The pacing and tempo of running in the analysis of the performances of the top hurdlers at the olympic games in paris

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Dr. Hab., Associate Professor **A.L. Ogandzhanov**[1]
PhD **G.V. Samoylov**[2]
PhD, Associate Professor **M.B. Salamatov**[3]
PhD, Associate Professor **A.V. Larin**[3]
[1]Moscow City University, Moscow
[2]Victoria Sports School, Moscow Region
[3]The Russian University of Sport «GTSOLIFK», Moscow

Corresponding author: Oga2106@mail.ru

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Abstract

Objective of the study was to pinpoint the crucial kinematic metrics that contribute to the success of the world's top male hurdlers in the 110-meter hurdles, we conducted a thorough examination of their performances at the Olympic Games in Paris.

Methods and structure of the study. The examination of official documents, the study of video recordings of elite hurdlers in competition, and the application of statistical techniques are conducted.

Research results and conclusions. It has been discovered that in modern men's short-distance hurdling, the runners maintain a rapid pace between obstacles, often exceeding the speed of highly skilled sprinters. The limited space between hurdles and the high hurdles force athletes to rely on speed, rather than distance, to achieve success. The running technique of the Olympic champion G. Holloway (USA) is characterized by the efficient execution of motor actions, particularly in terms of technical aspects at the hurdle distance. As the distance and competitive result increase, the athlete's pace of steps accelerates, and the speed of the hurdle step also increases. In these circumstances, the hurdle step appears to be a running step executed with a greater amplitude and a higher trajectory compared to a regular running step, while the entire distance appears to be covered in a single motion.

Keywords: *hurdles, biomechanical analysis, competitive activity, rhythm-tempo structure.*

Introduction. In the 110 m hurdles, the determining factors for success are the hurdlers' ability to quickly overcome obstacles, maintain a high pace of running movements between hurdles, and the ability to maintain a stable rhythm of movements at all sections of the distance without slowing down due to fatigue [1-3]. In men's 110 m hurdles, the clear favorite in recent years has been the long-term leader of the world ranking, American G. Holloway (12,86 s at the 2024 US Olympic selection). The best places in the final were claimed by the winners of the US Olympic selection F. Kritenden (12,93 s), D. Robertson (12,96 s), and the European champion, Italian L. Simonelli (13,05 s). High results before the Olympic Games were also shown by O. Bennett from Jamaica (13,09 s), Japanese R. Muratake (13,07 s) and S. Izumya (13,10 s), Spaniard E. Lyopis (13,10 s), and Jamaican champion R. Broadbell (13,09 s).

Objective of the study was to pinpoint the crucial kinematic metrics that contribute to the success of the world's top male hurdlers in the 110-meter hurdles, we conducted a thorough examination of their performances at the Olympic Games in Paris.

Methods and structure of the study. An analysis of documentary materials was carried out 1,2, video analysis of the competitive activity of the world's leading hurdlers using the Dartfish software, methods of mathematical statistics.

Results of the study and discussion. In the course of the video analysis of the competitive activity of hurdlers in the semi-final and final races of the 2024 Olympic competitions in the 110 m hurdles, we identified the main factors influencing the efficiency of the hurdlers' actions, as well as the degree of their

[1] Available at: https://en.wikipedia.org/wiki/Athletics_at_the_2024_Summer_Olympics.
2_Available at: https://worldathletics.org/.

Table 1. Average inter-hurdle step tempo and hurdle step time of athletes participating in the 2024 Paris Olympic Games in the semi-final and final races

