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Physiological, skill development and motor learning considerations for the 100 metres

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ABSTRACT

Appropriate physiological characteristics are crucial for achieving success in the 100 metres. Sprinters who lack the required biological and physiological characteristics will not be able to achieve the highest level in this discipline. However, there are other training factors that are relevant in building success in sprinters, particularly among beginners. In this paper, the authors argue that developing good sprinting skills is as important an instructional goal as facilitating physiological abilities. After reviewing the physiological mechanisms involved in the event they discuss the contribution of two additional factors in the training process, namely skill development and motor learning principles.

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Introduction

A typical training programme for the 100 metres is composed of several phases, among them preparation, competition, and transition (Bompa, 1999). In each phase, physical, technical, tactical, and psychological fundamentals are involved and an interrelation among these aspects should exist (Blumenstein & Lidor, in press). The interaction of these fundamentals and the ability of coach and athlete to benefit from this interaction are key factors in helping sprinters reach their highest possible performance level.

The purpose of this paper is to examine aspects of the 100m that should be taken into account when planning a training programme for beginning sprinters. We discuss three areas: physiology, skill development, and motor learning.

It is suggested that in order to provide beginning sprinters with an effective training programme, emphasis should be placed not only on the physiological fundamentals but also on principles of motor learning, which will assist with the development of a solid sprinting technique (Schmidt & Wrisbeg, 2000). Our main argument is that the physiological aspects of the training programme

should be linked to instructional aspects and practice arrangements. We believe that in strong learning environments, beginning sprinters can improve their physiological traits.

Physiological considerations

In the 100m, sprinters activate their muscles at the highest possible rate for about 10 to 11 seconds. The obvious requirement for such an activity is the immediate availability of energy to power maximum muscular activity. The power that a sprinter develops relies mostly on the rate that energy is being produced in the working muscles (Costill, Daniels, Evans, Krahenbuhl, & Saltin, 1976). This energy is released through the anaerobic pathways of adenosine triphosphate (ATP)-Creatinephosphate (CP) and glycolysis.

CP may be considered as the "fast fuel" since it can be used instantaneously to regenerate ATP. Yet, its amount in the muscles is very small, and therefore it serves as the main energy source for maximal efforts that last only a few seconds. On the other hand, glycolsis is a more complex system, but it possesses the ability to function for a longer period of time. Therefore, its contribution will be more significant in physical activities that last a longer time.

While the CP is limited by its small amount, glycolsis is limited by the level of lactic acid being produced in the muscle cell during exercise. When lactic acid in the cell reaches a high level, glycolsis can no longer release energy, and muscle work is slowed down.

Stages in the 100 metres

The 100m can be divided into three stages: acceleration, maintenance, and deceleration.

Acceleration stage: The acceleration stage lasts from the time the sprinter leaves the blocks to the point when he or she reaches maximal velocity. The initial speed of an elite sprinter is about 4-5m/s, which increases to more then 10m/s at the 30m point. A typical velocity curve shows fast acceleration at the beginning of the race and as the speed increases, decreasing acceleration until the maximal velocity is reached. International caliber sprinters continue to accelerate up to about 50-60m, reaching a top speed of about 10.5 and 12m/s for females and males, respectively. The slower the sprinter the sooner maximal velocity is reached. For example, an untrained individual will complete his or her acceleration at about 20-25m.

Maintenance stage: The distance that maximal velocity can be maintained is relatively short - 20-30m and 15-20m for males and females sprinters, respectively. During the maintenance stage the sprinter has to combine most efficiently the frequency and length of strides. The ability to execute this combination successfully is one of the elements that distinguishes between - elite- and low-level sprinters. For example, Mero, Luhtanen, Viitasalo, and Komi (1981) found that elite sprinters were able to produce more power in a shorter time while pushing off the ground, when running at maximal speed, compared to low level sprinters (226kg in 0.1sec versus 181 kg in 0.125sec, respectively). It should also be noted that air resistance at this stage becomes a significant factor in influencing the ability to sustain high speed.

