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Competition Model Characteristics of Elite Male Sprinters

by Hristo Stoyanov

ABSTRACT

The aim of this study was to help coaches with the planning and management of the training process for the men's 100m by studying the characteristics of the competition models of elite sprinters. Discovering the internal structure and dynamics of top performances allows the coach to select training means that develop the athlete's characteristics towards that of the top performance model. Thirty-five 100m performances, including several world records, at the IAAF World Championships in Athletics and Olympic Games were analysed. The performances were divided into three groups. The analysis of the effort distribution for the three groups indicates those elements of the race that impact the final result and thus call for development through training. The findings include that in the top performances (those below 9.86 sec), athletes reach maximal velocity within 60m and maintain their velocity better than the other two groups studied. A regression model was created to help coaches evaluate this sprint endurance capability of the athlete and predict the 100m result based on his 60m time.

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Introduction

The men's 100m is currently in a period of extremely high quality performances. Less than ten years ago, the world record stood at the 9.79 sec by Maurice Green (USA), which was set back in 1999. Starting in 2005 Asafa Powell (JAM) lowered the global mark no less than four times, reaching 9.74 in 2007. Then came the era of Usain Bolt (JAM), who altered everyone's concept of what is possible in the event by breaking the world record on three occasions, bringing it down to the current standard of 9.58 in 2009. Since setting that mark Bolt has continued to excel, running under the 9.79 on five occasions, including a 9.63 to win the 2012 Olympic Games in London. With Bolt on the scene, others like Tyson Gay (USA) at 9.69 sec, Yohan Blake (JAM) at 9.69 and Nesta Carter (JAM) at 9.78 have stepped up to a level that would have given them the world record at the beginning of the century and even Powell improved his personal best to 9.72. In this same period we have seen a number of national records in other countries and the eight fastest 4 x 100m relay times ever.

According to MURASE et al.[15] the sprint races comprise three phases: acceleration, maximum speed and deceleration and the 100m is often analysed on the basis of its elements: start and acceleration, maximum velocity, and speed endurance[4]. Many authors [7,8,9,11,14,15,20] have studied the effect of biomechanical parameters on velocity in the 100m. MACKALA[13] showed how these parameters affect the different phases, and his results indicate that maintaining optimal stride length for as long as possible is a key to technical effectiveness and optimisation of results in 100m. ANTONOV[1], BACHVAROV[3], BARTENEV[5], PRIMAKOV[16], SLAVCHEV[18] and some others came to conclusion that the start and acceleration have the principal role in the factorial structure of sprint races: reaching maximum velocity quickly and then maintaining it is the basis for success. RYU et al.[17], who studied the running velocity of 11 elite 100m sprinters at the IAAF World Championships in Athletics in 2007, 2009 and 2011, made similar findings.

From the point of view of training, top results in any athletics discipline are a result of the long-term preparation of the athlete, and innovations in the training methods used by their coaches. Planning and management of the training process requires the identification of model characteristics for the discipline[2]. This identification is based on the factorial structure of the event. FILIPOV & DIMITROV[10] studied the phase structure of the sprints and noted that with an understanding of the internal phases of a given sprint event, the coach could improve the particular physical characteristics of the runner, acting on them selectively within an overall preparation system. In other words, the model characteristics, based on the factorial structure of the performance, are the basis for the coach's selection of the training contents required to reach a new level. This calls for the development of tests and indicators providing information about the athlete's status with regard to the main factors of performance.

The aim of the present work was to help coaches in the planning and management of the training process for the men's 100m by studying the characteristics of the competition models of elite sprinters. The approach included the following tasks:

- Determining the velocity dynamics in the three race phases for elite 100m sprinters of different performance levels.
- Investigating the realisation of sprint endurance in elite 100m sprinters.

Methods

Thirty-five men's 100m results achieved during the IAAF World Championships in Athletics (WCs) and Olympic Games (OG) were analysed. The survey includes most of the world's best performances in the event, including several world records. A total of 25 athletes were included in the survey.

The performances were divided into three groups. The first group includes times faster than 9.86 sec. The athletes represented in this group include champions of six WCs. The second group includes 12 results between 9.86 and 10.00, most of the athletes represented being medallists or finalists at the WCs and OG. The third group includes results in the range 10.00 to 10.20, some by athletes with personal bests below 10 seconds and some by major event medal winners at 60m and 200m.

