Mid-phase movements of Tyson Gay and Asafa Powell in the 100 metres at the 2007 World Championships in Athletics

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ABSTRACT

This study examines the running movements of two of the fastest sprinters in history, Tyson Gay (USA) and former 100m world record holder Asafa Powell (JAM). They were filmed at the 60m mark in the 100m final at the 2007 IAAF World Championships in Athletics, where they placed first (9.85) and third (9.96) respectively. The data obtained were analysed and compared to past data in order to determine the characteristics of both sprinters and identify points of advice for aspiring athletes and coaches. The parameters covered are step frequency and step length, recovery leg movement and support leg movement. The landing distance for Gay and Powell is comparable to 11 sec 100m performers and both continue to bend the knee of the support leg during the support phase. The authors' suggestions include that training guidance instructing sprinters to actively extend the knee and ankle joints of the support leg should be re-evaluated.

AUTHORS

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Introduction

Although the 100 metres might appear to be an uncomplicated discipline, the athletes seem only to be required to run at top speed, the winner of the event normally receives the greatest accolades of all the athletes at a major championship. The most important element for success is maximum running velocity, though a fast reaction time after the start signal and quick acceleration are also important. World-class male sprinters reach their maximum velocity at about 70-80m of the race[1], and the maximum sprint running velocity of sprinters who run 100m in less than 10 seconds is ⩾12.1m/s[2]. To achieve such a velocity, a sprinter requires a strong body and efficient running movements.

The 100m final at the 2007 IAAF World Championships in Athletics in Osaka featured a much-anticipated duel between two of the fastest sprinters of all time, Tyson Gay (USA) and the then world record holder Asafa Powell (JAM). The race was won by Gay in 9.85 seconds, with Powell placed third in 9.96.

In this study, the running movements of Gay and Powell in the top velocity phase of that race are analysed and compared to data previously obtained[2] in order to determine the characteristics of the two athletes and identify points of advice that might be given to aspiring athletes and their coaches.

Methods

Two high-speed video cameras (Phantom v4, Vision Research Inc, USA) were placed in the highest row of the spectator stands above the start line and above the finish line in order to capture the two athletes at the 60m mark of the race. The two were synchronised and captured images at 100Hz. 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 0.005m, 0.005m and 0.005m, respectively. The three-dimensional coordinates were subjected to smoothing at 7Hz using the Butterworth method.

For comparison, data obtained from men's 100m events in international competitions and official Japanese track and field meetings were used. In the comparison data, the best time was the 9.86 run by Carl Lewis (USA) at the 1991 IAAF World Championships in Athletics in Tokyo.

Results and Discussion

Step frequency and step length

Running velocity was determined based on the distance covered by the body's centre of mass over two steps; the running velocity at the measurement point was 11.85m/s for Gay and 11.88m/s for Powell. Figure 1 shows the relationships among running velocity, step frequency and step length.

