PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Phase-specific changes in running velocity during the 100 m sprint in university athletes

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Abstract

Background and Study Aim The 100 m sprint is widely used as an indicator of human neuromuscular performance and maximal running speed. Sprinting over this distance is characterized by distinct phases, including acceleration, maximum velocity, and deceleration, each associated with specific biomechanical demands and performance characteristics. Despite the application of various analytical approaches to describe sprint phases, their relative expression in male and female university athletes remains a matter of practical interest. This study examined phase wise variations in running velocity during a 100 m sprint to compare the patterns between male and female university athletes.

Material and Methods A cross-sectional design was employed involving 230 university athletes (125 males and 105 females). Participants performed a maximal 100 m sprint divided into three phases: acceleration (0–10 m), maximum velocity (45–55 m), and deceleration (90–100 m). Split times were recorded using digital stopwatches. Locomotion speed (m/s) was calculated for each phase. Data were analyzed using descriptive statistics and one-way repeated-measures ANOVA with Bonferroni post hoc correction ($p < 0.05$).

Results Both sexes displayed the lowest speed during the acceleration phase and the highest speed during the maximum velocity phase. A decline was observed during the final phase. Male athletes recorded higher absolute speeds (5.08, 7.58, 7.09 m/s) than female athletes (4.93, 7.04, 5.92 m/s).

Conclusions University athletes exhibit a consistent phase-wise velocity pattern similar to that of elite sprinters. Despite higher absolute speeds in males, both sexes show similar velocity trends. This highlights the importance of phase-specific sprint training for enhancing performance.

Keywords: locomotion speed, acceleration, top speed, deceleration, university athletes, sprint phases

Introduction

The 100 m sprint represents one of the widely applied models for examining short duration, high intensity human locomotion in sport. Sprint performance over this distance emerges from the interaction of neuromuscular coordination, force production, and mechanical efficiency, which together shape the athlete's ability to generate and maintain speed. The sprint action unfolds through distinct but interrelated phases, during which running velocity changes dynamically under the influence of technical execution and fatigue development. Analysis of velocity changes across these phases allows interpretation of sprint performance and supports the design of training approaches that address the specific demands of each segment of the race.

In this context, the 100 m sprint is regarded as one of the most recognized events in track and field athletics. It serves as a benchmark for assessing maximal human running speed and neuromuscular performance [1]. Sprinting over this distance is not a continuous or uniform activity. It consists of distinct phases, each governed by specific biomechanical and physiological demands [2]. Analysis of running velocity changes across these phases supports the evaluation of sprint performance and the development of training strategies.

Contemporary sprint biomechanics literature commonly divides the 100 m sprint into three primary phases: acceleration, maximum velocity, and deceleration or retardation [1, 3]. The acceleration phase typically occurs within the initial 30-40 m of the race. It is characterized by a progressive increase in running velocity driven by horizontal force production, motor unit recruitment, and changes in stride length and frequency [4, 5, 6]. Changes occurring in this early phase influence overall sprint performance, particularly in developing and university-level athletes who may not yet possess fully matured sprint mechanics [7].

The maximum velocity phase generally occurs between 40 m and 60 m. It represents the highest running speed attained during the sprint [8, 9]. This phase is associated with coordination between stride length and stride frequency, reduced ground contact time, and increased musculoskeletal

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stiffness [10, 11]. Previous studies have shown that elite sprinters are able to maintain maximum velocity over a longer distance compared with sub-elite or developing athletes. This observation reflects the role of speed endurance and technical efficiency [12].

After the attainment of maximum velocity, most athletes demonstrate a gradual decline in running speed during the final segment of the race. This segment is referred to as the deceleration or retardation phase [13]. The reduction in velocity has been attributed to neuromuscular fatigue, reduced force-producing capacity, and changes in sprint mechanics [13, 14]. The extent of speed loss during this phase affects sprint outcomes, particularly in the final 10-20 m of the race [15].

Sex-related differences in sprint performance have been consistently reported in the literature. Male athletes generally exhibit higher absolute running velocities, greater force-generating capacity, and longer stride lengths than female athletes [16, 17]. Despite these differences in magnitude, the relative pattern of velocity change across sprint phases appears to be similar between sexes. This suggests that phase-specific sprint principles can be applied across sexes when adjusted for training load and physiological characteristics [18].

