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THE INFLUENCE OF SPRINT BLOCK START ELEMENTS ON INITIAL VELOCITY OF 100 METRE RACE

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Abstract. The aim of this paper was to investigate whether it is possible to evaluate the relationship between different phases of sprint start objectively. The participants of the research were the top level of elite National Sprint Team (8 female, 9 male). The run times were as follows: 10.39 ±0.12 s for men and 11.63 ±0.20 s for women. The data that were taken into account during the research in order to examine typical kinetic parameters of the sprint start were: reaction time, delay between simple reaction time and reaction time (IAAF), time to front peak force, time to rear peak force, delay between end of front force and gun signal and total start time. The analysis of the study identifies the major kinematic parameters of the phases of the sprint start and block acceleration that influence the results of sprint running. The following correlation analyses were conducted, a linear regression for the typical kinetic parameters of the sprint start, initial speed on 100 metre race. Finally, a simple coaching related model for the development of sprinting is presented which is consistent with scientific evidence recommendations for coaches to make changes in training.

Key words: sprint start, velocity, reaction time, speed measurement, laser

Introduction

The main task of a crouch start is to begin a systematic increase of temporary velocity (Maćkała and Kowalski 2007). A block start is claimed to be the best method for beginning sprint race (Iskra et al. 2002), however, it is hard to establish whether a crouch start or a standing start is more efficient when it comes to the obtained race speed since the differences are not significant and dependent on many parameters (Salo and Bezodis 2004). A starting procedure in sprint races has been unified and since the beginning of the Olympic Games in London in 1948 in 100 metres race there is no possibility to choose the types of the start. The moment of the beginning of sprint races is strictly regulated by IAAF Competition Rules. The current false start criterion in a sprint used by the International Association of Athletics Federations is based on this assumed auditory reaction time of 100 ms (IAAF 2013). The race starts with the starting shoot that activates timing at the same time. The period from the activation time of the stimulus until the initiation time of movement is called a starting response (Sozański and Witczak 1981). As far as 100 metres men's race is concerned the starting response is between 0.105–0.150 s among the best runners and 0.140–0.190 s among worse runners. As far as women are concerned the starting responses are slightly weaker. The reaction of starting response has little influence (on the level of 1–2%) on the final result (in seconds) in 100 metres race (Tellez and Doolittle 1984; Bruggemann and Glad 1990; Mero and Komi 1990; Delecluse et al. 1992). The reaction time is not included in the overall time of being in the starting block (Fortier et al. 2005) and has no influence on the total amount of time of being in the starting block (Bradshaw et al. 2007). However, the actual starting moment of the race, as a kinematic activity, and the completion of the entire runner's procedure connected with the crouch start should be considered as a moment of leaving the starting block due to the fact that all the activities until this moment do not cause the actual speed growth in the race, they only cause a slight displacement of the centre of mass of the body (Terczyński 2009). In spite of the fact that the race has actually started (the time is running) the runner still is in contact with the starting block, which is situated in front of the starting line. Typical starting kinetic parameters of the time components are: reaction time, front force duration, rear force duration, total block time, time to front peak force, time to rear peak force, front peak force, rear peak force, delay between rear and front force onset, and delay between end of rear and front force offset (Fortier et al. 2005)

Taking into consideration the running speed it is visible that the starting reaction time is the lost time since there is no visible movement of the runner and simultaneously this time is included into the overall time of 100 metres race (Terczyński 2010). The studies suggest that it is worth taking into account, during the sports training, the issues of the improvement of the starting reaction time (Bruggemann and Glad 1990).

The time span needed for leaving the starting block (the separation of the front leg) is from 0.345 to 0.422 s (without the reaction time) (Henry 1952; Fortier et al. 2005; Bradshaw et al. 2007). This parameter is relatively stable and impervious to wide ranges of changes. The initial velocity of the runner during 100 metres race is not a zero value and is from 2.2 m/s to 3.6 m/s (Henry 1952). The precise measurements made by cinematographic method with the use of „fast cameras" show that the centre of the mass of the body of the world class runners starting in 100 m race in the first step, which means in the moment of leaving the starting block, obtains horizontal velocity fluctuations in the range of 2–4 m/s (Coh et al. 2006).

