STUDY ON THE COMPLEX FACTORS INFLUENCING THE MEN'S 110 M HURDLES DISCIPLINE

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ABSTRACT
Among all disciplines in the athletics program, the men's 110 m hurdles stand out as a discipline that demands peak performance in speed and strength, along with a running rhythm and technique for overcoming hurdles. A primary factor affecting the training process is the complex nature of sports performance, including acceleration, maximal hurdle speed, and specialised speed endurance, and how these elements are expressed across the competitive distance. To gain a more comprehensive understanding of the manifestations of individual factors in sports achievement, we aim to analyse the changes in speed during different segments of the racing distance and how they relate to one another. A total of 39 individuals were studied, all of whom are participating in the Paris 2024 Olympic Games. For the study's purposes, we analyse the time taken to complete each segment of the race distance (each separate interval) using the official data provided by the Olympic Committee. We applied variation, correlation, and frequency analysis for the study's needs. The outcomes were assessed based on the level of sporting achievement and the stage of competition at which they occurred. Respondents' average sports result is 13.45 seconds, with a range of 12.98 to 14.13 seconds. This reflects the high level of sports qualifications among the subjects studied. Analysing the changes in running speed indicates that the factors impacting sports performance have varying levels of influence on the outcome. The most significant factor is special (hurdle) endurance. During the initial acceleration, we observe superior individual characteristics. The maximal hurdle speed is reached between the third and fifth hurdles, and also has individual characteristics.

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INTRODUCTION

Athletics encompasses a wide range of disciplines that showcase motor qualities more fully than other sports. The central event is the short hurdle sprint, considered one of the most technically demanding disciplines, which requires the speed of an elite sprinter and the strength of a thrower.

Over the years, numerous studies have been conducted in biomechanics, examining hurdle stride and running speed independently to optimise training and enhance sports performance. (Amara et al., 2019; Amo et al., 2018; Čoh, 2012; Iwasaki et al., 2022; López, 2011; Park et al., 2011; Tsiokanos et al., 2018)

Several studies have examined various biomechanical and kinematic factors influencing 110-metre hurdles performance. Iwasaki et al. (2022) investigated the kinematic elements related to hitting the first hurdle during the race's initial phase. They proposed a predictive model of touchdown times for elite hurdlers averaging 13.65 seconds. Similarly, Amo et al. (2018) analysed the running phase from the start to the first hurdle using data from the IAAF World Championships in Beijing 2015. Park et al. (2011) carried out a kinematic analysis of the hurdle clearance technique based on performances from the 2011 World Championships in Daegu, while Lopez et al. (2011) provided a biomechanical and functional assessment of former world record holder Dayron Robles. Mansour et al. (2024) focused on efficiency factors in hurdle clearance techniques, and one of the early contributors in this field, M. Coh, offered foundational insights into hurdle clearance mechanics (Coh & Iskra, 2012). Amara et al. (2019) identified key kinetic and kinematic factors affecting 110-metre hurdles performance, and Tsiokanos et al. (2018) proposed a race pattern model based on time analysis of Olympic-level performances.

Aim and Objectives

The primary aim of this study is to examine the variation in speed across the race distance of elite

110 m hurdlers. As a secondary aim, we will explore the changing influence of complex factors (acceleration, maximal speed, and speed endurance) in top-level athletes.

Based on our objective, we aim to quantify the velocity profile and identify the peak speed and its location over the race distance. For the study, we will also relate segment speed to total race time. The study will measure acceleration, maximum speed, and speed endurance.

METHODOLOGY

The study included 39 athletes, who registered 89 results across the various phases of the competition – Round 1, Repechage, Semi-final, and Final. All of these athletes participated in the 2024 Paris Olympic Games. Thirteen athletes have three registered results, twenty-four hurdlers have two results, and only two participants in the Olympic tournament have just one registered official result. The respondent group represents the contemporary world elite in the studied discipline.

