The pace and tempo of running in the analysis of the performances of the top hurdlers at the Olympic games in Paris

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Abstract

Objective of the study was to pinpoint the key kinematic features that contribute to the success of the world's top male hurdlers in the 110m hurdles race, we conducted a thorough examination of the performances at the Paris Olympics.

Methods and structure of the study. The examination of official records, the study of video footage of elite hurdlers in competition, and the application of statistical techniques are all part of the process.

Results and conclusions. It has been discovered that in modern men's short-distance hurdling, the athletes run at a rapid pace between the hurdles, with some of the top athletes even reaching a pace that is faster than that of highly skilled sprinters, reaching up to 5.3-5.5 steps per second. The limited distance between the hurdles and the high height of the hurdles force the athletes to achieve speed primarily through their pace of running steps, rather than through their length. The running style of the Olympic champion G. Holloway (USA) is characterized by the efficiency of his motor actions in terms of technical execution at the hurdle distance. As the athlete increases their speed and improves their competitive result, their pace of running steps also increases, resulting in a faster barrier step. In these circumstances, the athlete's barrier step is perceived as a running step performed with a greater amplitude and a higher trajectory than a regular running step, while the entire distance is visually perceived as a single continuous movement.

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). Other high results before the Olympic Games were 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 key kinematic features that contribute to the success of the world's top male hurdlers in the 110m hurdles race, we conducted a thorough examination of the performances at the Paris Olympics.

Methods and structure of the study. An analysis of documentary materials was conducted[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 activ-

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

Table 1. Average 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	Tempo	$T_{bar.step}$	BRS	CR	CR- BRS
				s/s	S	S	S	S
1	G. Holloway	USA	Final	5,28+0,24	0,43+0,03	12,86	12,99	0,13
			semi-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
			semi-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
			semi-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
			semi-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
			semi-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
			semi-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
			semi-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
			semi-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.

ity 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 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:

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**
			semi-final	**-0,613**	**0,859**	**-0,919**
2	D. Roberts	USA	Final	-0,306	**0,761**	**-0,827**
			semi-final	0,306	0,370	**-0,761**
3	R. Broadbell	Jamaica	Final	-0,005	**0,621**	**-0,779**
			semi-final	0,015	**0,743**	**-0,633**
4	E. Lyopis	Spain	Final	0,410	**0,648**	-0,420
			semi-final	-0,318	**0,628**	**-0,930**
5	R. Muratake	Japan	Final	-0,522	**0,872**	**-0,854**
			semi-final	0,507	0,418	-0,564
6	F. Critenden	USA	Final	-0,328	**0,913**	**-0,648**
			semi-final	-0,064	**0,667**	**-0,763**
7	O. Bennett	Jamaica	Final	-0,476	**0,771**	**-0,910**
			semi-final	-0,230	**0,813**	**-0,731**
8	H. Parchment	Jamaica	Final	-0,351	**0,697**	**-0,901**
			semi-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 barrier block	6-10 barrier block	Difference	Finish	CR
				S	S	S	S	S	S
1	G. Holloway	USA	Final	2,46	3,89	4,16	0,27	1,47	12,99
			semi-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
			semi-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
			semi-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
			semi-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
			semi-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
			semi-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
			semi-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
			semi-final	2,60	4,00	4,12	0,12	1,43	13,19

"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 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 short-distance hurdling 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 running 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 a best sports result faster than 13,10 s, the average time to complete a hurdle step from 0,46±0,02 s, the average tempo of steps between obstacles is 5,24±0,16 steps/s. The electronic time to overcome the first hurdle varies from 2,46 to 2,61 s. The time to overcome inter-hurdle blocks 2-5 is from 3,89 to 4,10 s, the time to overcome inter-hurdle sections of blocks 5-9 is from 4,10 to 4,17 s. The time of the finishing section fluctuates 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 hurdle race 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 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, 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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