Research aims: To define basic kinematic components of the crouch start among 100 metres runners; to define the value of the initial velocity during the 100 metres race; to find trade figures between kinematic parameters during the block start and directly after it; to check the merits of the application of the time measurements for 30 metres during so a called "detachment of the rear leg" from the ground (training standing start); to verify the use of the technical solution of the measuring system.

Materials and Methods

Participants

The participants of the study were 17 runners (female = 8, male = 9) running short distance races with such result's ranges female 11.63 ±0.20 s (min – 11.34, max – 11.85) and male 10.39 ±0.12 s (min – 10.21, max – 10.62) in 100 metres race. The participants of the study were the National Sprint Team runners who take part in the Olympic Games, IAAF World Championships and European Athletics Championships.

Procedure

The study was conducted during starting conditions during Polish Athletics Championships organized by Polish Athletics Association in order to gain the most reliable results which can be useful for the analysis of this phenomenon later.

In order to do the research a positive opinion from Bioethical Commission was gained.

Measurements

The analysis of the kinematic parameters during the block start was obtained thanks to ReacTime Championchip False Start Detection RT8LWL system produced by Lynx Developers USA. The analysis consisted of reading the waveforms of the time series of the starting reaction of an individual runner. It was performed by the use of ReacTime Championship Software. The procedure is presented in Figure 1.

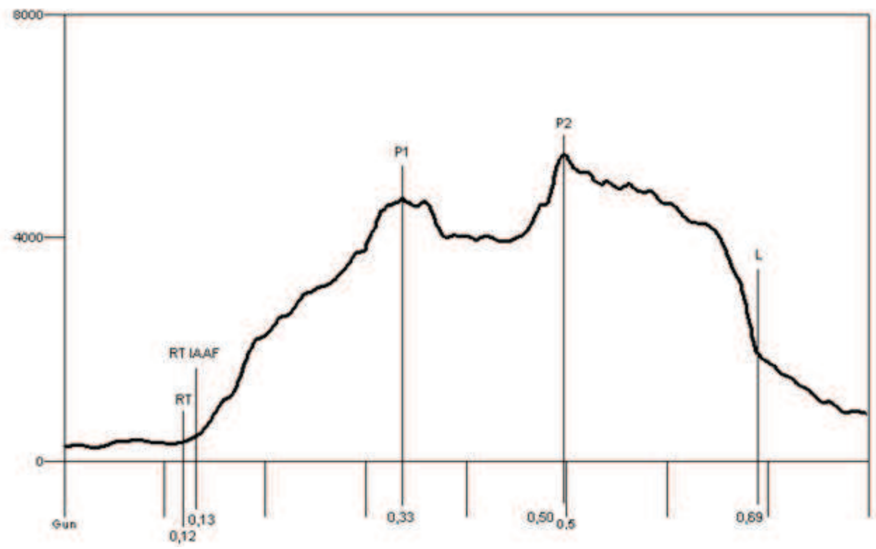

Figure 1. Kinematic parameters of the block start by the use of ReacTime Championship Software (Terczyński 2010). The times were indicated with the use of a marker RT – Reaction Time – defined as the time from the gun signal to the first detectable change of pressure in the instrumented blocks; (0.12 s); RT IAAF – Reaction Time IAAF – defined as the time from the gun signal to the detectable change of pressure in the instrumented blocks according to IAAF Rules (0.13 s); P1 – Peak 1 – defined as the time from the gun signal time to rear peak force (0.33 s); P2 – Peak 2 – defined as the time from the gun signal time to front peak force (0.50 s); L – Leave – defined as the time between the gun signal and the front force offset (0.69 s). (Athlete: Marika Popowicz, 31.07.2009 Polish Athletics Championships – 100 m – 11.38 s).