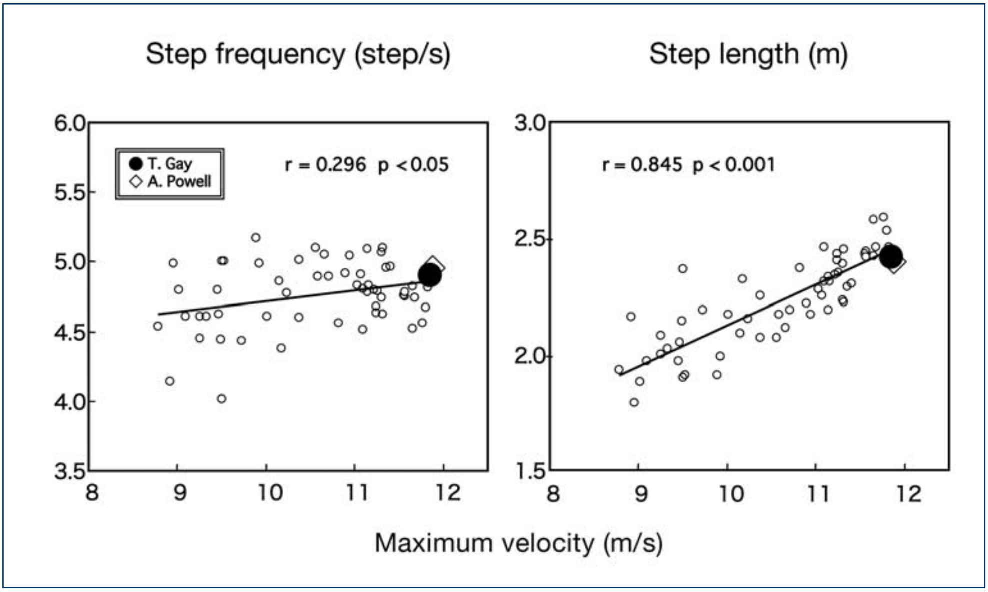

Figure 1: Relationships among running velocity, step frequency and step length

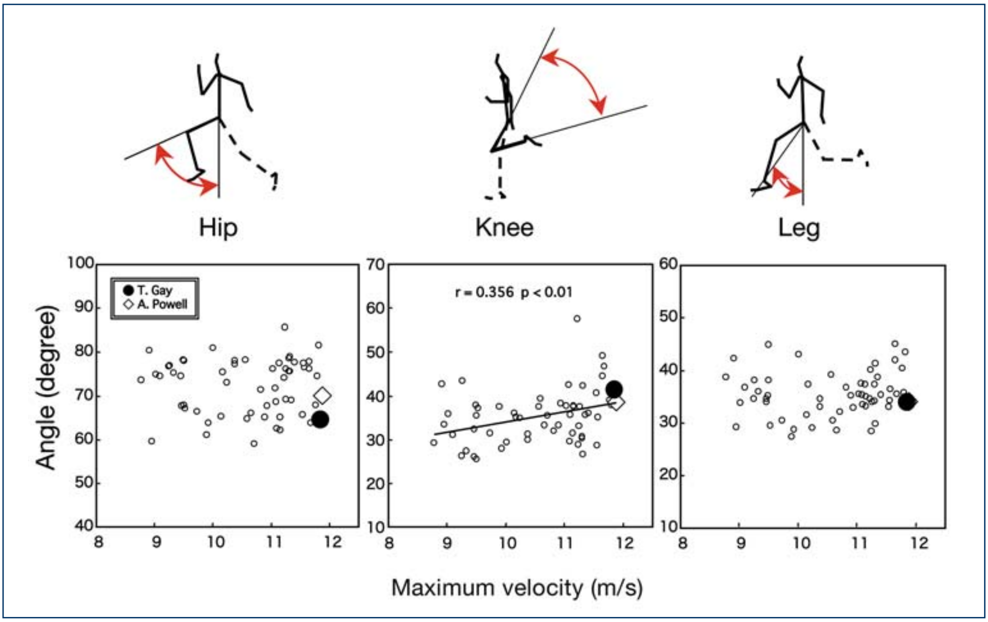

Figure 2: Relationships among running velocity and recovery leg movements

According to past data[2], the faster the running velocity, the greater the step frequency and 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 2.40m, respectively. These numbers mostly agreed with past data.

Gay is 1.83m tall and Powell is 1.90m tall. The step length to height ratio for Gay and Powell is 1.32 and 1.26, respectively. Hence, while Gay can be said to be a step-length type sprinter, Powell is a step-frequency type sprinter. When Lewis set the then world record of 9.86 in 1991, his step frequency was 4.67 steps/s, his step length was 2.53m and his step length-to-height ratio was 1.35[2].

Recovery leg movements

Leg movements during the recovery phase - when the support leg leaves the ground and then is moved forward - were analysed for maximum thigh angle (the maximum angle formed by the thigh and the vertical line), minimum knee angle, and maximum leg angle (the maximum angle formed by the vertical line and the line connecting the hip joint and the lateral malleolus) (Figure 2).

