The Dynamics of Velocity Development in Elite Women Sprinters

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by Hristo Stoyanov

ABSTRACT

This study builds on previous work conducted on male sprinters, which revealed differences in each phase of the 100m between the champions at major international events and those who medalled. Data on a total of 31 performances by several generations of top women sprinters at the IAAF World Championships in Athletics and Olympic Games were analysed. The objectives were to study the velocity dynamics and identify the factors that distinguish the very top women sprinters and thus the priorities for the planning of training programmes. According to the results, the start and the subsequent acceleration were important for the final result, since within the first 10m of the distance the athletes attained a high percentage (47.36%) of their maximum velocity. Also important is the ability to maintain the level of velocity attained for as much of the distance as possible. The author concludes with the hope that the analysis will help coaches develop methods to best prepare sprinters to match the requirements of each phase of the ideal competition model he provides.

AUTHOR

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Introduction

The biomechanical studies organised by the IAAF at major championships since 1987 have helped to build the understanding of the 100m and the factors affecting performance in what is considered by many to be athletics' blue riband event. Interest has continued through the present day with various authors taking different approaches to the analysis of the event.

Some experts (e.g. MURASE et al[21], BACHVAROV[2]) showed that the 100m should be divided into three phases: acceleration, maximum speed and speed decrease. There are studies (e.g. COPPENOLLE & DELECLUSE[6,7], SCHOT & KNUTZEN[24], KORCHEMNY[17], GUISSARD et al[11], HARLAND & STEELE[12], SLAVCHEV[26], WANG[30], ĆOH et al[5], BABIĆ & DELALIJEA[1]) that focus on the importance of reaction time while others, like MARTIN & BUONCHRISTIANI[19], consider the length of the acceleration phase and the achievement of maximum velocity as exceptionally important.

A number of authors (MURASE et al[21], VOLKOV & LAPIN[29], BRÜGGEMANN & GLAD[3], MORAVEC et al[20], GAJER et al[10], BRÜGGEMANN et al[4], SHEN[25], FERRO et al[8]) have studied the effects of biomechanical parameters on running velocity. Some of these showed that there should be negative relationship between stride length and stride frequency, especially in the beginning of the acceleration phase. MACKALA[18] showed how these two parameters affect the different phases and how maintaining optimal stride length for longer contributes to the overall performance.

Other studies on the running characteristics of elite sprinters (RYU et al[22,23], STOYANOV[28]) brought clarity on the distribution of effort in the race and insights that help coaches with their work on the methods of preparing elite sprinters. Further study of the dynamics of maximum running velocity will help with the development of training practice, particularly for intervening selectively for stride length and stride frequency with the aim of achieving the optimum ratio of these two parameters. According to some (STOYANOV et all [27], GADEV[9]), this is a key for technical effectiveness and improved results.

The focus of the present work is on elite women 100m sprinters. We have drawn on data published by the IAAF on the best performances achieved by several generations of top performers to study the velocity dynamics of their competition models to detect the realisation of maximum velocity in the different phases of the race. Our aim was to identify those factors that distinguish the very top women sprinters and thus the priorities for the planning of training programmes.

Methods

A total of 31 women's 100m performances from both the IAAF World Championships in Athletics (WCA) and Olympic Games (OG) were included. First, a careful analysis was conducted on the wind-aided 10.70 and 10.54 sec races of Florence Griffith-Joyner (USA) at the 1988 OG in Seoul. Then we looked at the races of Gail Devers (USA), Merlene Ottey (JAM) and Gwen Torrence (USA), from the 1993 WCA in Stuttgart and the 1996 OG in Atlanta. Finally, data from the biomechanical analyses of the 1997, 1999, 2007, 2009 and 2011 WCAs allowed us to include two more generations of elite female athletes in the study. In total 21 athletes were included.