Analysis of research findings has shown that sprint performance over 100 m is associated with phase specific changes in running velocity and their interaction with technical and neuromuscular factors. Researchers emphasize that the structure and expression of acceleration, maximum velocity, and deceleration phases contribute to overall sprint outcomes across different athlete populations. At the same time, the interpretation of velocity patterns in university athletes, including sex related characteristics of these phases, remains methodologically complex and context dependent. Sprint phase characteristics have been extensively examined in elite and professional sprinters, whereas their expression at the university level reflects a transitional stage between general training and high performance sport. Examination of phase wise velocity changes in university athletes therefore supports a more precise understanding of sprint performance patterns and informs the application of phase oriented training approaches in applied settings.

Purpose and Hypotheses

The purpose of the present study was to examine phase wise changes in running velocity during the acceleration (0-10 m), maximum velocity (45-55 m), and retardation (90-100 m) phases of the 100 m sprint among university athletes. The study also aimed to compare these velocity patterns between male and female participants. It was hypothesized that:

1. Running velocity would differ significantly across the three sprint phases.
2. Both male and female athletes would achieve their highest running velocity during the maximum velocity phase.
3. Male athletes would demonstrate higher absolute running velocities than female athletes across all phases.
4. Despite differences in absolute speed, both sexes would exhibit a similar phase wise pattern of velocity change during the 100 m sprint.

Materials and Methods

Participants

The study involved 230 university athletes (125 males and 105 females) who voluntarily participated in the research. All participants were actively engaged in university level track and field training programs and had previous experience in competitive sprinting. At the time of data collection, the athletes reported no musculoskeletal injuries. No participants were excluded from the analysis after enrollment. All participants were informed about the purpose and procedures of the study. Written informed consent was obtained prior to participation. The study protocol was approved by the institutional ethics committee and was conducted in accordance with the principles of the Declaration of Helsinki.

Research Design

A cross sectional descriptive research design was used to examine variations in running speed at different stages of the 100 m sprint in university athletes. Sprint performance was divided into three stages: acceleration, maximum velocity, and retardation.

Data Collection: Sprint Test Procedure

Participants were briefed on the testing procedures, and informed consent was obtained prior to testing. Data were collected using a 100 m sprint run test conducted as follows:

- The total sprint distance of 100 m was divided into five reference points at 10 m, 45 m, 55 m, 90 m, and 100 m. Based on these points, three zones were defined: 0-10 m as the acceleration zone, 45-55 m as the maximum velocity zone, and 90-100 m as the retardation zone.
- Five trained timekeepers were positioned along the track and used digital stopwatches (model XL 009B) to record split times.
- The starter provided the start signal simultaneously to the athlete and all timekeepers.
- Each participant performed the 100 m sprint

individually following the standard starting commands.
- Upon the starting signal, the athlete began running and the timekeepers started their stopwatches.
- When the athlete crossed each marked zone, the corresponding timekeeper stopped the stopwatch.
- After completion of the 100 m sprint, all recorded times were documented.
- Split times were recorded at 10 m, 45 m, 55 m, 90 m, and 100 m.
- Zonal times for the three sprint stages were calculated from the recorded split times.

The time required to cover each zone was measured in seconds. Mean locomotion speed (m/s) was calculated by dividing the distance of each zone by the corresponding time. Male and female athletes were analyzed separately.

Calculation of Locomotion Speed

Locomotion speed was calculated using the following formula:

$$S = \frac{\text{distance (m)}}{\text{time (s)}}$$

Zonal locomotion speed was calculated separately for each sprint phase as follows:

$$S_{\text{acceleration}} = \frac{10\,\text{m} - 0\,\text{m}}{\text{mean time}_{0-10\,\text{m}}}$$

$$S_{\text{max velocity}} = \frac{55\,\text{m} - 45\,\text{m}}{\text{mean time}_{55\,\text{m}} - \text{mean time}_{45\,\text{m}}}$$

$$S_{\text{retardation}} = \frac{100\,\text{m} - 90\,\text{m}}{\text{mean time}_{100\,\text{m}} - \text{mean time}_{90\,\text{m}}}$$

In these calculations, distance represents the length of the corresponding sprint zone in meters, and time represents the mean split time recorded for that zone in seconds.

Statistical Analysis

The collected data were analyzed using statistical procedures. The mean was calculated as a measure of central tendency, and the standard deviation was used as a measure of variability. Statistical analyses were performed using IBM SPSS version 26. Differences in running velocity between sprint phases were examined using one way repeated measures ANOVA with Bonferroni post hoc correction. Effect sizes were reported as partial eta squared, and statistical significance was set at $p < 0.05$.