The speed measurement of the runners was conducted according to the established methodology with the use of Laser Distance Measuring Module LDM 300C – Sport produced by Jenoptik of German production (Turk-Noack and Schmalz 1994; Terczyński 2009). A laser head was positioned behind the runner while the laser beam was thrown on the part of the lumbar spine (on the level of the centre of gravity). The estimation of the leaving speed from the starting block was made on the basis of detailed analysis of the position of the centre of gravity during the first running step and placing it in time. Laser Distance Measuring Module LDM 300C – Sport software LAVEG was not used. The analysis was conducted with the use of Excel MS Office Professional 2010. The procedure is presented in Figure 2.

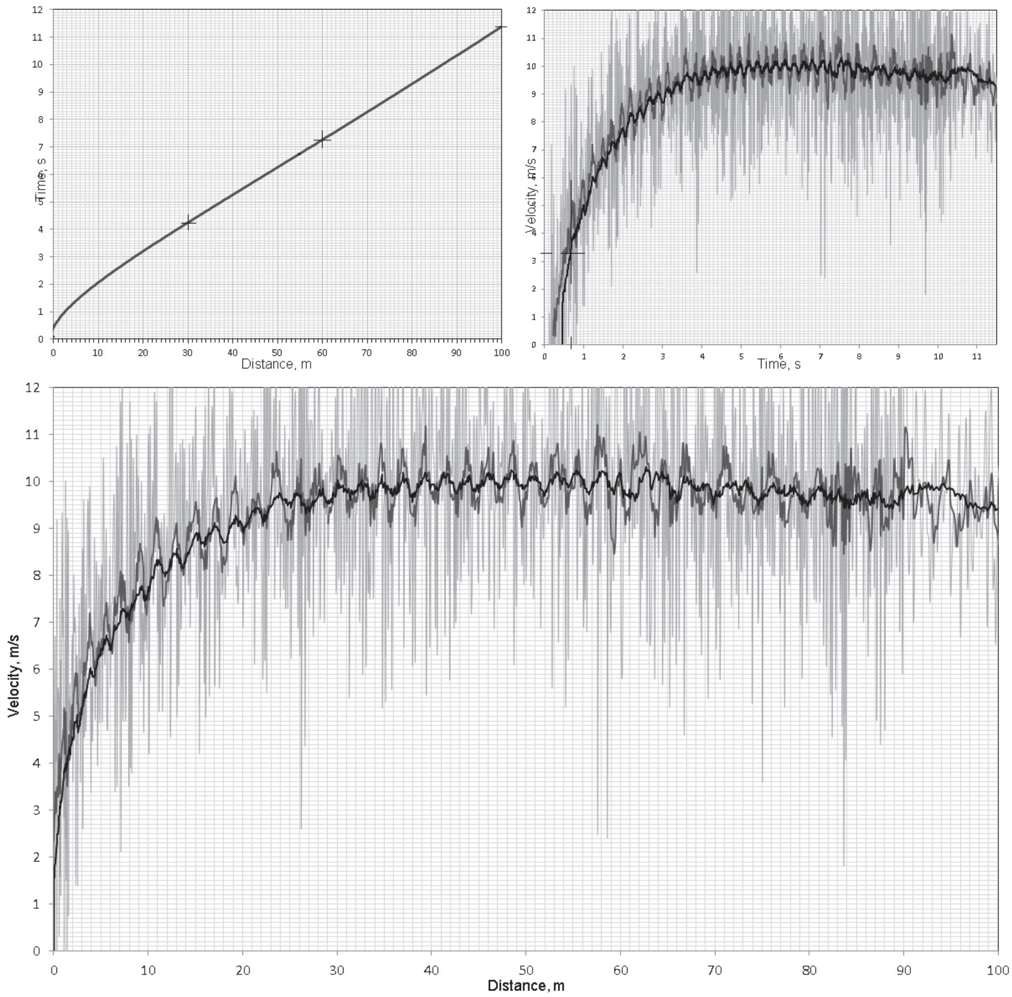

Figure 2. The example of a velocity distribution during the start and the time of leaving starting block (with markers) in 100 m race. The time of leaving the starting block t = 0.68 s and the speed of leaving the starting block V = 3.3 m/s were indicated with the use of a marker. (Athlete: Marika Popowicz, 31.07.2009 Polish Athletics Championships – 100 m – 11.38 s).