The times were subjected to statistical analysis. We followed the dynamics in velocity development, subdividing the distance into 10m segments and studied the time necessary to cover each 10m. We used mean values of velocity and time necessary to cover each 10m segment.

Results and Discussion

Analysis of the first 10m of the race (reflecting the start and initial acceleration) showed that the sprinters of Group 1 with a mean result

Table 1: Mean values of 10m split times, velocity and 10m segment times for the three performance groups

10 Split Time:	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**
Group 1 (Below to 9.86 sec)	**1.87**	2.89	**3.81**	4.69	5.54	**6.37**	7.21	**8.06**	8.90	**9.78**
Group 2 (from 9.86 to 10.0 sec)	**1.86**	2.92	**3.86**	4.73	5.60	**6.46**	7.32	**8.18**	9.06	**9.94**
Group 3 (from 10.00 to 10.20 sec)	**1.91**	2.95	**3.88**	4.78	5.67	**6.55**	7.43	**8.30**	9.19	**10.10**
Velocity ($m.s^{-1}$):	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**
Group 1 (Below to 9.86 sec)	**5.35**	9.73	**10.88**	11.47	11.72	**11.96**	11.93	**11.82**	11.73	11.49
Group 2 (from 9.86 to 10.0 sec)	**5.37**	9.48	**10.79**	11.29	11.55	**11.69**	11.63	**11.63**	11.39	11.32
Group 3 (from 10.00 to 10.20 sec)	**5.24**	9.55	**10.74**	11.12	11.31	**11.32**	11.42	**11.38**	11.22	10.99
10m Segment Time:	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**
Group 1 (Below to 9.86 sec)	**1.87**	1.03	**0.92**	0.87	0.85	**0.84**	0.84	**0.84**	0.85	**0.87**
Group 2 (from 9.86 to 10.0 sec)	**1.86**	1.06	**0.93**	0.89	0.87	**0.86**	0.86	**0.86**	0.88	**0.88**
Group 3 (from 10.00 to 10.20 sec)	**1.91**	1.05	**0.93**	0.90	0.88	**0.88**	0.875	**0.88**	0.89	**0.91**

9.78 ran slower than those in the second group (with a mean result 9.94). However, the difference is minimal, - 1.87 vs 1.86 and is statistically insignificant (Table 1). The slowest result, – 1.91 - was in the third group (the one with a mean result of 10.10).

At 30m, considered the end of main acceleration phase, the times show another configuration; the sprinters of Group 1 ran this distance in an mean of 3.81, Group 2 in 3.86 and Group 3 in 3.88. It should be noted that in spite of the small difference, only 0.07 sec between Group 1 and Group 3, the dynamics in efforts distribution is different (Figure 1).

While the Group 1 performances are characterised by continuous acceleration – mean of 1.03 and 0.92 sec for the second and third 10m segments, respectively, the mean time of Group 3 in the second 10m is better than that of Group 2 - 1.05 and 1.06 sec, respectively. The mean times for the next 10m segment are equal for these two groups – 0.93 sec. Probably this is due to the competition among the athletes, on the one hand, and to investing more effort at this point in the race by the slower athletes, on the other. Keeping the ascending dynamic in velocity development and passing to the next race phase with high velocity, the first two groups reach their maximum velocity at 60m, mean of 11.96 $m.s^{-1}$ for Group 1 and 11.69 $m.s^{-1}$ for Group 2. In Group 3, the mean maximum velocity, 11.42 $m.s^{-1}$, was reached at 70m.

It should be noted that in the transition from initial acceleration to maximum velocity phase, all three groups of athletes put in maximum effort between 30 and 40m. The mean time of Group 1 at 60m is 6.37, 6.46 for Group 2 and 6.55 for Group 3. The difference between the groups is 0.08, which corresponds to about one meter.