Results

Speed of Locomotion in Different Zones of the 100 m Sprint

Locomotion speed of male and female sprinters was assessed across three sprint phases: the acceleration phase (0–10 m), the maximum velocity phase (45–55 m), and the retardation phase (90–100 m). Descriptive statistics are presented in Tables 1 and 2, and graphical representations are shown in Figures 1 and 2.

Male Sprinters

Table 1 and Figure 1 present locomotion speed and mean time values across sprint phases in male sprinters.

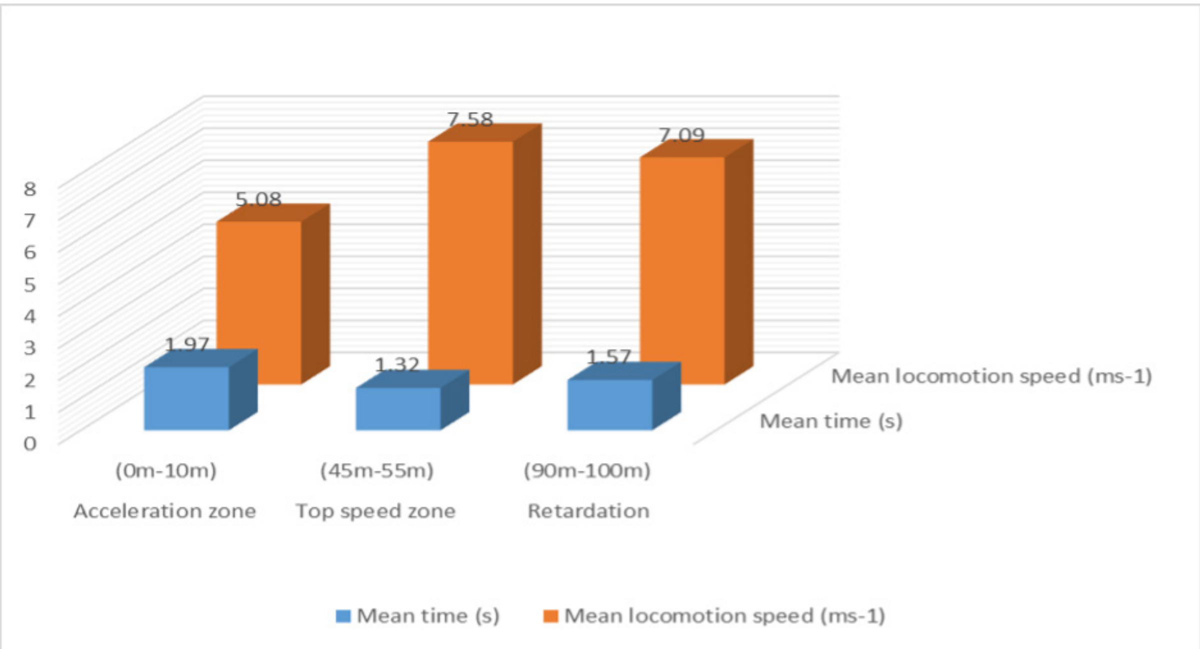

Figure 1. Locomotion speed across sprint zones in male sprinters.