Our study is based on official data from the Paris 2024 Olympic Games, provided by the Olympic Committee, and all data were measured using the Omega timing system. The time splits/laps for different race segments were calculated using the Real Time Tracking System (RTTS) – Figure 1 (IOC, 2024). The RTTS system measures approximately 2,000 data points per athlete per second during the race, including instantaneous speed, position, acceleration, and other metrics. In hurdle running, split/lap times are measured on touchdowns after clearing the hurdle (Omega, 2024). Based on experience, this approach is more reliable for both scientific analysis and practical use in sports.

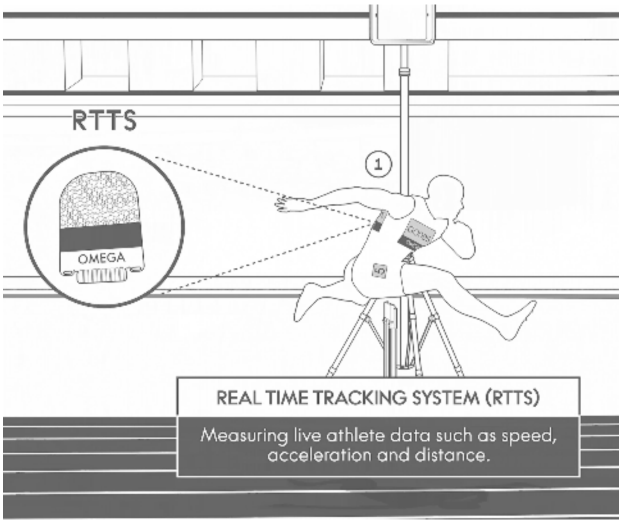

Figure 1. *Omega Real-Time Tracking System (RTTS) measures split and lap times during the Olympic Games in Paris 2024.*

For the study, we analyse each of the 89 results, split/lap times, and divide the competition distance into different segments – starting reaction, start to first hurdle clearance, first to second hurdle clearance, etc., up to the tenth hurdle and final. For data processing, we utilised Microsoft Excel and IBM SPSS 27. We employed these tools to conduct descriptive statistics and correlation analysis.

RESULTS

The average across all 89 studied cases is 13.45 seconds, with a range of 12.98 to 14.13 seconds. We observe a normal distribution of sports results, as indicated by the asymmetry and excess coefficients. (see Table 1).

From the values, we can infer that elite contemporary hurdlers are included in this study.

Table 1. *Studied cases' descriptive statistics*

	N	Range (R)	Min.	Max.	*Mean*	*SD*	Coeff. of variation (CV%)	Skewness	Kurtosis
Sport result (SR) in all studied cases – sec.	89	1.15	12.98	14.13	13.45	0.22	1.66%	0.398	0.544

Table 2 presents descriptive statistics for all split times, providing vital information on the time required to clear different parts of the race. The most significant differences are found in the start reaction and the time needed to reach the first, second, and third hurdles. This part of the race is influenced by the acceleration phase, during which hurdlers adopt different approaches based on their running rhythm, technique, and speed-strength. Based on Skewness and Kurtosis, we conclude that the split times follow a normal distribution.