In addition, control measurements were made with the use of photocell split timing system in the following measurement points: on the 30th, 60th and 100th m. FK 2000 photocells sets produced by Slandi of Polish production and PTB 606 chronometer by Tag Heuer of Swiss production were used. An example of a single measurement series made with the use of cascade of photocells is presented in Table 1.

Table 1. Sample time values in 100 m race obtained by photocell path method and comparison by Laser Distance Measuring Module LDM 300C – Sport

Method	Distance									
	10	20	30	40	50	60	70	80	90	100
Photocell	–	–	4.22	–	–	7.24	–	–	–	11.38
Laser	2.07	3.19	4.24	5.25	6.30	7.25	8.26	9.29	10.32	11.40

Athlete: Marika Popowicz, 31.07.2009 Polish Athletics Championships – 100 m – 11.38 s.

Statistical analyses

Basic mathematical analysis of the results was conducted with the use of Excel MS Office Professional 2010. This mathematical analysis consisted of standard ordering and data collecting procedures with general statistical analysis (means, standard deviations, correlation). To determine the validity of correlation coefficients were calculated among handled tests. If a correlation is less than $r < 0.30$ it was considered small; $0.31 < r < 0.49$ – moderate; $0.5 < r < 0.69$ – large; $0.70 < r < 0.89$ – very large and $r \geq 0.90$ – near perfect. Negative values mean that value increase of one characteristic is accompanied with the value decrease of the second characteristic. Reliability was presented for the following levels: $p = 0.05$ (*) and $p = 0.005$ (**). The obtained results were verified in terms of average estimation. The values of standard deviation were similar which proves the homogeneity of group selection for further analysis.

Study results

The results were presented in the forms of tables. Table 2 presents basic kinematic parameters of a sprint block start where: RT – Reaction Time (the time from the gun signal to the first detectable change of pressure in the instrumented blocks); RT IAAF – Reaction Time IAAF (the time from the gun signal to the detectable change of pressure in the instrumented blocks according to IAAF Rules); P1 – Peak 1 (the time from the gun signal time to rear peak force); P2 – Peak 2 (the time from the gun signal time to front peak force); L – Leave (the time between the gun signal and the front force offset).

Table 2. Kinematic parameters of a sprint block start in 100 m race

Parameters	Units	Gender	
		Woman	Man
Reaction Time, RT	ms	158 ±25	150 ±60
Reaction Time IAAF, RT IAAF	ms	165 ±33	171 ±18
Peak 1, P1	ms	382 ±38	373 ±22
Peak 2, P2	ms	622 ±72	570 ±29
Leave, L	ms	790 ±88	737 ±77
100 m race, t_{100m}	s	11.63 ±0.20	10.39 ±0.12

1s = 1000 ms.

In the groups that took part in the study a simple reaction time on the acoustic stimulus (muscle leg) was 158 ±25 in a female group and 150 ±60 in a male group. The official time of reaction according to IAAF Rules was respectively165 ±33 and 171 ±18. The highest pressure of a women's front legs were 382 ±38 and men's 373 ±22, and rear legs 622 ±72 and 570 ±29 ms. Women left their starting blocks in time of 790 ±88 from the starting shoot and men 737 ±77 ms.