Table 1: Mean values of split time, segment time and velocity necessary for each 10m segment for the three groups of female athletes http://www.abv.bg

	10m Split Time (sec)									
	10m	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**
Group I	1.98	3.09	**4.09**	5.05	6.00	**6.94**	7.88	**8.83**	9.79	**10.77**
Group II	2.01	3.12	**4.12**	5.10	6.06	**7.01**	7.97	**8.94**	9.92	**10.93**
Group III	2.01	3.13	**4.14**	5.12	6.09	**7.05**	8.01	**9.00**	10.00	**11.03**
	10m Segment Time (sec)									
	10m	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**
Group I	1.98	1.106	**1.004**	0.965	0.949	**0.935**	0.943	**0.948**	0.964	**0.975**
Group II	2.01	1.110	**1.000**	0.979	0.961	**0.949**	0.956	**0.973**	0.982	**1.01**
Group III	2.01	1.117	**1.015**	0.978	0.968	**0.960**	0.964	**0.987**	1.002	**1.03**
	Average Velocity ($m.s^{-1}$)									
	10m	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**
Group I	5.05	9.04	**9.96**	10.36	10.54	**10.69**	10.60	**10.55**	10.37	**10.26**
Group II	4.97	9.00	**10.00**	10.21	10.41	**10.54**	10.46	**10.28**	10.18	**9.90**
Group III	4.97	8.95	**9.85**	10.22	10.33	**10.42**	10.37	**10.13**	9.98	**9.70**

Table 2: Percent realisation of maximum race velocity in each 10m segment for the three groups of female athletes

	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m
Group I	**47.24%**	**84.57%**	**93.17%**	**96.91%**	**98.60%**	**100%**	**99.16%**	**98.69%**	**97.01%**	**95.98%**
Group II	**47.15%**	**85.39%**	**94.88%**	**96.87%**	**98.77%**	**100%**	**99.24%**	**97.53%**	**96.58%**	**93.93%**
Group III	**47.70%**	**85.89%**	**94.53%**	**98.08%**	**99.14%**	**100%**	**99.52%**	**97.22%**	**95.78%**	**93.09%**
Mean %	**47.36%**	**85.28%**	**94.19%**	**97.29%**	**98.83%**	**100%**	**99.31%**	**97.81%**	**96.46%**	**94.33%**

The performances were subdivided into three groups based on time. The first group included 12 performances below 10.85 sec and comprised champions and medal winners from the last ten WCAs, plus two wind-aided results from the OG in Seoul 1988 (Griffith-Joyner and Heike Drechsler (GDR)). The second group included 12 performances between 10.85 and 11.00 sec, with the majority of the athletes also being either champions or finalists over the last ten WCAs. The third group included major championship medallists with personal best times between 11.00 and 11.10 sec.

Table 1 contains the dynamics of the development of running velocity for each 10m segment of the race by group. The percentage of maximum velocity for the whole race that was achieved in each 10m segment by each group is given in Table 2

Results and Analysis

The analysis of the start and initial acceleration shows that the sprinters of Group I (mean performance 10.77 sec) covered the first 10m in an average of 1.98 sec, with those in Groups II and III (mean performances of 10.93 and 11.03 sec, respectively) running the first 10m in 2.01 sec. At the 20m point, the average times for the groups were 3.09, 3.11, and 3.12 sec, respectively. The velocity of the three groups in the first two 10m segments was approximately equal, with the average for the first 10m being about 5 $m.s^{-1}$, and the second 10m being approximately 9 $m.s^{-1}$. This is consistent with previous findings for top male 100m sprinters that the biggest increase in running velocity takes place between the 10 and 20m marks[18, 28].