Deceleration stage: Maximal speed can not be maintained until the end of the 100m. Deceleration usually starts at about 80m for an elite sprinter. At this point, the sprinter loses power and is unable to maintain his or her strides' frequency and length. The reasons for power loss are associated with energy changes that are taking place in the muscles during the run. However, good sprinting techniques should conserve energy and postpone the appearance of fatigue to later stages of the sprint.

Studies show that the ability to sustain high running speed depends on the level of CP in the muscle cells. As long as CP level in the

cells is high, the sprinter is able to maintain maximum speed (Hirvonen, Rehunen, Rusko, & Harkonen, 1987). This is expected, as CP provides an immediate reserve for resynthesis of ATP. The precise amount of CP needed for all-out muscle work is not clear. Most studies show that 5-7 seconds after the initiation of maximal activity, CP is reduced to a low level in the muscle and can no longer serve as the main energy source for maximal activity. When the CP level is reduced the muscle starts using energy that is released via the glycolysis system. However, the energy production rate from CP stores is much higher than that from glycolsis. Therefore, when CP stores are depleted to a certain level the total energy production in the form of ATP is noticeably reduced.

If one looks at the stages of velocity in the 100m - acceleration, maintenance, and deceleration - it could be inferred that they are tied to the levels of ATP and CP in the exercising muscles. Thus, a sprinter will accelerate and maintain maximal speed as long as adequate levels of CP are available. The reduction of speed in the last 20m of the race suggests that at this stage glycolsis becomes the main energy source. The possibility that the accumulation of lactic acid in the muscle causes fatigue and speed reduction is rejected due to the relatively low level of blood lactic acid (7-9mmol/l) in such a short duration of activity.

The contribution of additional variables

Biological and physiological factors are essential for achieving success in the 100m. However, in preparing the sprinter to challenge performance standards, coaches must reject the old adage that "a sprinter is born and not made", and additional training factors should be taken into account. More specifically, coaches should consider the needs of the sprinter in relation to the demands of the discipline. In order to do this, the potential contribution of all relevant resources should be evaluated by both coaches and sprinters. Then, coaches will be able to build an appropriate training programme that will meet short-, medium-, and long-term objectives.

The importance of the anaerobic energy system to the 100m has already been discussed. Still, other physiological variables have to be examined in order to establish their status in the sprinter's training programme. Among these, strength (absolute and relative), aerobic power, flexibility, and body composition are worth mentioning. It is also important to determine which muscles are the prime movers and what forces will produce the greatest performance in the short sprint.

One study (Meckel, Atterbom, Grodjinovsky, Ben-Sira, & Rotstein, 1995) examined the contribution of a variety of factors to success in the 100m. Specifically, the researchers looked at the characteristics of female 100m sprinters of different performance levels. The participants (n = 30) in this study were assigned, according to their 100m times, to one of three groups: "fast" (11.8sec), "average" (12.7sec), and "slow" (14.2sec). They were tested for their maximal anaerobic power and capacity, relative strength, reaction time, flexibility, aerobic power, fat %, and running skill. The results indicated significant differences among all three groups for maximal anaerobic power and capacity as well as for relative strength. Significant differences in fat % and running skill were found between the fast and the slow groups and between the average and the slow groups. However, no significant differences in fat % and running skill existed between the fast and the average groups. The differences in reaction times were significant between the fast and the average groups only. No group was significantly different from the other in flexibility and aerobic power.

The results obtained by Meckel et al. suggested that the 100m is an event that relies first and foremost on muscular strength and power. Physiological variables such as aerobic power, flexibility, and reaction time are not significant factors in distinguishing

between different levels of female sprinters. It was also observed that skill and movement technique are important factors in determining sprint performance.

Skill considerations

Skill training in certain athletic events seems to be a key element in successful performance (McClements & Sanderson, 1998). It is customary to differentiate between highly technical events, such as gymnastics, and less technical events, such as long distance running. There has been an increasing awareness of the importance of technique training among sprinters, especially in the 100m. As a result, coaches now place much greater emphasis on technique exercises, especially during the initial training phase. The reason for this may lay in the fact that speed improvement, as far as the metabolic and the nerve system physiology is concerned, is limited. While power is the key element at the acceleration stage and speed endurance is significant at the end of the sprint, technique is crucial mainly in the maintenance stage.