Basic kinematic parameters of a 100 m race were shown in Table 3. Starting velocity is the velocity of leaving the starting block by a runner. The time of t_{30m} and t_{100m} are the times that were respectively on the 30th and 100th m of distance. The parameter Δt_{30m} is the time obtained by the runner that could be gained during so called "detachment of the rear leg" from the ground (race time for 30 m minus the time of leaving the starting block), which is the type of measurement used in practice by couches in the process of sports training.

Table 3. Basic kinematic parameters of a 100 m race

Parameters	Units	Gender	
		Woman	Man
Leave Start Block, L	s	0.79 ±0.09	0.74 ±0.08
Initial velocity, V_0	m/s	2.41 ±0.66	3.69 ±0.34
Difference t_{100m} – L, Δt_{30m}	s	3.54 ±0.10	3.25 ±0.06
30 m race, t_{30m}	s	4.33 ±0.07	3.99 ±0.07
100 m race, t_{100m}	s	11.63 ±0.20	10.39 ±0.12

An average velocity of leaving a starting block by women was 2.41 ±0.66. Among men these values were estimated on the average level of 3.69 ±0.34. An average time of 100 m race among the participants was: for women 11.63 ±0.20 with the split times on the 30th metre of this distance 4.33 ±0.07 while men respectively 10.39 ±0.12 and 3.99 ±0.07 s.

Table 4 presents a matrix of correlation coefficients between the component factors of a crouch start and the strength of existing relationships between them.

Table 4. Matrix of correlation coefficients between the components of sprint block start of 100 m race

Parameters	Gender	Parameters				
		RT	RT IAAF	P1	P2	L
Reaction Time, RT		1	0.69	0.64	0.56	0.71
Reaction Time IAAF, RT IAAF		0.69	1	0.80*	0.76*	0.60
Peak 1, P1	Woman	0.64	0.80*	1	0.93**	0.61
Peak 2, P2		0.56	0.76*	0.93**	1	0.80*
Leave, L		0.71	0.60	0.61	0.80*	1
Reaction Time, RT		1	0.99**	0.91*	–0.78	–0.19
Reaction Time IAAF, RT IAAF		0.99**	1	0.95*	–0.84*	–0.21
Peak 1, P1	Man	0.91*	0.95*	1	–0.97**	–0.44
Peak 2, P2		–0.78	–0.84*	–0.97**	1	0.55
Leave, L		–0.19	–0.21	–0.44	0.55	1

* Correlation is significant at the 0.05 level; ** Correlation is significant at the 0.005 level.

Taking into account women's components of a crouch start there is a strong relationship between the time of obtaining a maximum pressure of a front leg and the time of obtaining maximum pressure of a rear leg ($r = 0.99$; $p < 0.005$). What is more, there is also a strong relationship between: the time of a starting reaction and the time of obtaining a maximum pressure on the starting block by a rear leg ($r = 0.80$; $p < 0.05$); the time of starting reaction and the time of obtaining a maximum pressure of a front leg ($r = 0.76$; $p < 0.05$) as well as the time of leaving the starting block ($r = 0.80$; $p < 0.05$). Additionally, there were strong relationships between the time of leaving the starting block and all the other $0.61 \leq r \leq 0.71$, however, they are not statistically significant. Taking into account men, the structure of relationships is a bit different. There are strong relationships between: the time of a simple reaction and the time of a starting reaction ($r = 0.93$; $p < 0.005$); the time of obtaining the maximum pressure of a front leg and the time of obtaining the maximum pressure of a rear leg ($r = -0.97$; $p < 0.005$) but on the basis of a reverse. In addition to it, there are strong relationships between: the time of obtaining the maximum pressure on the starting block of a rear leg and the time of a simple reaction ($r = 0.91$; $p < 0.05$) and the time of a starting reaction ($r = 0.95$; $p < 0.05$); there is an inverse relationship between the time of a starting reaction and the time of obtaining the maximum pressure of a front leg ($r = -0.84$; $p < 0.05$).

Table 5 presents a matrix of correlation coefficients between the component factors of a crouch start and the starting velocity with which the runner is leaving the starting block.

