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ORIGINAL ARTICLE

Temporal characteristics of 100-m hurdles performance based on race analysis–ranging 12–18 s

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ABSTRACT

The aim of this study was to clarify the characteristics of 100-m hurdles performance in female athletes, spanning from the world-record time to the 18-s range. Video data were randomly selected from internet broadcasts, covering race times from 12.12 s to 18.98 s, from international and national competitions held between 1987 and 2024. Time for each hurdle section from start to finish was measured, along with the total number of steps. Maximal running velocity occurred in the 4th and 5th hurdles (H4–5) for athletes at the world-class and national championship levels, similar to the finding for a 100-m sprint race around the 50-m mark. Conversely, athletes at the regional competition level tended to show maximal running velocities in the early sections of the race (H1–2 or H2–3), followed by a decrease in velocity. Across all groups, the ratio of running to hurdling time in the shortest interval section was consistently approximately 60%–40%. In the final section (H9–10), running time increased in the 17-s and 18-s groups. Sprinting ability and step count are crucial factors in determining race patterns. Athletes with more than 35 steps in total were limited to performances in the high 15-s range.

Keywords: Performance analysis, Female athletes, Competition level, Race pattern, Step count.

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INTRODUCTION

The 100-m hurdles is a short-distance track and field event involving 10 hurdles placed at 8.50-m intervals. This event is different from a sprint in that that it requires running between and clearing hurdles (Bissas et al.,2022; Healy et al., 2022; Jiménez et al., 2020).

In sprinting, achieving maximum running velocity (V_{max}) closer to the finish line effectively improves performance (Healy et al., 2022). Moreover, clear differences in track and field characteristics between skilled and unskilled athletes determine performance. Previous research has shown that athletes who achieve high sprint velocities combine a high step frequency with a long step length (Weyand et al.,1991).

In the 100-m hurdles, changes in running velocity and motion characteristics during a race have also been studied from a kinematic perspective (Ghareb et al., 2021; Hanley et al., 2021; Tsiokanos et al., 2017; Amara et al., 2019). A study on the relationship between hurdle interval distance and performance revealed that, for athletes with times between 12 s and the low 13-s range, increasing the hurdling distance to shorten the interval running distance and increase interval running velocity led to improved performance (McArdle et al., 1991). Another study was conducted to analyse the hurdling and running distances between each hurdle for athletes with times from 13.00 s to the high 14.50-s range. it revealed that athletes in the high 14-s range group showed a tendency for shortened hurdling distance in the latter half of the race and lengthened interval running distance, specifically showing a shorter landing distance after clearing a hurdle (Takahashi, 2010) In race analysis, numerous studies have focused on the time required for each section and the mean running velocity from start to finish (Ghareb et al., 2021; Hanley et al., 2021; Tsiokanos et al., 2017; Takahashi, 2010).World-class and national championship-level athletes have been reported to show high acceleration in the early part of the race and maintain high running velocity in the first half (i.e., the sixth hurdle, S-H6) (Hanley et al., 2021; Tsiokanos et al., 2017). Furthermore, V_{max} has been reported to occur between the 4th and 6th hurdles in a 12-s race (Tsiokanos, et al., 2017; Hücklekemkes., et al. 1990).

However, these studies have mainly focused on world-class and national championship-level athletes, and a fundamental comprehensive knowledge on the temporal characteristics of athletes across a wide range of race times remains lacking.

Therefore, the purpose of the present study was to examine the interval times of the women's 100-m hurdles and to clarify the characteristics of each hurdle section for across a wide range of competition levels.

MATERIALS AND METHODS

This study was conducted in accordance with previously reported methods (González-Frutos et al., 2020).

Data collection

Videos were obtained from publicly available internet platforms (YouTube, Google, LLC, United States). The extraction period targeted the 100-m hurdles held in international competitions hosted by World Athletics and domestic regional competitions certified by the Japan Association of Athletics Federations (JAAF) from 1987 to 2024. This study was approved by the Waseda University Ethics Review Committee on Research with Human Subjects for the 2024 academic year (2024-HN007).

Data selection criteria

Race data were selected to include times ranging from 12.12 to 18.98 s, with two races randomly extracted for each 0.1-s interval. As the world record (until 2024) is 12.12 s, only 17 races were extracted for the 12-s group. In total, 137 races were analysed. To avoid duplication, races involving the same athlete were excluded. Based on the analytical approach in a previous study, factors such as weather, competition level, and running lane, which can significantly affect performance, were not considered (Aoyama, 2011). The video extraction criteria required that each athlete completely crossed the finish line and excluded races where there was a clear deceleration of velocity before reaching the finish line.

Data processing

The video data were recorded at a frame rate of 30 Hz and analysed using video playback software (QuickTime for Windows 7.7.9, Apple Inc., United States). The athletes' official times were obtained from the official race records. All data analyses were conducted by a single person to ensure consistency.

Data classification

The target races were classified into seven groups, each with a 1-s increment based on race time (e.g., 12-s group, 13-s group). Although the 12-s group had a small sample size, this was determined not to affect the analysis, even when considering statistical variance between groups.

The start of the athlete's movement was defined as the first video frame, and both the number of steps and time taken to reach the 10th hurdle (H10) were recorded. Some race videos did not show flashes at the beginning. To standardize the analysis, the time from the start to H10 was calculated by adding the reaction time of 0.15 s to the time obtained from the video (measured from the start of movement) (Pain, 2007; Borysiuk et al., 2018).

