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Essential considerations for the development of a teaching model for the 100 metres sprint

Vern Gambetta

The author offers the sprints coach a conceptual framework for the development of a training model suitable for individual athletes of varying ability. He discusses in detail the biomechanical, physiological and motor-learning aspects of sprint performance, relating each to the separate phases of the 100 metres, and offers considerations for improvement. He ends the study with proposed areas for further questions and research.

Vern Gambetta is a member of the NSA Advisory Editorial Board.

1 Introduction

My goal in this article is to provide the coach with a conceptual framework for sprinting. This is not an attempt to develop a universal model, which has been done many times before. Instead, it is intended to help each coach develop their own model based on the level of the athlete that they are working with at the time. They must keep in mind the 'finished product', which is the world-class sprinter, but also realize that reaching the elite level necessitates an evolutionary growth process of constant refinement. Once the significant factors in sprint performance are identified and measured quantitatively, the next step is to be able effectively to design training that is specific to the needs of the individual athlete.

Typically, a sprint model focuses solely on the biomechanical parameters of sprint performance, with the main emphasis on the absolute speed phase of the sprint. Much of this is due to methodological limitations imposed by camera location and angles for filming in major competitions. To develop a teaching model it is necessary to take a more multifaceted approach and to look at the biomechanical, physiological and motor-learning areas. In the following study I will discuss these, concentrating on the classic sprint event, the 100 metres.

Sprinting speed is an important requirement for success in a variety of track and field disciplines. The principles discussed here are applicable to all events for which sprinting speed is a prerequisite for good performance. The key is the ability to apply that speed to the specific demands of the event.

2 Fundamental assumptions

Speed is a biomotor quality defined as the ability to perform a specific movement in the shortest possible time. Sprinting is a motor skill which is enhanced through adherence to sound motor-learning principles. Traditional thinking dictates that: 'Sprinters are born, not made.' This is true to the extent that it is not possible to be a world-class sprinter without genetic endowment. Fortunately, sport science and coaching practice have done much to refute this limiting statement. A high degree of motor skill is necessary to enhance that genetic endowment to its highest potential level. Speed as a motor skill is definitely trainable.

3 Objective

The ultimate objective of sprinting is to achieve maximum velocity as soon as possible, and to maintain that speed for as long as possible through the finish for the fastest possible time.

4 Biomechanical considerations

Dividing the sprint into phases provides a context in which to evaluate the race, as well as a logical division for the training process. This division relates directly to the concept of race distribution.

4.1 Phases of the race

4.1.1 The start

The goal is not to 'win the start', as many young athletes seem to think. It is rather to gain momentum, and to achieve a body position conducive to acceleration, as soon as possible. The key, as in any other aspect of the sprint, is efficiency in beginning a sound pattern of distribution of effort. The start includes the reaction to the gun and the drive from the blocks.

Reaction time is the time necessary for the muscles to respond to the starting stimulus. There is some confusion between reaction and reflex. A reflex is an involuntary action that occurs below a conscious level and is not under the athlete's control. An example of a reflex would be touching an object that was hot and immediately pulling back the hand.

Reaction, on the other hand, is a conscious voluntary action under the athlete's control. It is trainable and can be improved through recognition of the correct stimulus and execution of the correct pattern of movement (Dick, 1987). This can be achieved through skill work and conditioning. Based on a statistical analysis of reaction times in major competitions, a reaction time of 0.130 sec. or less is outstanding for males; 0.135 sec. or less is outstanding for females. The average reaction at the II World Championships in Athletics, Rome, 1987 was .185 sec. for males and .211 sec. for females (Moravec et al., 1988).

An efficient start is dictated by the set position in the blocks. Position in the blocks is determined by the strength level of the individual sprinter and by body dimensions. The start of the race is the portion of the race most influenced by absolute strength. Tremendous contractile strength is necessary, both to exert pressure against the blocks in order to generate the high forces required to overcome inertia, and to push against the ground in the first four to six strides.

4.1.2 Acceleration

Acceleration is the rate of change of velocity that allows the sprinter to reach maximum speed in a minimum amount of time. Most sprinters, whatever the level of performance, reach maximum speed between 30 and 60m. The ability to accelerate correlates directly with the level of ability of the sprinter. This quality is indicated by the steepness of the speed increase (Brüggemann, 1988).