Table 5. Matrix of correlation coefficients between the component factors and the starting velocity

Parameter	Gender	Parameters				
		RT	RT IAAF	P1	P2	L
Initial velocity, V_0	Woman	–0.41	–0.53	–0.80	–0.87*	–0.63
	Man	0.27	0.21	0.23	0.00	0.11

* Correlation is significant at the 0.05 level.

Taking into account women, there is an opposite strong relationship between the starting velocity and the time of obtaining the maximum pressure of a front leg ($r = -0.87$; $p < 0.05$) in the way that: the longer the time is, the smaller the starting velocity is. There were not any relationships between the components of a crouch start and starting velocity when taking into account men.

Table 6 presents relationships between the time of a 30 m race and other significant parameters of a sprint race such as: the time of a starting reaction, the time of leaving the starting block, the time of 30 m race excluding the component of a crouch start and the time of a 100 m race.

Table 6. Relationships between the time of a 30 m race and other significant parameters of 100 m race

Parameter	Gender	Parameters				
		RT IAAF	L	V_0	Δt_{30m}	t_{100m}
30 m race, t_{30m}	Woman	0.26	0.23	–0.22	0.55	0.76**
	Man	0.50	0.65	0.05	0.49	0.73*

* Correlation is significant at the 0.05 level; ** Correlation is significant at the 0.005 level.

The only statistically significant relationships were between the time of a 30 m race and the time of a 100 m race: taking into account women they were very strong ($r = 0.76$; $p < 0.005$) and taking into account men they were a bit lower ($r = 0.73$; $p < 0.05$).

Discussion

The analysis of kinematic parameters concerns the best runners in Poland (in relay races – 4 × 100 metres – one of the best in the World) which proves the time parameters of 30 m and 100 m races. The time of 100 m race among the female participants was on average 11.63 ±0.20 with the split times on the 30th m distance 4.33 ±0.07 while male participants 10.39 ±0.12 i 3.99 ±0.07 s. The starting velocity and the time of individual activities in the starting block were identified correctly thanks to the use of a technical solution that required indirect coupling of a false start apparatus with the laser distance measuring module. During sports competition it is only possible to have the parameters of the time reaction according to IAAF Rules and the final result. A decomposition into prime factors of all phases, which are done by a runner during the crouch start, gives the complexity of this phenomenon and this fact was supported by the research results that are not homogenous for all the runners. The results obtained by Polish runners are in accordance with the literature, however it is worth remembering that in literature so called "total block time" does not include the time of a starting reaction and, as a result this value, in the context of leaving the block during the sprint race, must be added.

The obtained mutual relationships between the kinematic factors during the crouch start meet the expectations due to the fact that the crouch start is a very complex activity, however it is done almost automatically by the human organism. The relationships among women were linear which means that the faster is the activity during the crouch start, the faster the next one is done. There is no such relationship among men and it may be caused by different conditions. There is a strange fact that among women it was not possible to find a simple strong relationship between the time of a simple reaction of leg's muscles on the acoustic signal and the time of a starting reaction according to applicable IAAF rules. Perhaps the sample size of the participants was too small, however it requires deeper analysis in the further phase due to the fact there may be some additional time reserves in this element.

There is a different strong relationship between the starting velocity and the time of obtaining the maximum pressure of a front leg: among women the study shows that the longer the time is, the bigger the starting velocity. This fact shows that the growth of the power factor has an important meaning which has a different course among men and in this case it is not significant. No relationships between 30 m race and the time of starting reaction, the time of leaving the starting block and the starting velocity can be a reason to think that there are many other factors that can have an influence on achieving a success. What is more a 100 m race is a much more complex process than it is supposed. According to the expectations the time of 100 m race is strongly correlated with the time of 30 m race.

It is very surprising that there is no significant relationship between 30 m race from the starting block and the time obtained by the runner for 30 m with so called "detachment of rear leg" from the ground (training standing start), because it is the measurement that is very often used in sports practice. However, there is no practical use of it in starting conditions.