According to Ito et al. (1998), running velocity is not related to maximum thigh angle and maximum leg angle, but the faster the running velocity, the greater the minimum knee angle. The maximum thigh angle for Gay and Powell was comparable at 65° and 70°, respectively; the minimum knee angle was 41° and 38°, respectively; and the maximum leg angle for both sprinters was 34°. These numbers were similar to the previously obtained data[2].

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 body's centre of mass (this

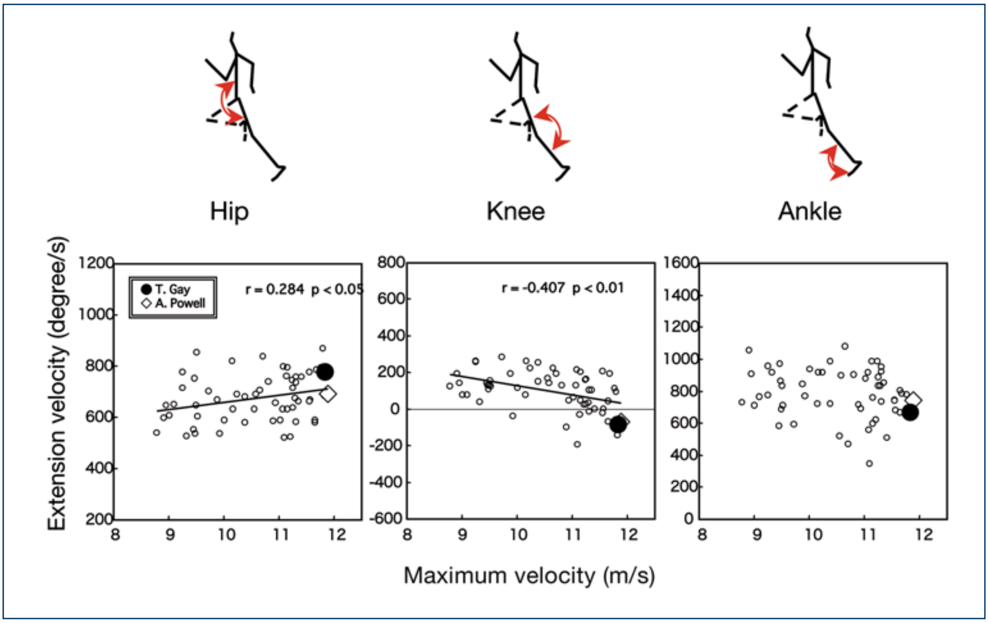

Figure 3: Relationships among running velocity and support leg movements

relates to the maximum leg angle) for the two sprinters was 0.31m, and this number is comparable to that for sprinters who run 100m in 11 seconds[3]. This tells us that it is not necessarily good for the foot to land immediately underneath the centre of mass.

Support leg movements

In the present study, the driving movements of the support leg were analysed 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. reported that while fast sprinters exhibited fast hip extension and slow knee extension, the maximum ankle extension velocity did not correlate to running velocity[2]. 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. When acceleration force was expressed during the later half of the support phase, the extension velocity had a negative value: -50°/s for Gay and -68°/s for Powell. According to our unpublished data, former world record holder Maurice Greene (USA) exhibited a similar movement whereas the knee extension velocity for Lewis was almost zero[2]. The results of the present study suggest that sprinting technique has entered a new era.

With regard to knee extension velocity, if the knee joint is fixed like in 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 in 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°/s, and the maximum ankle extension velocity 664 and 743°/s, respectively. These values were mostly comparable to the data obtained by Ito et al.[2]

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 by coaches seeking to strongly correct step frequency and length.

Past studies have shown that the maximum ankle extension velocity is constant and is not related to running velocity. 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 running velocity by reducing the deceleration associated with landing should be re-examined, because the landing distance for Gay and Powell is comparable to that of sprinters who run 100m 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 should be re-evaluated.

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