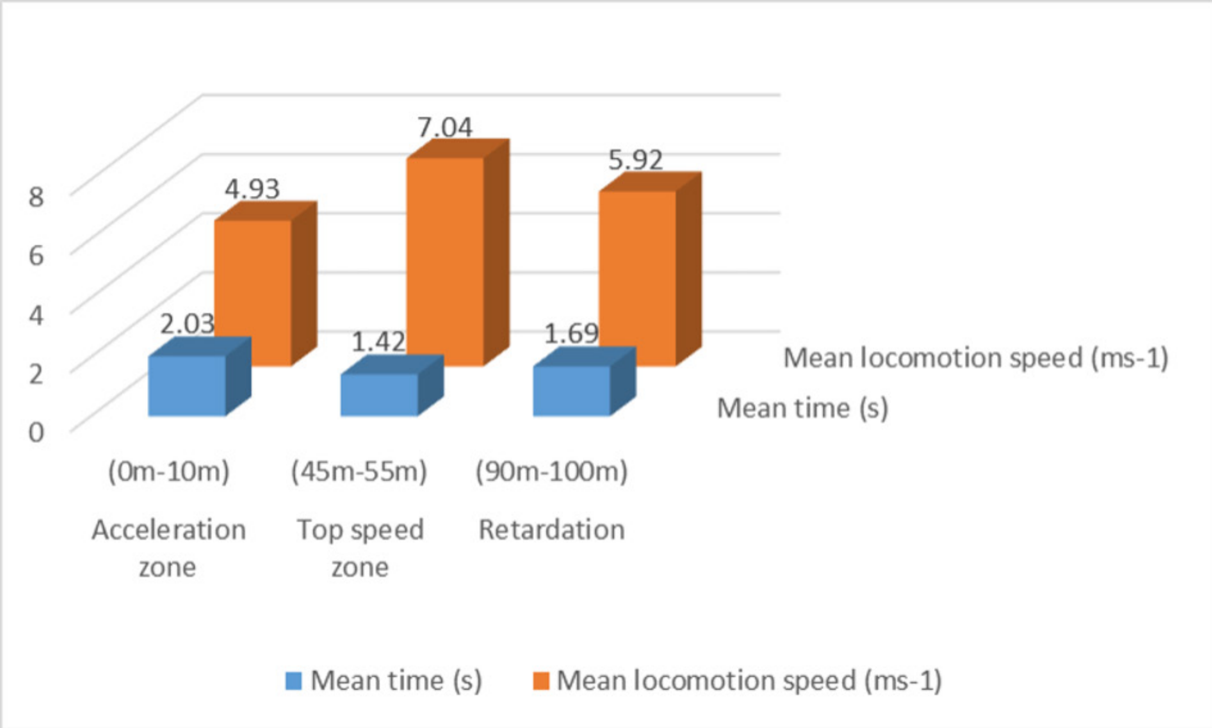

Figure 2. Locomotion speed across sprint zones in female sprinters.

Table 1. Locomotion speed and mean time of male sprinters across sprint zones

Variable	**Acceleration zone (0–10 m)**	**Maximum velocity zone (45–55 m)**	**Retardation zone (90–100 m)**
Mean time (s)	1.97	1.32	1.57
Mean locomotion speed (m/s)	5.08	7.58	7.09

Table 2. Locomotion speed and mean time of female sprinters across sprint zones

Variable	**Acceleration zone (0–10 m)**	**Maximum velocity zone (45–55 m)**	**Retardation zone (90–100 m)**
Mean time (s)	2.03	1.42	1.69
Mean locomotion speed (m/s)	4.93	7.04	5.92

As shown in Table 1, the mean time in the acceleration zone was 1.97 s, corresponding to a mean locomotion speed of 5.08 m/s. The highest locomotion speed was observed in the maximum velocity zone, with a mean time of 1.32 s and a mean speed of 7.58 m/s. In the retardation zone, the mean time increased to 1.57 s, and the mean locomotion speed decreased to 7.09 m/s.

As illustrated in Figure 1, male sprinters demonstrated an increase in locomotion speed from the acceleration phase to the maximum velocity phase, followed by a reduction in speed during the final phase.

Female Sprinters

Table 2 and Figure 2 show locomotion speed and mean time values across sprint phases in female sprinters.

According to Table 2, the mean time in the acceleration zone was 2.03 s, corresponding to a mean locomotion speed of 4.93 m/s. The maximum velocity zone showed the highest speed, with a mean time of 1.42 s and a mean locomotion speed of 7.04 m/s. In the retardation zone, the mean time increased to 1.69 s, and locomotion speed decreased to 5.92 m/s.

As shown in Figure 2, female sprinters reached their highest locomotion speed in the middle section of the race, followed by a decrease in speed during the final phase.

Sex Based Comparison

Across both groups, male and female sprinters achieved their maximum locomotion speed in the middle section of the race (45–55 m). A decrease in speed was observed in the final 10 m in both groups, indicating the onset of deceleration. Across all sprint phases, male sprinters demonstrated higher mean locomotion speeds than female sprinters.

Discussion

The aim of the present study was to examine phase wise variations in running velocity during the 100 m sprint and to compare these patterns between male and female university athletes. The findings indicate that sprint performance is characterized by a phase dependent velocity pattern rather than a uniform distribution of speed across the race. This observation corresponds to biomechanical models of sprinting described in previous studies [1, 2, 3].

