Identification of kinematic predictors of starting speed in track and field sprinters

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Abstract

Objective of the study is to identify the kinematic indicators of running steps that determine the effective achievement of starting speed by sprinters.

Methods and structure of the study. The subjects, 23 student athletes (age 22.6±3.2 years; weight 77.6±7.4 kg; height 1.78±0.03 m) engaged in athletics, performed six 10-metre sprint tests, which were recorded on video for subsequent kinematic analysis. The correlation coefficient of the kinematic indicators of running steps and running speed during the initial segment of the sprint distance was calculated.

Results and conclusions. The expediency of differentiated work on increasing the length of sprinters' running steps in balance with indicators of step frequency, ground contact time, and non-support phase time, which also characterize the deepening of morphofunctional changes that determine the effectiveness of increasing starting speed, has been confirmed.

Keywords: *sprinting, acceleration, kinematic indicators, student athletes, correlation coefficient.*

Introduction. Starting acceleration from a stationary position is an integral component of competitive activity for sprinters. In terms of duration, starting accelerations performed in sports are usually relatively short, lasting two seconds or less, which corresponds to a distance of about 15 metres. In this regard, the ability to accelerate – to achieve the maximum running speed over a short distance in a unit of time – is a significant factor in achieving high competitive results in sprinting.

To a large extent, the effectiveness of starting acceleration is determined by the kinematic indicators of running technique: step length, step frequency, ground contact time, and non-support phase time. It is believed that in order to increase the effectiveness of start acceleration, there should be an improvement in one or more parameters that affect a sharp increase in running speed – step length or step frequency [3].

A number of studies have established a relationship between acceleration intensity and high step frequency [4]. However, in mountain runners, after special speed training, the increase in running speed during acceleration was mainly associated with an increase in step length [1]. It is important for general physical training specialists to understand which of these two factors is most closely related to high running speed at the beginning of a short acceleration.

When analysing the kinematic factors that determine an athlete's acceleration efficiency, the temporal characteristics of the sprinter's step must also be taken into account. In particular, reducing the contact time with the ground contributes to an increase in step frequency, which also determines effective acceleration [2]. However, despite the overall increase in running speed, special speed training does not lead to a change in the contact time with the support surface when athletes run short distances at high speed [5].

Since the time of the non-support phase is related to the length of the step, acceleration on the running track increases with a shorter non-support phase. But if a longer step length increases acceleration, it may also mean that athletes with high speed capabilities have a longer ground contact phase in their running technique. Thus, the influence of ground contact time and ground contact phase on athletes' acceleration capabilities requires further research.

Objective of the study is to identify the kinematic indicators of running steps that determine the effective achievement of starting speed by sprinters.

Methods and structure of the study. 23 student athletes (age 22.6±3.2 years; weight 77.6±7.4 kg; height 1.78±0.03 m) involved in athletics and with no health issues were recruited for the experiment.

The testing was conducted in an athletics hall. The subjects performed six 10-metre sprint tests, which were recorded on video for subsequent kinematic analysis. The 10-metre distance was chosen as the initial acceleration phase of the start, which is important for sprinters. The reliability of the data collection procedures used in the study has been established in previous studies [3]. A 10-minute standardized warm-up was conducted before the testing.

For the kinematic analysis of technique, each subject performed six 10-metre sprint segments. During the first three start accelerations, the athlete's passage of the first 5 meters was recorded; during the next three segments, the athlete's passage of the second 5 meters was recorded. The time was measured using a speed meter placed on a table 0.7 m high and located 1.5 m behind the test subject. The speed meter consisted of a nylon line attached to the test subject's shorts and the other end wound on a reel, which unwound as the athlete moved. An optical sensor sent electrical impulses to the processor for every 0.1 meters of linear displacement of the test subject, and the time was recorded using an attached Seiko stopwatch. When starting from a standing position, the test subjects used a versatile stance and started on their own when ready.

The distance covered was recorded by a Sony HVR-Z5E high-speed video camera. The camera was placed at a distance of 8.0 m from the test subject's running line. To film the 0-5 m interval, the camera was set at a mark 2.5 m from the starting line, and to film the 5-10 m interval, it was set at a mark 7.5 m from the starting line. The video camera was synchronized with Motion Trace software, which allows visualizing the trajectories of the biomechanical links of the athlete's body and obtaining graphs of movements, speeds, and accelerations broken down by rectangular coordinates.

Statistical calculations were performed using the Statistica 12.0 package.

Results of the study and discussion. The running technique used by sprinters during the initial run-up is characterized by differences in kinematic indicators at the beginning of the race (Table 1).

All significant correlations between step kinematics and running speed from the start ranged from moderate to high values.

Table 1. Kinematic indicators of sprinting technique at various distance intervals

Indicator	Distance interval, m		
	0-5	5-10	10-15
Step length, m	1,18± 0,32	1,63±0,41	1,44±0,57
Step frequency, n/s	3,93±0,32	3,87±0,31	3,83±0,38
Time of contact with the support, s	0,15±0,03	0,13±0,04	0,14±0,02
Time of the unsupported phase, s	0,09± 0,01	0,13 ± 0,04	0,12±0,02

Table 2. Correlation coefficients between kinematic indicators and running speed at different distances

Indicator	Interval, m		
	0-5	5-10	10-15
Step length	436	496	447
Step frequency	-169	-016	-085
Time of contact with the support	-338	-384	-398
Time of the unsupported phase	438	268	339

The average step length at all distance intervals – 0-5 m, 5-10 m and 10-15 m – is significantly related to running speed in the initial acceleration phase. A longer step is associated with the effective development of push-off force during the contact phase, which is a special physical quality of a sprinter.

Long steps usually result in a longer non-support phase, which has the most significant correlation with running speed in the initial 5-metre segment. This indicates that a longer groundless phase results in a higher starting speed and is a consequence of the longer steps shown by athletes with high speed capabilities.

The contact time with the ground on the 0-5 m and 0-10 m segments, as well as the step frequency on the 10-15 m segment, also contribute to running speed efficiency. To effectively generate propulsive force, the duration of the support phase must remain within the optimal range, as this determines step length and, consequently, overall running speed.

No correlation was found between step frequency and running speed on distances longer than 5 m.

Step frequency over 5-10 m is a predictive variable for speed in the starting run-up section.

Increasing step frequency is especially important when transitioning to high speeds, including after the first 5 m of a sprint. No significant correlation between step frequency and running speed was found in any of the distance segments. This could be due to the longer step length shown by the subjects at much higher speeds. Since faster sprinters tend to have longer step lengths during the initial acceleration, this could have reduced the significance of step frequency in the study.

Conclusions. The analysis of the relationship between kinematic indicators and starting speed in sprinting confirmed the advisability of differentiated work on speed characteristics, using exercises aimed at developing push-off power and increasing the length of sprinters' strides. Step frequency, ground contact time and non-support phase time indicators also characterize the deepening of morphofunctional changes that determine the effectiveness of increasing starting speed.

Mobilization stimuli in exercises for developing starting speed should ensure a balance between the length, frequency characteristics of the running stride and the time parameters of acceleration in sprinting.

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