During the maintenance stage, the sprinter reaches maximum speed when coordination balances precariously on the brink of risk. At this point the smallest mistake can cause a great lost of speed or even an injury. Thus, when running at full speed, technique must be controlled to perfection. Obviously, like all techniques, it must be practiced. However, the difficulty is that if sprinters must endure the exhausting experience of maximal acceleration in order to reach maximum speed, the number of repetitions they can perform will be limited.

Another problem rises from the fact that sprinters differ from each other in their body physique and each one may use different running style, appropriate to his or her specific size. However, since running technique is crucial to development of maximum speed, some key features are worth review. Five basic technique components that are considered to be "gold standards" among sprint coaches are presented in Table 1. In Meckel et al.'s (1995) study, it was found that significant differences existed in skill when comparing slow and fast female sprinters. In addition, a negative and significant correlation (r = -.85) between the skill and the 100m time was found.

Technique components	Description
Knee lift	An optimal knee lift should form a 90° angle between the thigh and the trunk
Arm and shoulder control	The hand should swing up to the shoulder level, the wrist and shoulder should be loose and relaxed
Trunk posture and rotation	The trunk should be maintained in an upright steady position while avoiding any side rotation
Head and neck movement	The head and neck should avoid any movement during the sprint, maintaining relaxation
Overall relaxation	Reflected by smooth, relaxed limb movement while the sprinter is in full control and well-coordinated

Table 1: Basic technique components of the 100 metres.

Motor learning considerations

The five components outlined in Table 1 should be emphasised in each drill given to beginning sprinters. These are the key factors of an effective sprinting technique. Although not all the sprinters will perform exactly the same pattern of these basic five technique components, all should be part of any drill performed during early practice sessions. While planning the practice session and selecting the appropriate drills, coaches should be aware of two motor learning considerations that have been found to enhance motor skill acquisition: variability in practice and contextual interference (Lee, Chamberlain, & Hodges, 2001; Schmidt & Lee, 1999).

Although the 100m can be classified as more of a closed learning environment than an open one (Schmidt & Wrisberg, 2000), the main objective of early practices in sprinting is to provide the beginning sprinter with solid fundamentals of the sprinting technique. However, the learning environment should also be sensitive to future needs of the beginning sprinter. The acquisition phase should be dynamic and flexible enough to enable the sprinter to acquire the basic components of the sprinting technique, but in such a way that he or she will be able to apply them in different ways and under different conditions. This means that the early learning experiences should provide beginning sprinters with enough flexibility to be able to adjust the learned technique according to their own needs and to the environmental demands.

The variability of practice principles requires coaches to set goals that are systematically varied from trial to trial during practice (Schmidt & Lee, 1999). In variable practice the sprinter attempts a number of selected movement variations. For example, the sprinter performs the same drill (task) at different distances, speeds, and angles.

The contextual interference principle applies the interference effects in performance and learning that arise from practicing one task in the context of other tasks (Schmidt & Lee, 1999). This principle can be applied in two types of practice: blocked and randomised. In blocked practice all the trials of one task are done together, uninterrupted by practice of any of the other tasks. In random practice the tasks being practiced are ordered randomly across trials.

Both the variability and the contextual interference principles assist beginners in establishing a set of rules for moving as well as in developing more meaningful and distinctive representations of the different memorized tasks. By applying these principles, coaches can allow their novice sprinters to effectively acquire the components of the sprinting techniques that most fit their biological characteristics and body constraints. The sprinters will be able to increase their awareness of the way they execute the components of the technique and how they implement them at the track. This can help sprinters to strengthen their own sprinting skills, from which they will benefit most during the maintenance stage of the 100m.

Summary

It is true that the appropriate physiological characteristics are crucial to achieving success in the 100m. However, other factors related to the training process should be seriously taken into account by coaches and sprinters. Training benefits can be obtained by sprinting skill development and by motor learning principles applied in early practices. Developing good sprinting skills is as important an instructional goal as facilitating physiological abilities. This should be accepted by coaches who work with young sprinters.

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