004). Relationship between sprint running velocity and changes in the horizontal velocity of the body's center of gravity during the foot contact phase. Japan J. Phys. Educ. 49, 29-39. In Japanese.

Ito, A, Ichikawa, H., Saito, M., Sagawa, K., Ito, M. and Kobayashi, K. (1998). Relationship between sprint running movement and velocity at full speed phase during a 100 m race. Japan J. Phys. Educ. 43, 260-273. In Japanese.