№	Athlete	Country	Stage	Temp	$T_{Bar.step}$	BRS	SR	SR-BSR
				S/s	A	A	A	A
1	G. Holloway	USA	Final	5,28+0,24	0,43+0,03	12,86	12,99	0,13
			s/final	5,35+0,26	0,44+0,02	12,86	12,98	0,12
2	D. Roberts	USA	Final	5,16+0,14	0,45+0,1	12,96	13,09	0,13
			s/final	5,33+0,40	0,47+0,1	12,96	13,10	0,14
3	R. Broadbell	Jamaica	Final	5,25+0,15	0,45+0,1	13,09	13,09	0,00
			s/final	5,09+0,35	0,45+0,1	13,09	13,21	0,12
4	E. Lyopis	Spain	Final	4,92+0,16	0,42+0,02	13,09	13,20	0,11
			s/final	5,02+0,42	0,44+0,01	13,09	13,17	0,08
5	R. Muratake	Japan	Final	5,52+0,15	0,48+0,01	13,07	13,21	0,14
			s/final	5,37+0,41	0,49+0,02	13,07	13,26	0,19
6	F. Critenden	USA	Final	5,43+0,08	0,48+0,02	12,93	13,32	0,39
			s/final	5,15+0,22	0,46+0,01	12,93	13,23	0,30
7	O. Bennett	Jamaica	Final	5,22+0,15	0,46+0,01	13,09	13,34	0,25
			s/final	5,29+0,32	0,46+0,02	13,09	13,09	0,00
8	H. Parchment	Jamaica	Final	5,26+0,16	0,46+0,02	13,18	13,39	0,21
			s/final	5,14+0,41	0,45+0,01	13,18	13,19	0,01

Note: BRS – best result of the season; CR – competition result; Tbar.step – time of the hurdle step.

influence on the final competitive result. For this purpose, the following were determined: the frequency of steps on each inter-hurdle segment and the time of performing a hurdle step on each obstacle. The time of performing a hurdle step (the time interval from the moment the foot is placed on the support during the push-off to the moment it touches the track during the landing after the hurdle) is largely determined by the time it takes to overcome the obstacle. At the same time, it is interpreted as a running step performed over the obstacle, which corresponds to the target tasks of hurdle running: "to overcome obstacles with a running step, not a jump" [2]. In the table. 1 shows the average hurdle step tempo and hurdle step execution time of the participants in the semi-finals and finals of the Paris Olympic Games in the 110 m hurdles.

Video analysis of competitive activity of hurdlers showed that changing the rhythm of steps in hurdling

Table 2. Statistical relationship indicators for the tempo of inter-hurdle steps, time of hurdle step and time to overcome inter-hurdle blocks among the finalists of the 2024 Olympic Games.

№	Athlete	Country	Stage	Correlation relationship indicators		
				$Temp/T_{bar.step}$	$T_{Bar.step}/T_{block}$	$T_{block}/Temp$
1	G. Holloway	USA	Final	**-0,635**	**0,888**	**-0,917**
			s/final	**-0,613**	**0,859**	**-0,919**
2	D. Roberts	USA	Final	-0,306	**0,761**	**-0,827**
			s/final	0,306	0,370	**-0,761**
3	R. Broadbell	Jamaica	Final	-0,005	**0,621**	**-0,779**
			s/final	0,015	**0,743**	**-0,633**
4	E. Lyopis	Spain	Final	0,410	**0,648**	-0,420
			s/final	-0,318	**0,628**	**-0,930**
5	R. Muratake	Japan	Final	-0,522	**0,872**	**-0,854**
			s/final	0,507	0,418	-0,564
6	F. Critenden	USA	Final	-0,328	**0,913**	**-0,648**
			s/final	-0,064	**0,667**	**-0,763**
7	O. Bennett	Jamaica	Final	-0,476	**0,771**	**-0,910**
			s/final	-0,230	**0,813**	**-0,731**
8	H. Parchment	Jamaica	Final	-0,351	**0,697**	**-0,901**
			s/final	-0,265	**0,617**	**-0,912**

Note: Tbar.step – time to complete a barrier step; Tblock – time to overcome a barrier block.

Table 3. Time on individual sections of the distance for athletes participating in the 2024 Olympic Games in the semi-final and final races in the 110 m hurdles

№	Athlete	Country	Stage	1st barrier	2-5 bar. block	6-10 bar. block	Difference	Finish	CR
				A	A	A	A	A	A
1	G. Holloway	USA	Final	2,46	3,89	4,16	0,27	1,47	12,99
			s/final	2,50	3,89	4,17	0,28	1,45	12,98
2	D. Roberts	USA	Final	2,49	4,08	4,11	0,03	1,36	13,09
			s/final	2,51	4,02	4,12	0,10	1,40	13,10
3	R. Broadbell	Jamaica	Final	2,59	4,04	4,08	0,04	1,34	13,09
			s/final	2,60	4,10	4,10	0,00	1,38	13,21
4	E. Lyopis	Spain	Final	2,58	4,04	4,15	0,11	1,38	13,20
			s/final	2,58	4,02	4,12	0,10	1,40	13,17
5	R. Muratake	Japan	Final	2,61	4,05	4,14	0,11	1,36	13,21
			s/final	2,61	4,10	4,15	0,05	1,36	13,26
6	F. Critenden	USA	Final	2,62	4,10	4,16	0,06	1,38	13,32
			s/final	2,60	4,09	4,13	0,04	1,37	13,23
7	O. Bennett	Jamaica	Final	2,57	4,08	4,19	0,07	1,45	13,34
			s/final	2,53	3,98	4,14	0,16	1,39	13,09
8	H. Parchment	Jamaica	Final	2,63	4,10	4,16	0,06	1,44	13,39
			s/final	2,60	4,00	4,12	0,12	1,43	13,19