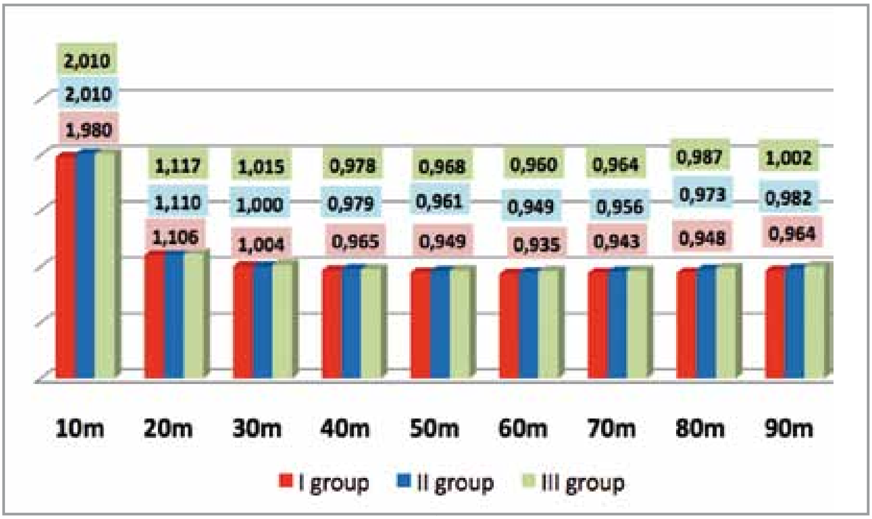


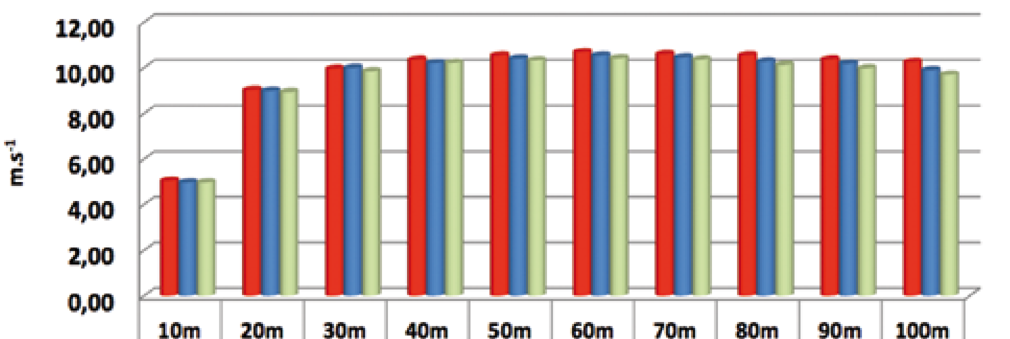
Figure 1: Time for each 10m segment for the three groups of female athletes

At the end of 30m the Group I sprinters had covered the distance in an average of 4.09, Group II in 4.12, and Group III in 4.14 sec, respectively. The average velocity for the three groups in the third 10m segment was 9.98 $m.s^{-1}$, which is approximately 94.19% of the average maximum race velocity. Note that although Group II shows an unexpectedly faster time and higher velocity than Group I for this segment, the differences are probably within the margin of error for the recording and data analysis systems used and should not be over interpreted.

Maintaining the ascending dynamics in the development of velocity into the second, maximum velocity, phase of the race there is a continuous acceleration in all three groups. For Group I, for example, the average times for the next three segments are 0.965 sec (30-40m), 0.949 sec (40-50m) and 0.935sec (50-60m). All three groups reached their maximum velocity for the race in the 50m to 60m segment, for Group I 10.69 $m.s^{-1}$, for Group II 10.54 $m.s^{-1}$ and for Group III it was 10.42 $m.s^{-1}$, with the average of the times being 6.94, 7.01, and 7.05 sec, respectively. It should be noted that in the middle 10m segment of this phase (40 to 50m), all three groups reached 98.83% of their maximum velocity, which continued in the next phase (maintaining & decreasing velocity) of the race.