Table 2. *Descriptive statistics for split times in the 110 m hurdles event*

Descriptive Statistics – Split (sec.)	*N*	Range (R)	Min.	Max.	*Mean*	*SD*	Coeff. of variation (CV%)	Skewness	Kurtosis
Start reaction	89	0.099	0.104	0.203	0.153	0.017	11.10	0.41	1.52
Hurdle 1 (split)	89	0.23	2.29	2.52	2.41	0.05	2.18	-0.15	-0.63
Hurdle 2 (split)	89	0.30	3.32	3.62	3.49	0.07	1.88	-0.42	0.04
Hurdle 3 (split)	89	0.40	4.29	4.69	4.53	0.08	1.70	-0.75	1.09
Hurdle 4 (split)	89	0.46	5.27	5.73	5.55	0.09	1.60	-0.90	1.46
Hurdle 5 (split)	89	0.56	6.24	6.80	6.58	0.10	1.58	-0.90	1.80
Hurdle 6 (split)	89	0.68	7.22	7.90	7.60	0.12	1.57	-0.77	1.76
Hurdle 7 (split)	89	0.79	8.22	9.01	8.64	0.14	1.57	-0.66	1.80
Hurdle 8 (split)	89	0.84	9.24	10.08	9.69	0.15	1.55	-0.55	1.39
Hurdle 9 (split)	89	0.90	10.29	11.19	10.76	0.17	1.55	-0.30	0.86
Hurdle 10 (split)	89	0.92	11.37	12.29	11.84	0.18	1.55	-0.11	0.35
Sport result (110 m)	89	1.15	12.98	14.13	13.45	0.22	1.66	0.40	0.54

For a detailed analysis, we must use lap times. Based on them, we can calculate the speed for each part of the race.

Table 3. *Statistics describing sports results, lap times.*

Descriptive Statistics – Lap (sec.)	*N*	Range (R)	Min.	Max.	*Mean*	*SD*
Start reaction	89	0.099	0.104	0.203	0.153	0.017
Hurdle 1 (lap)	89	0.23	2.29	2.52	2.41	0.05
Hurdles 1-2 (lap)	89	0.11	1.01	1.12	1.08	0.02
Hurdle 2-3 (lap)	89	0.12	0.97	1.09	1.04	0.02
Hurdle 3-4 (lap)	89	0.10	0.97	1.07	1.02	0.02
Hurdle 4-5 (lap)	89	0.11	0.96	1.07	1.02	0.02
Hurdle 5-6 (lap)	89	0.12	0.98	1.10	1.03	0.02
Hurdle 6-7 (lap)	89	0.12	0.99	1.11	1.04	0.02
Hurdle 7-8 (lap)	89	0.11	1.00	1.11	1.05	0.02
Hurdle 8-9 (lap)	89	0.13	1.02	1.15	1.06	0.03
Hurdle 9-10 (lap)	89	0.13	1.03	1.16	1.08	0.03
Hurdle 10-Final (lap)	89	0.43	1.52	1.95	1.61	0.06
Sport result (110 m)	89	1.15	12.98	14.13	13.45	0.22

In Figure 2, we present the average times to clear the different parts of the race. Keep in mind that these values must be used as a reference for hurdlers with a similar level of sports qualification.

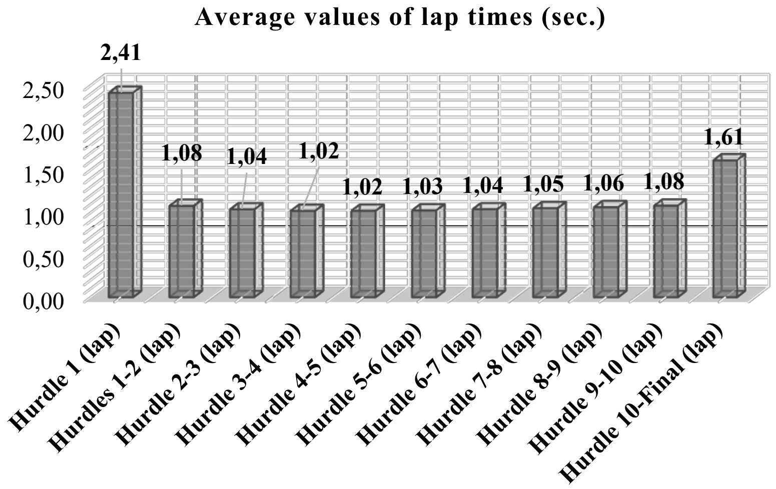

Figure 2. *Average values of lap times*

Using the data from Figure 3, we calculated the average speed (m/s) for clearing each part of the competition distance. Based on this, we can define the influence of the acceleration phase (from start to the third or fourth hurdle), maximal speed (between the fourth and sixth hurdle), and endurance from the seventh hurdle to the final line.