significantly affects the final sports result. It would be logical to assume that as the speed of overcoming the hurdle blocks increases, the time of performing steps between the hurdles should decrease in parallel (i.e., the step tempo should increase) and, in parallel with this, the time of overcoming the obstacle should decrease (i.e., the hurdle step time should decrease). This should be expressed in the form of a direct statistical relationship between all three characteristics. But in practice, this is not achieved by all athletes, but only by the Olympic winner G. Holloway (USA), whose indicators show the indicated reliable relationships (Table 2). High statistical relationship between the time of overcoming the inter-hurdle block with the tempo of inter-hurdle steps ($r = -0,919–0,917$, $p < 0,001$) and the time of performing the hurdle step ($r = 0,859–0,888$, $p < 0,01$) in both races. An obvious statistical relationship was also found between the step tempo and the hurdle step time ($r=-0,613–-0,635$, $p<0,05$). That is, with the increase in the distance speed, the athlete's step tempo increases and the speed of the hurdle step execution increases. Under these conditions, the hurdle step is perceived as one of the running steps, executed with a greater amplitude and along a higher trajectory, and visually the entire run is perceived as a single step.

The Olympic champion's running is appropriate and logical in terms of solving technical problems from start to finish. Other athletes lack such integrity and stability of technique. The only downside to G. Holloway's running is a slight drop in speed in the second half of the distance. The athlete covered the first four inter-hurdle blocks in the semi-finals and finals in 3,89 sec, the last four blocks in 4,16 sec and 4,17 sec, respectively, i.e. the time loss was 0,27-0,28 sec. This is undoubtedly the reserve of an athlete who is already potentially ready to set a new world record at this distance. In general, the running of most finalists can be characterized as follows: as the speed increases and the time to overcome the inter-hurdle blocks decreases, athletes primarily increase the pace of steps between the hurdles. This is clearly demonstrated by the running of 6 out of 8 finalists, for whom the level of correlation in relation to the pace of steps in the best runs exceeds 0,8 ($p < 0,05$). There are far fewer athletes who, as the speed of hurdling increases, reliably improve the time of execution of the hurdle step. Olympic champion G. Holloway, despite the high frequency of running steps between the hurdles, demonstrates running movements with a large amplitude and active interaction with the support. This is what allows him to maintain a purely running character of movements over most of the distance (Table 3).

Conclusions. 1. Modern men's hurdling at a short hurdle distance is characterized by a high tempo of running steps between obstacles, which among leading athletes reaches 5,3-5,5 steps per second. It is very important that with such a high tempo of steps

between obstacles, the run retains its integrity and naturalness, as well as the amplitude necessary for more active interaction with the support and reduction of vertical oscillations of the athlete's CM.

2. High-level athletes, finalists of the 2024 Olympic Games, have the best sports result faster than 13,10 s, the average time of the hurdle step from 0,46±0,02 s, the average pace of steps between the hurdles is 5,24±0,16 steps/s. The electronic time of overcoming the first hurdle varies from 2,46 to 2,61 s. The time of overcoming the inter-hurdle blocks 2-5 is from 3,89 to 4,10 s, the time of overcoming the inter-hurdle sections of blocks 5-9 is from 4,10 to 4,17 s. The time of the finishing section varies from 1,36 to 1,47 s.

3. The run of the Olympic champion G. Holloway (USA) from the beginning to the end of the hurdles distance is appropriate and logical from the point of view of solving technical problems. With the growth of the distance speed and competitive result, the athlete's step rate increases and the speed of the hurdle step increases. Under these conditions, the hurdle step is perceived as one of the running steps, performed with a greater amplitude and along a higher trajectory than the running step, while the entire run along the distance is visually perceived as a single step.

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