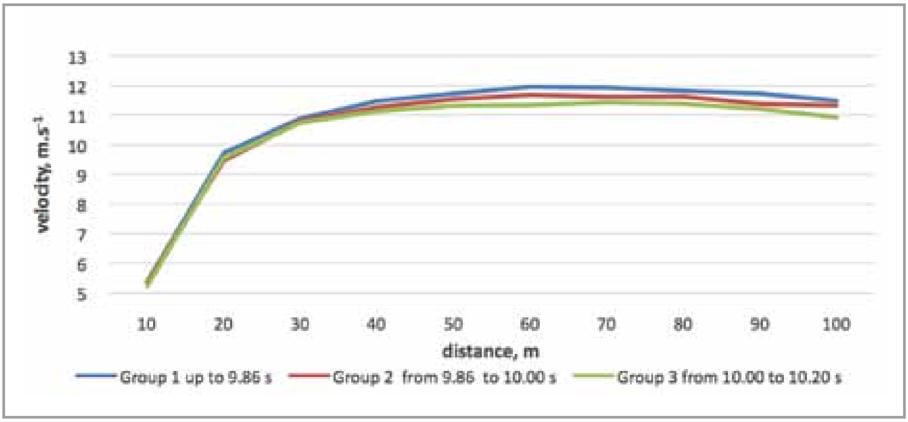

Figure 1: Dynamics of velocity development at each 10m for the three groups of performances

An interesting fact is that the sprinters of Group 1 reach their maximum velocity first and are able to maintain it longer, leading us to the next element of performance – sprint endurance, i.e., the ability to maintain the maximum velocity achieved for as long as possible* running (see Figure 1). Similar dynamics can be observed in the performances of Group 2.

After reaching a mean maximum velocity of 11.69 $m.s^{-1}$ at 60m the velocity in the next two 10m segments remains practically the same – 11.63 $m.s^{-1}$ each. Passing three 10m segments (50-80m) in an mean of 0.84 sec for the first group and 0.86 for the second group (Figure 2), respectively, sets up the Group 1 athletes to maintain roughly the same velocity in the last 20m and the Group 2 athletes to minimise deceleration (Figure 1). The dynamics in the Group 3 performances is quite different. After reaching maximum velocity the mean velocity decreases continuously to the finish line (Figure 2).

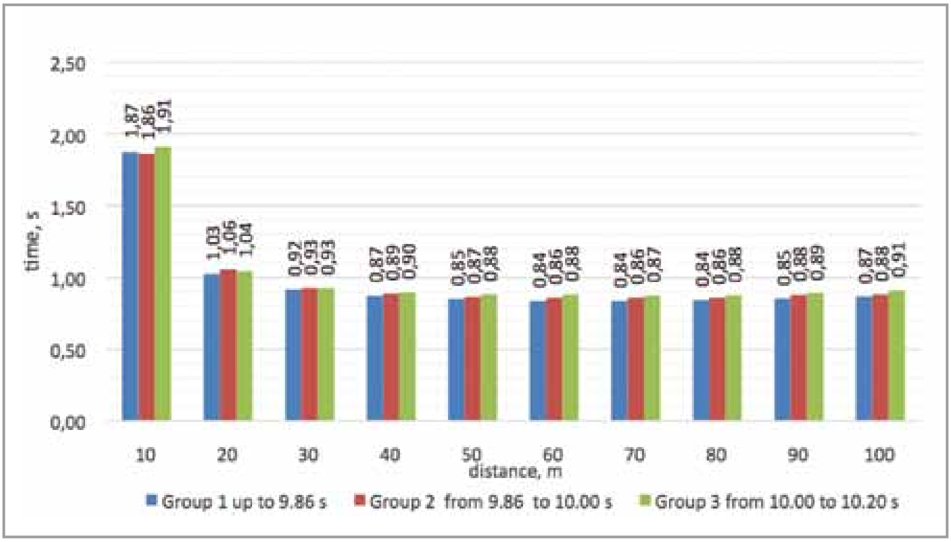

Figure 2: Time for 10m segments in the three groups of performances

* *As opposed to speed endurance, which the ability prolong the time where new maximum running velocity can be maintained.*

With a closer look we see that the velocity development in the last 20m (80-100) for the first two groups is different. After maintaining the velocity achieved for 30m, Group 1 performances show only slight decrease, mostly in the last 10m (keep in mind that many cases the winners finish with hands up, which negatively affects the velocity in the last 10m). In some cases the last two 10m segments are passed at the same velocity. Looking at the last 20m of the performances in Group 2, as shown in Figure 2, we see that the last two 10m segments are covered in a mean of 0.88 seconds and even in some cases the last 10m is faster than the next to last. On the one hand, this indicates highly developed sprint endurance, and on the other hand, it could indicate a problem in effort distribution.

A proof of the sprint endurance demonstrated in the first two groups of performances is the comparative analysis of next two last 20m segment (60-80m of the distance) and the last 20m segment (80-100m). The mean time for covering these two segments by Group 1 athletes is 1.68 and 1.72 seconds, respectively. The times for the Group 2 athletes are 1.72 and 1.76 seconds, respectively. The small difference of 0.04 seconds between the last two 20m segments indicates the importance of development of sprint endurance for sport performance (Figure 2).