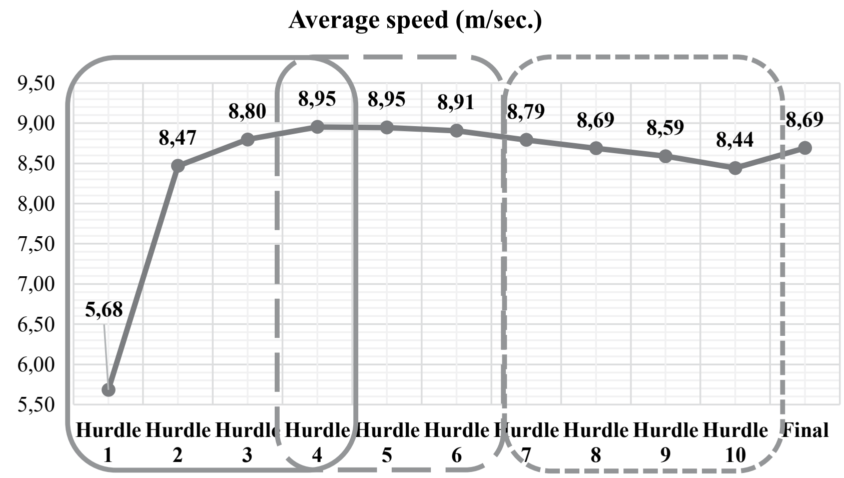

Figure 3. *Average speed (m/sec.)*

To better understand different race segments and their relationships, we present the correlation matrix in Table 4. From this, we can infer that the start reaction, clearing the first hurdle, and the distance between the first and second hurdles function as a single unit because of the high correlation between these parts. From a sports perspective, this section is crucial for establishing the proper running rhythm, a prerequisite for good performance throughout the rest of the race. To better understand the interrelation between lap and sport results, we removed data that did not correlate at a significant level.

In generalising the interrelationships between the individual parts of the racing distance, we can deduce that each part correlates significantly with the intermediate distances before and after it.

Table 4. *Correlation matrix presenting different competition relations*

	Start reaction	Hurdle 1 (lap)	Hurdles 1-2 (lap)	Hurdle 2-3 (lap)	Hurdle 3-4 (lap)	Hurdle 4-5 (lap)	Hurdle 5-6 (lap)	Hurdle 6-7 (lap)	Hurdle 7-8 (lap)	Hurdle 8-9 (lap)	Hurdle 9-10 (lap)	Hurdle 10-Final (lap)	Sport result (110 m)
Start reaction	1												
Hurdle 1 (lap)	.537**	1											
Hurdles 1-2 (lap)	.320**	.562**	1										
Hurdle 2-3 (lap)	.179	.274**	.719**	1									
Hurdle 3-4 (lap)	.113	.311**	.578**	.656**	1								
Hurdle 4-5 (lap)	.181	.323**	.648**	.759**	.748**	1							
Hurdle 5-6 (lap)	.099	.221*	.599**	.657**	.689**	.826**	1						
Hurdle 6-7 (lap)	.069	.214*	.497**	.591**	.580**	.746**	.802**	1					
Hurdle 7-8 (lap)	.044	.212*	.387**	.477**	.374**	.540**	.654**	.759**	1				
Hurdle 8-9 (lap)	-.023	.253*	.349**	.358**	.303**	.451**	.574**	.657**	.797**	1			
Hurdle 9-10 (lap)	-.089	.069	.140	.197	.280**	.407**	.495**	.553**	.692**	.803**	1		
Hurdle 10-Final (lap)	-.144	.040	.135	.157	.156	.328**	.420**	.523**	.597**	.712**	.794**	1	
Sport result	.165	.484**	.646**	.637**	.625**	.776**	.803**	.829**	.812**	.823**	.737**	.708**	1

*Note: **. Correlation is significant at the .01 level (two-tailed); *p < .01. Correlation is significant at the 0.05 level (2-tailed).*

We are particularly interested in the relationship between the race result and each intermediate distance (lap times) – see Figure 4. Our analysis shows that the second part of the race (from the fifth to the sixth hurdle, and from the eighth to the ninth hurdle) has a stronger correlation with the final result.