The Group I sprinters succeeded in maintaining the maximum velocity they achieved into the 60 to 70m and 70 to 80m segments, covering these in an average of 0.943 and 0.948 sec, respectively. For the other two groups, the picture differs slightly. For Group II the velocity decreases gradually, with the 10m from 60 to 70m run in 0.956 sec (velocity of 10.46 $m.s^{-1}$) and the 70 to 80m segment run in 0.973 sec (velocity 10.28 $m.s^{-1}$). Group III showed the same trend, covering 60 to 70 m in 0.964 sec. (velocity10.37 $m.s^{-1}$) and 70 to 80 m in 0.987 sec (velocity 10.13 $m.s^{-1}$). These results illustrate the superiority of the Group I athletes with regard to the proper distribution of efforts and preparation. The only athlete to achieve almost equal velocity of 10.98 $m.s^{-1}$ in the interim segments (60-70m, 70-80m and 80-90m) was Florence Griffith-Joyner.

The average times at the 80m mark for the three groups were 8.83, 8.94, and 9.00 sec, respectively. Analysis of the percentage of maximum velocity shows decreases of 1.31, 2.47, and 2.78% in Group I, Group II and Group

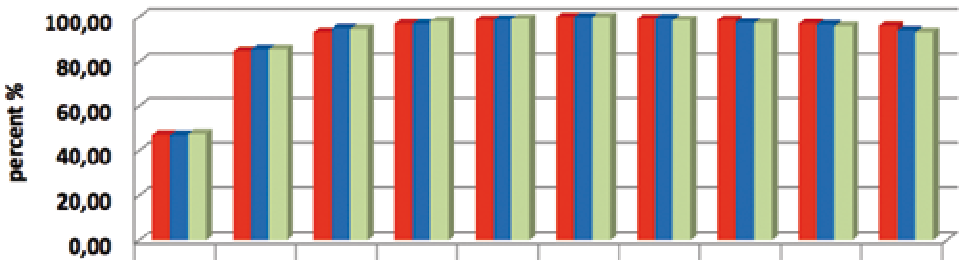


	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m
I group	5,05	9,04	9,96	10,36	10,54	10,69	10,60	10,55	10,37	10,26
II group	4,97	9,00	10,00	10,21	10,41	10,54	10,46	10,28	10,18	9,90
III group	4,97	8,95	9,85	10,22	10,33	10,42	10,37	10,13	9,98	9,70

Figure 2: Velocity dynamics for each 10m segment for the three groups of female sprinters

III, respectively (Figure 3). This trend continues until the finish for all three groups. Group I covers the next two 10m segments (80-90 and 90-100m) in 0.964 and 0.975 sec, respectively (velocity of 10.37 and 10.26 $m.s^{-1}$). The same dynamic but more pronounced is observed in Groups II and III. Group II covers the last two segments in 0.982 and 1.01 sec, respectively (velocity 10.18 $m.s^{-1}$ and 9.90 $m.s^{-1}$). The decrease in velocity is even more pronounced in the Group III: 1.00 and 1.03 sec, respectively. A comparative analysis of the delay of Groups II and III versus Group I at each 10m point is shown in Figure 4.

The percentage decrease in the last 20m shows that the velocity of Group I drops to 95.98% of the maximum achieved earlier in the race. It is 93.93% for Group II and to 93.09% for Group III. Again, this distribution of effort demonstrates the superiority, which is indicative of a good preparation, of the Group I athletes.



	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m
I group	47,24	84,57	93,17	96,91	98,60	100,00	99,16	98,69	97,01	95,98
II group	47,15	85,39	94,88	96,87	98,77	100,00	99,24	97,53	96,58	93,93
III group	47,70	85,39	94,53	98,08	99,14	100,00	98,52	97,22	95,78	93,09

Figure 3: Dynamics of the percent realisation of the maximum running velocity in each 10m segment for the three groups of female sprinters