Study of the characteristics of competition models allows for an evaluation of the level of sprint endurance, i.e. by juxtaposing the times at 60m with those at 100m. Regression analysis was performed for determining the relationship between the results at 100m and the time spent for the first 60m. Figure 3 shows that a positive linear relationship was found with a coefficient of correlation r=0.93 and determination coefficient r^2=0.859, which indicates very strong relationship between the time at 60m and 100m results, covering of variance of almost 88%. The regression equation developed allows predicting the result in 100m based on the time at 60m:

$$Y = 1.599x-0.391$$

where Y – expected (predicted) result in 100m,
x – achieved result in 60m.

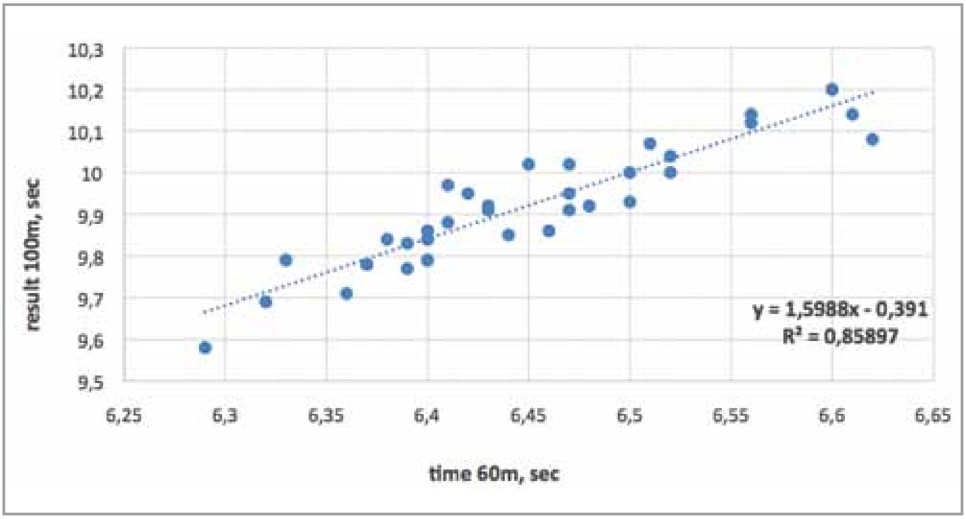

Figure 3: Correlation between 60m time and 100m result with regression model for predicting 100m result and the degree of realisation of sprint endurance

Table 2: Real and theoretical (predicted) results in the 100m based on the time for 60m and the realisation of sprint endurance for selected performances