Both male and female athletes demonstrated the lowest locomotion speeds during the acceleration phase (0-10 m). This result is consistent with earlier research showing that the initial phase of sprinting involves overcoming inertia and progressively increasing velocity through horizontal force production and neuromuscular activation [1, 4, 5]. The lower speeds observed in this phase among university athletes may reflect differences in force production capacity and sprint specific technique when compared with elite sprinters [6, 7].

Previous studies have reported that improvements in acceleration ability are associated with changes in overall sprint performance, particularly in developing athletes [6]. Training approaches such as resisted sprinting, plyometric exercises, and start specific drills have therefore been applied to address performance during this phase [7, 18]. The results of the present study are consistent with the application of phase specific training approaches in university level sprint preparation.

The highest locomotion speeds in both sexes were recorded during the maximum velocity phase (45-55 m), indicating that peak sprint speed occurred in the middle segment of the race. This finding aligns with earlier investigations reporting that maximum velocity in the 100 m sprint is typically reached between 40 m and 60 m [8, 9, 11]. Performance during this phase has been associated with coordination between stride length and stride frequency, ground contact characteristics, and musculoskeletal stiffness [10, 11].

Although maximum velocity was attained within the expected distance range, the absolute speed values observed were lower than those reported for elite sprinters [3, 12]. This difference may be related to variation in training background, neuromuscular efficiency, and mechanical execution between elite and university athletes [9, 12]. These factors are commonly considered when examining the ability to maintain near maximal velocity over longer sprint distances.

A reduction in running velocity was observed in the final 10 m of the sprint (90-100 m) in both male and female athletes, indicating the onset of the deceleration phase. This decrease in speed has been associated with neuromuscular fatigue, reduced force production, and changes in sprint mechanics [13, 14]. Earlier studies have reported that the extent of velocity loss during this phase is related to overall sprint performance [12, 15].

The greater decrease in locomotion speed observed among female athletes during the retardation phase may be related to sex associated differences in anaerobic capacity, muscle strength, and fatigue response [16, 17]. Previous research has shown that elite sprinters are able to maintain maximal velocity for longer distances, which has been linked to speed endurance characteristics [3, 12].

Across all sprint phases, male athletes demonstrated higher absolute locomotion speeds than female athletes. This finding corresponds to previous reports and has been attributed to differences in muscle mass, maximal strength, and power output [16, 17]. Despite these differences in absolute values, the pattern of velocity change across sprint phases was similar between sexes.

The similarity in phase wise velocity distribution suggests that basic sprint performance structure follows comparable patterns in male and female athletes [18]. Phase specific sprint training principles may therefore be applied across sexes, with appropriate adjustment of training load, intensity, and recovery.

Limitations of the Study and Future Research Directions

Interpretation of the present findings should take into account several methodological and contextual considerations. This study employed a cross sectional design, which does not allow causal interpretation of changes in sprint phase velocity. The sample included only university athletes, which limits the generalizability of the findings to elite or youth populations. Sprint split times were recorded using digital stopwatches rather than automated timing systems, which may introduce small measurement errors. Biomechanical variables such as stride mechanics and force production were not assessed. Training background and environmental conditions were also not fully controlled.

Future research may apply longitudinal or intervention based designs to examine training related changes in sprint phase performance. The use of automated timing systems and biomechanical analyses would increase measurement accuracy. Studies involving athletes from different competitive levels and age groups would improve generalizability. Additional investigations may address sex related adaptations and approaches aimed at reducing speed loss during the final phase of the sprint.

Conclusions

The present study indicates that running velocity during the 100 m sprint varies across different race stages in university athletes. Both male and female sprinters showed the following patterns:

- lower running speed during the acceleration phase;
- highest running speed during the mid race maximum velocity phase;
- a reduction in running speed during the final retardation phase.

Male athletes demonstrated higher absolute running velocities across all sprint phases, whereas female athletes showed a greater reduction in speed during the final phase. These findings indicate that sprint training at the university level should address acceleration development, maintenance of maximum velocity, and resistance to fatigue during the final segment of the race. The results may be applied by coaches, sport scientists, and physical educators involved in sprint training at the university level.

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Conflict of Interest

The authors declare no conflict of interest.

AI Tools Usage

During the preparation of this manuscript, ChatGPT was used for language checking and assistance with phrasing to improve clarity. All content was reviewed and edited by the authors, who take full responsibility for the final version of the manuscript and the accuracy of the presented information.

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