Conclusions

1. The time of starting reaction for the top sprint runners is 165 ±33 ms for women and 171 ±18 ms for men. The time after which they leave the starting block after the starting shoot is respectively 790 ±88 ms and 737 ±77 ms. The highest correlation is between the time of the maximum peak force of the front leg with the time obtained for maximum peak force of the rear leg for female ($r = 0.99$; $p < 0.005$) and for male ($r = -0.97$; $p < 0.005$).

2. Velocity of leaving the starting block for women is 2.41 ±0.66 m/s. For men this value is on the level of 3.69 ±0.34 m/s.

3. There are no statistically significant relationships between the individual phases of the block start and the starting velocity. Only in case of women there was a relationship between the starting velocity and the time of obtaining the maximum peak force of the front leg ($r = -0.87$; $p < 0.05$).

4. There is no statistically important relationship between the time of 30 m race from the starting block and the time for 30 metres obtained by the runner so called "detachment of the rear leg" from the ground (training standing start).

5. The applied method of measurement is suitable for versatile estimation of kinematic parameters of a crouch start. All the studied parameters can be very carefully isolated. Additionally, the system is very developmental and allows cooperation with additional outer devices.

References

Bruggemann G., Glad B. Time analysis of the sprint events. Scientific Research Project at the Games of the XXXIV Olympiad Seoul 1988. IAAF, New Studies in Athletics. 1990; Supplement.

Bradshaw E., Maulder P., Keogh J. Biological movement variability during the sprint start: performance enhancement or hindrance? Sports Biomechanics. 2007; 6 (3): 246–260.

Coh M., Tomazin K., Štuhec S. The biomechanical model of the sprint start and block acceleration. Facta Universitatis Physical Education and Sport. 2006; 4 (2): 103–114.

Delecluse C., Coppenolle H., Diels R., Goris M. The F.A.S.T. project – A scientific follow – up of sprinting abilities. New Studies in Athletics. 1992; 11 (2–3): 141–143.

Henry F. Force-time characteristics of the sprint start. Research Quarterly. 1952; 23: 301–318.

Fortier S., Basset F., Mbourou G., Favérial J., Teasdale N. Starting Block Performance in Sprinters: A Statistical Method For Identifying Discriminative Parameters of the Performance and an Analysis of the Effect of Providing Feedback over a 6-Week Period. Journal of Sports Science and Medicine. 2005; 4: 134–143.

IAAF. Competition Rules 2012–2013. Monaco 2013.

Iskra J., Osik T., Walaszczyk A. Trening w biegach sprinterskich dla początkujących i zaawansowanych. ARF Media. Poznań 2002.

Maćkała K., Kowalski P. Trening w biegach krótkich – założenia teoretyczne i implikacje praktyczne. Wydawnictwo AWF. Wrocław 2007.

Mero A., Komi P. Reaction time and electromyography activity during a sprint start. European Journal of Applied Physiology. 1990; 61: 73–80.

Salo A., Bezodis I. Which starting style is faster in sprint running- standing or crouch start. Sports Biomechanics. 2004; 3 (1): 43–54.

Sozański H., Witczak T. Trening szybkości. Sport i Turystyka. Warszawa 1981.

Tellez T., Doolittle D. Sprinting from start to finish. Track Technique. 1984; 88: 2802–2805.

Terczyński R. Rozkład prędkości w biegu na 100 metrów na różnym poziomie sportowym. Sport and Tourism in Modern Lifestyl. Monografie AWF Poznań. 2009: 393, 35–42.

Terczyński R. Dylematy startów i falstartów. Magazyn Lekkoatletyczny. Lama Production. Warszawa 2010; 1: 36–38.

Turk-Noack U., Schmalz T. Field trial of the LAVEG laser diode system for kinematic analysis in various kinds of sports. Paper presented at Biomechanics in Sports XII: Proceedings of the 12th International Symposium on Biomechanics in Sports. Budapest 1994.

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