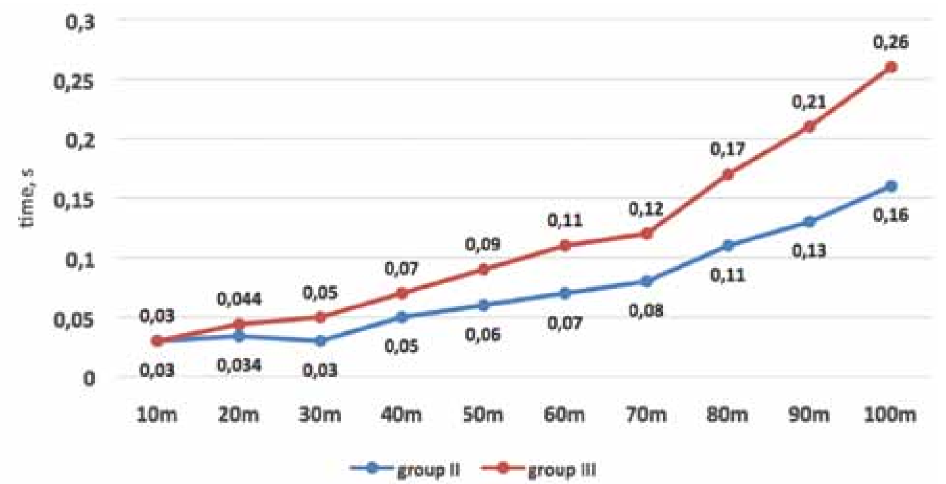


Figure 4: Comparative analysis of the delay of Group II and III against Group I at each 10m point of the race

Table 3: Competition model for the women's 100m

Distance	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m
Time (sec)	**1.98**	3.09	**4.09**	5.05	6.00	**6.94**	7.88	**8.83**	9.79	**10.77**

Conclusions and Implications for Coaching Practice

Building on our previous studies of the running characteristics of elite male sprinters[28], this analysis reveals differences in the three phases of the race for the three groups of elite women sprinters studied. The results provide an insight to the race model required for success at the top level in the women's 100m (see Table 3), which are summarised in the following points. Note that the validity of the model was confirmed at the 2015 IAAF World Championships in Athletics, where Shelly-Ann Fraser-Price (JAM) won with result of 10.76 seconds.

1. The analysis shows that the start and initial acceleration are important for the final performance, with the subjects on average attaining approximately 47.46% of their maximum velocity in the first 10m and 94.19% by 30m. This steep acceleration curve is a prerequisite for a successful transition into the next phase of the race, the maximum velocity phase.

2. Between 30 and 50m the subjects accelerate to an average of 98.83% of their maximum race velocity, which all reach in the 50-60m segment. It is intuitive that the level of velocity reached in the maximum velocity phase is an important factor for success in the 100m.

3. In the 60-70m and 70-80m segments maintenance or an insignificant decrease of the maximum race velocity is observed (average of 99.31% and 97.81%, respectively). We believe that this ability to hold a high velocity and thereby extend the maximum velocity phase of the race is a prerequisite characteristic of being competitive at the level of the WCA or OG.

4. In the last 20m of the race there is a noticeable drop off in the percentage of the maximum race velocity for all the subjects (average of 96.46% and 94.33% for the 80-90m and 90-100m segments) and small but significant differences between the three groups studied. These differences are the measures of the proper distribution of effort and sprint endurance, which are essential for competitive success in this event.

We can conclude with the observation that in the training of top-level women's 100m runners it is particularly important to focus on ways to increase maximum running velocity and to extend the period of maximum or near-maximum running velocity. To achieve this, an athlete's training needs to focus on developing 1) the ability to accelerate quickly and attain a high percentage of the eventual maximum velocity in the first phase of the race and 2) sprint endurance to maintain the level of velocity reached for as much of the distance as possible.

It is hoped that the analysis presented here will provide coaches with a prioritisation of the necessary abilities and benchmarks for developing methods to best prepare the sprinters to match the requirements of each phase of the ideal competition model.

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