In the Games of the XXIVth Olympiad, Seoul, 1988, the male finalists reached maximum speed between 50 and 60m. The females accelerated for longer, and reached maximum speed between 60 and 70m.

4.1.3 Maximum speed

At this stage of the race the sprinter is running at his or her highest velocity. This phase has also been termed 'fast co-ordination', because it demands high levels of neuromuscular co-ordination. Ultimate sprinting success is predicated on maximum speed. In Seoul, maximum speeds of 12.05 m/sec. for men and 10.99 m/sec. for women were reported for the fastest 10m segment of the 100 metres. All male finalists in Seoul achieved a speed of 11.5 m/sec. or faster; all women 10.4 m/sec. or faster.

4.1.4 Speed endurance

This is defined as the ability to hold the highest possible percentage of maximum speed through the finish. This is highly related to good sprint mechanics as well as to alactate anaerobic capacity. It can be determined by analysis of 10m segments in the second half of the race, as well as by comparing the first half with the second half of the race.

In summary, the higher the level of development of the sprinter, the shorter the reaction times and the speed endurance phase and the longer the acceleration and maximal speed phase.

4.2 Sprint mechanics

Regardless of the phase of the race, sprint mechanics should be evaluated in the context of the following areas.

4.2.1 Posture

The position and alignment of the body, especially the head and trunk.

4.2.2 Arm action

The position and amplitude of movement of the arms and hands.

4.2.3 Leg action

The cyclic movement of the legs involves the foot, ankle, knee and hip. Ac-

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cording to Dick (1987), there are three specific leg actions relative to the phase of the race:

(a) the driving phase, characterized by the feeling of pushing back behind. This occurs out of the blocks and during the first 20 to 30m from the start;

(b) the striding phase, which occurs during the next 40m of the race. It is characterized by feeling of a 'hips tall' position, with the feet striking the ground as close as possible to the centre of gravity;

(c) the lifting phase. The emphasis here is on holding form, characterized by a feeling of running over the ground.

Each area of sprint mechanics has a profound effect upon the other two areas. If one is deficient there will be a corresponding negative compensation in the other two. It has been my experience that deficiencies generally occur in the enumerated order; in other words, poor posture will lead to faults in the arm action and a reduced amplitude of movement with the legs.

4.3 Stride length/frequency

Ultimately sprint performance is determined by an optimum combination of stride length and stride frequency. World-class sprinters run at 12 m/sec. for men and 11 m/sec. for women. The range in number of strides for the male finalists in Seoul was 43.6 to 46.6, and their range of stride frequency 4.76 to 4.39 strides/sec. The number of strides for the female finalists in Seoul ranged from 42.6 to 50.8, with a range of stride frequency of 3.88 to 4.69 strides/sec.

Of the two, stride frequency is considered a more limiting factor in sprint performance than stride length, so the trend has been for sprinters to improve their performance through an increase in stride frequency rather than in stride length. However, the essential factor necessary to attain improvement is an increase in strength. Improved strength will enhance both frequency and stride length, and result in the ability to produce higher amounts of force more quickly. This ultimately decreases the duration of ground contact.

The sprint stride consists of two parts: the flight phase and the ground contact phase. This requires an optimum interplay between horizontal and vertical velocity. During the initial drive from the blocks, horizontal forces predominate. As the race progresses, vertically acting velocity plays a bigger role manifested by the sprinter being airborne for 50-60 % of the stride cycle. This flight time allows the legs to cycle properly in anticipation of ground contact. Nonetheless, for the optimum stride the foot should achieve contact as close as possible under the centre of gravity, in a position to impart as much force to the ground in the shortest possible time. This occurs in 0.1 sec. or less in a world-class sprinter!

5 Anthropometric considerations

Anthropometric characteristics such as height, weight and leg length are not significant factors in sprint success. These characteristics have varied in great sprinters, and anyway little can be done to modify them. Research has found that optimal stride length is usually 2.3 to 2.5 times the leg length. Another factor, body composition, does play a significant factor in sprint success. The leaner the sprinter, the more efficient the performance. Excess body weight carried as fat is always detrimental to performance.

6 Physiological considerations

6.1 Biochemical factors

Too much has been made of the role of the energy systems in sprint performance. The primary energy demand exerted by the act of sprinting is converted from the high energy phosphate stores. This is the anaerobic alactate system. The anaerobic lactate system has very little if any effect on performance in the 100 metres sprint. The aerobic system is not a factor in terms of actual performance of the event.