Athlete	Event	Year	Rank	Time 60m(sec)	Final time 100m (sec)	Theor. time 100m (sec)	Diff. btw theoretical and real result
Usain Bolt (JAM)	WC Berlin	2009	1	6.29	9.58*	**9.67**	**0.9%**
Usain Bolt (JAM)	OG Beijing	2008	1	6.32	9.69*	**9.71**	**0.2%**
Tyson Gay (USA)	WC Berlin	2009	2	6.36	9.71	**9.78**	**0.7%**
Asafa Powell (JAM)	Athens	2005	1	6.39	9.77*	**9.83**	**0.6%**
Tim Montgomery (USA)	Paris	2002	1	6.37	9.78*	**9.79**	**0.1%**
Ben Johnson (CAN)	OG Seoul	1988	1	**6.33**	**9.79****	**9.73**	**-0.6%**
Maurice Greene (USA)	Athens	1999	1	6.40	9.79*	**9.84**	**0.5%**
Ben Johnson (CAN)	WC Rome	1987	1	6.39	9.83**	**9.83**	**0.0%**
Asafa Powell (JAM)	WC Berlin	2009	3	6.40	9.84	**9.84**	**0.0%**
Bruni Surin (CAN)	WC Seville	1999	2	6.38	9.84	**9.81**	**-0.3%**
Tyson Gay (USA)	WC Osaka	2007	1	6.44	9.85	**9.91**	**0.6%**
Carl Lewis (USA)	WC Tokyo	1991	1	6.46	9.86	**9.94**	**0.8%**
Maurice Greene (USA)	WC Athens	1997	1	6.40	9.86	**9.84**	**-0.2%**
Leroy Burrell (USA)	WC Tokyo	1991	2	6.41	9.88	**9.86**	**-0.2%**
Derrick Atkins (BAH)	WC Osaka	2007	2	6.47	9.91	**9.95**	**0.4%**
Donovan Bailey (CAN)	WC Athens	1997	2	6.43	9.91	**9.89**	**-0.2%**
Carl Lewis (USA)	OG Seoul	1988	1	6.48	9.92	**9.97**	**0.5%**
Linford Christie (GBR)	WC Tokyo	1991	4	6.43	9.92	**9.89**	**-0.3%**
Yohan Blake (JAM)	WC Daegu	2011	1	6.43	9.92	**9.89**	**-0.3%**
Carl Lewis (USA)	WC Rome	1987	1	6.50	9.93	**10.00**	**0.7%**
Asafa Powell (JAM)	WC Osaka	2007	3	6.42	9.95	**9.87**	**-0.8%**
Frankie Fredericks (NAM)	WC Tokyo	1991	5	6.47	9.95	**9.95**	**0.0%**
Dwain Chambers (GBR)	WC Seville	1999	3	6.41	9.97	**9.86**	**-1.1%**
Obadele Thompson (BAR)	WC Seville	1999	4	6.50	10.00	**10.00**	**0.0%**
Mark Bruns (TTO)	WC Berlin	2009	7	6.52	10.00	**10.03**	**0.3%**
Tim Harden (USA)	WC Seville	1999	5	6.47	10.02	**9.95**	**-0.7%**
Ato Boldon (TTO)	WC Athens	1997	5	6.45	10.02	**9.92**	**-1.0%**
Tim Montgomery (USA)	WC Seville	1999	6	6.52	10.04	**10.03**	**-0.1%**
Jason Gardner (GBR)	WC Seville	1999	7	6.51	10.07	**10.02**	**-0.5%**
Churandi Martina (AHO)	WC Osaka	2007	5	6.62	10.08	**10.19**	**1.1%**
Robson Da Silva (BRA)	WC Tokyo	1991	7	6.56	10.12	**10.10**	**-0.2%**
Marlon Devonish (GBR)	WC Osaka	2007	6	6.61	10.14	**10.18**	**0.4%**
Bruni Surin (CAN)	WC Tokyo	1991	8	6.56	10.14	**10.10**	**-0.4%**
Saidy Jaysuma Ndure (NOR)	WC Berlin	2009	7SF	6.6	10.2	**10.16**	**-0.4%**
Samuel Frances (QAT)	WC Berlin	2009	18QF	6.6	10.2	**10.16**	**-0.4%**
			Mean	**6.45**	**9.93**		
			SD	**0.08**	**0.14**		

* World record; ** World record disqualified due to doping infringement

Comparing results, for example of Maurice Greene (Table 2) when setting a world record in Athens, 1999 – 9.79 sec, and his result achieved when winning the WC in Athens, 1997 – 9.86, it can be seen that he passed 60m in 6.40 in both cases. Using the regression model, we can conclude that in the case of the 9.86 he haad an unrealised sprint endurance of 0.2%. In the breaking world record he demonstrated improvement of this quality, and it was realised even with a reserve of 0.5 %. Probably this was due to a correction in his training programme.

The analysis performed of the effort distribution of the three groups of athletes revealed the necessity of development and improvement of the three identified elements of the performance. Studying the phase structure and dynamics of the elements allows the coach to influence the training process by using specific training tools during the different stages of preparation. This allows us to make the following inferences.

Conclusions and Recommendations

1. The analysis of the start and acceleration phase of the race showed that the first 10m is important but not determining and that the proper dynamics in the velocity development, due to the optimal combination of biomechanical parameters of the running stride, could lead to a successful transition to the next phase of the race.

2. Achieving maximum velocity within the first 60m allows the athlete to maintain velocity for a longer period, as demonstrated by the analysis of Groups 1 and Group 2 performances.

3. Running the last two 10m segments (80-100m) with maintained maximal velocity, or with an insignificant difference between the last two 20m segments (60-80 and 80-100m) proves well-developed speed endurance and proper distribution of effort over the course of the race.

4. The regression model established can help coaches with optimisation of the development of the model characteristics of elite 100m sprinters by providing a tool to evaluate the athlete's level of speed endurance.

The conclusions and the analysis of regression model allow us to recommend an optimal combination of development of physical qualities related to performance, with particular reference to sprint endurance in the training of sprinters.

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