The lower correlation observed between hurdles nine and ten can be explained by the fact that, from that point, the final effort begins, which involves controlling the opponent and preparing for the sprint after clearing the tenth hurdle. This differs from the biomechanics of running compared to the three-stride rhythm of the hurdles.

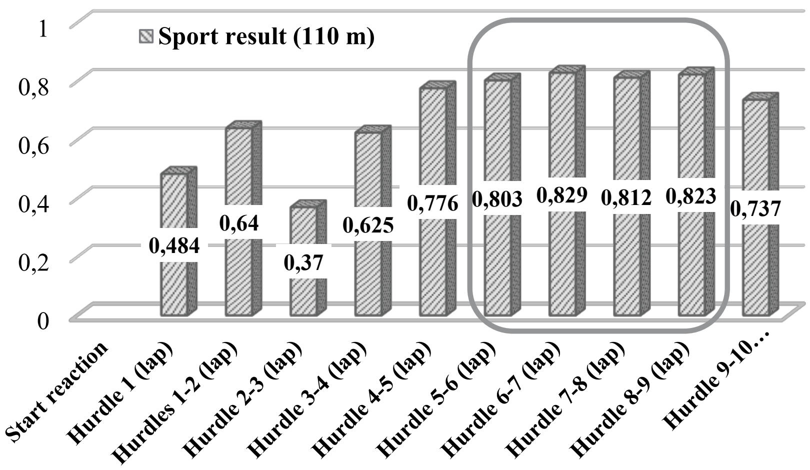

Figure 4. *Correlation between performance in 110 m hurdles and lap times*

DISCUSSION

The results presented above reveal the complexity of the 110m hurdles race. The importance of speed endurance between the hurdles is the key to elite performance. From a practical point of view, it will be helpful to compare these results with those of low to middle-level sport qualifications to identify differences in horizontal speed utilization.

Based on correlation, we can conclude that, at the highest level, performance is more strongly influenced by endurance in the later stages or by the ability to minimize horizontal speed loss during the second part of the race – a key difference between elite and middle-level athletes.

The lower correlation values between race segments for acceleration and maximum speed can be explained by greater individual performance variability. This is valid with full force for the missing correlation significance between the start reaction and the final result.

Research on the 110-m hurdles highlights the significance of both kinematic and kinetic factors throughout the race, especially during the start, hurdle clearance, and inter-hurdle stages. Amara et al. (2019) found that achieving optimal hurdle performance involves maintaining horizontal velocity and reducing braking forces at take-off and landing. Likewise, Iwasaki, Nunome, and Nozawa (2022) developed a predictive model that emphasizes the importance of touchdown times as indicators of race performance, showing that elite hurdlers maintain consistent step rhythms and experience minimal deceleration after each hurdle. The initial phase significantly impacts race results. Amo et al. (2018) noted that the acceleration pattern toward the first hurdle is crucial, as elite hurdlers have shorter contact times and higher stride frequency during the approach. Similarly, Tsiokanos et al. (2018) observed that faster hurdlers adopt a distinct race pattern marked by smooth transitions between hurdles and maintaining consistent timing.

CONCLUSION

In conclusion, we can observe that elite hurdlers possess a top level of speed endurance in hurdle running, which influences medal success. Maximal speed and acceleration abilities among world-class hurdlers, and how they demonstrate these in the early part of the race, reflect an individual approach.

Overall, the literature agrees that elite 110-m hurdlers combine powerful start dynamics, rhythmic inter-hurdle running, and biomechanically efficient clearance techniques. The integration of precise kinematic control and modern performance analytics continues to improve our understanding of what defines optimal hurdle performance.

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