6.2 Neuromuscular factors

The high intensity demands of sprinting tax primarily the nervous system, which is the 'central command' system of the body. This is the area that must receive careful consideration when designing a training programme and is the dominant influence on race performance. Care must be taken to design exercises and training sessions which facilitate the recruitment of the appropriate motor units to produce the greatest rate of force production in the shortest possible time. Due to improper training methods and frequent racing many sprinters work in a constant state of nervous system fatigue. A general training rule is to allow twice the recovery time for CNS work as for energy system work. Failure to observe this results in poor performance and frequent injuries to muscles and tendons.

There is a close correlation between the percentage of fast-twitch fibres and speed of movement. Although fibre type is genetic, training can have a tremendous effect on the recruitment and utilization of the correct fibres. Too much slow work will stimulate the intermediate fibres to assume the properties of slow-twitch fibres, and this will adversely affect peak power production. Conversely, high intensity work can train the intermediate fibres to take on the properties of fast-twitch fibres.

6.3 Strength/power

Improvement in speed is definitely linked to improvement in power. Power is defined as the capacity to produce the greatest amount of force in the shortest possible time. The strongest sprinters spend less time on the ground and have longer strides which they are able to repeat with greater frequency, all of which facts are directly related to strength. Maximal contractile strength is required at the start and the early stages of acceleration up to 7.5 m/sec. At that point the requirement begins to shift to elastic strength, which is dependent on the stretch/shortening cycle of muscular contraction.

6.4 Flexibility/mobility

Dynamic flexibility - the ability to move the appropriate joints through a large range of motion at high speeds - is essential. (This is often confused with static flexibility, which has little relation to performance.) A large amplitude of movement is demanded at the shoulders, hips and knees. The efficient application of these large ranges of movement is related to joint stabilization and balanced strength development. Perhaps the best way to express it is as the optimum combination of mobility with elasticity in order to move the joint through the largest range of motion in the shortest time.

7 Motor learning/teaching considerations

The role of maturation cannot be underestimated in the perfection of the motor skill of sprinting. Many technical problems that occur in young sprinters are due to a lack of physical maturity, which in turn is mainly due to weak joint stabilization strength and trunk (core) strength. This usually manifests itself as poor posture. As the sprinter matures, gains strength and improves body awareness, many technical faults are self-corrected.

In order to be able to develop speed to its ultimate potential, speed training should begin early. It is appropriate to begin at the age of 8-12, during the so-called 'skill-hungry years'. Training methods should be emphasized that stimulate frequency of movement and increase speed, with a focus on quality and intensity.

The quality of stride frequency must be developed early. It is important to emphasize that this should be done in an alactate environment of games, specific movement exercises and short relays.

The best way to learn how to sprint is to sprint. This may sound somewhat frivolous but it is true. The further away from actual sprinting the training activity becomes, the less application it has to sprinting. Therefore it is important not to deviate too far from the whole action, but to use a mixture of first and second derivative exercises.

First derivative exercises coincide exactly with how the movement is performed in the total movement. Second derivative exercises coincide only with part of the total movement. There have been many successful sprint schools that have made extensive use of drills. In analysing the majority of these, I feel that it is important for the coach to understand the purpose and application of the drill. Most drills are designed for specific strength, not sprint mechanics. Keep in mind that sprinting is a natural, rhythmic, flowing activity which cannot be made mechanical.

Skill work and correction of mechanical faults should always be done in a non-fatigued state. Too often the athlete is asked to make changes when the nervous system has been already maximally taxed; or, even worse, bathing in a pool of lactate from too much lactate anaerobic work.

When analysing and correcting skill, do so in the context of posture, arm action, and leg action in that order. I have found that this is an easy concept for the athlete to grasp in order to correct a fault.

8 Questions for further study

There are several areas which require further study to help with the understanding of what occurs during the sprint.

Acceleration mechanics need to be studied in races such as the World Championships and the Olympic Games. In addition, juniors and athletes of lesser ability need to be studied in order to identify the factors necessary to success.

The role of the arms need to be studied at all phases of the race to understand more fully their contribution.

Race distribution needs to be studied at the junior and younger levels to understand more clearly the development process.

9 Summary

In my opinion, sprinting is the most natural of all the track events; yet it is still a highly complex motor skill which can be improved significantly through proper training. Hopefully some of these concepts will help to develop a model appropriate to the individual athletes with whom the coach is working.

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