Owing to the unstandardized camera angles of the videos, it was difficult to accurately extract the motion from H10 to the finish line. Therefore, the time from H10 to the finish line was derived from the difference with the official timing record, and the step count was excluded.

Definitions of 100-m hurdles and sections

Each race was divided into 11 sections: S–H1 (start to first hurdle), H1–2 through H9–10 (intervals between hurdles), and H10–G (10th hurdle to finish line).

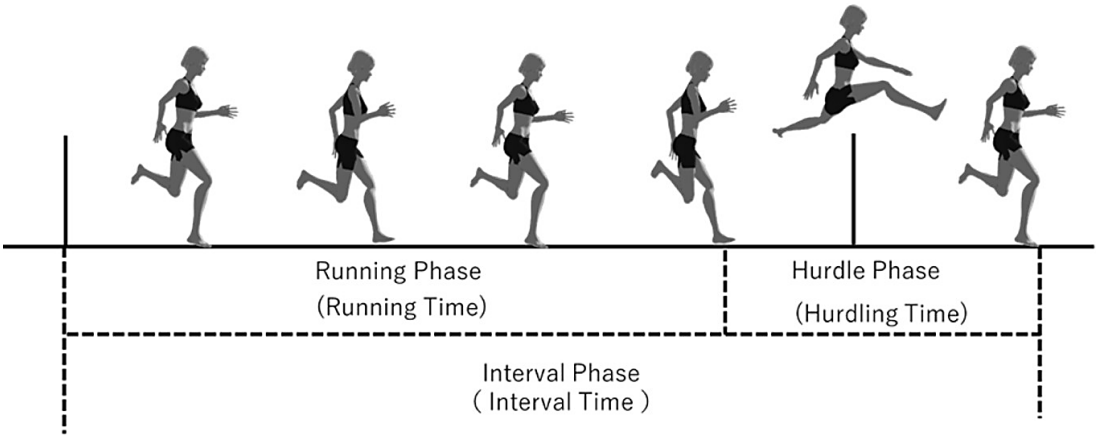

Figure 1. Definition of hurdle running phase of hurdle section.

The interval between hurdles was divided into two phases: the Running Phase, defined as the period from the landing of the lead leg immediately after hurdle clearance to the landing immediately before the next hurdle take-off; and the Hurdle Phase, defined as the period from the landing immediately before the hurdle take-off to the landing of the lead leg immediately after hurdle clearance. These two phases constitute the Interval Phase (Interval Time). (Figure 1)

Calculated variables

The number of steps in each section was counted, and corresponding values were calculated. The number of running steps was counted from the start to the landing of the lead leg at the 10th hurdle.

Statistical analysis

A one-way analysis of variance (ANOVA) was conducted to examine differences in race time, time of the shortest section for each group, and time of the final section (H9–10) between groups. For variables showing statistically significant differences, Bonferroni's multiple comparison test was performed to clarify the specific between-group differences. The significance level was set at 5% ($p < .05$). All statistical analyses were performed using the IBM SPSS Statistics software (version 29.0.2.0; IBM Corp., Armonk, NY, USA).

RESULTS

Group-specific race results

Table 1 shows the mean and standard deviation of race times and the number of steps up to the 10th hurdle for each group. Race times differed among the groups, with shorter times observed in the order of 12-s < 13-s < 14-s < 15-s < 16-s < 17-s < 18-s. The one-way ANOVA indicated a significant main effect of group on the mean race time (s) ($F (6, 130) = 1026.08$, $p < .001$). Subsequent Bonferroni post-hoc comparisons showed significant differences in race times among all groups ($p < .01$).

The number of steps showed an increasing trend from the 15-s group onwards, with the 16–18-s groups showing higher values, indicating that they ran with an increased number of steps. Significant differences in step count were observed across groups.

Table 1. Mean and the standard deviation of race time and step count for each group.

Groups	Race Time (s)	Step Number	n
12-s group	12.57 ± 0.25	35 ± 0	17
13-s group	13.50 ± 0.29	35 ± 0	20
14-s group	14.50 ± 0.29	35 ± 0	20
15-s group	15.49 ± 0.29	35 ± 1	20
16-s group	16.49 ± 0.29	39 ± 4	20
17-s group	17.48 ± 0.28	40 ± 4	20
18-s group	18.49 ± 0.29	47 ± 6	20

Group-specific sectional results

For the 12-s and 13-s groups, the interval time decreased until the middle of the race (H4–5). In contrast, for the 15-s and slower groups, the shortest interval time occurred early in the race (H1–2), after which it increased.

Time distribution in the shortest interval phase for each group

The average running time and its ratio to the hurdling time in the interval phase are shown. Fig 2A shows the average for the shortest section and Fig 2B shows the ratio. The time tended to increase from the 12-s to 18-

s group. The relative proportions of time were as follows: The relative proportions of time were 12-s group (running: 58.8%, hurdling: 41.2%), 13-s group (running: 58.6%, hurdling: 41.4%), 14-s group (running: 58.3%, hurdling: 41.7%), 15-s group (running: 57.4%, hurdling: 42.6%), 16-s group (running: 58.1%, hurdling: 41.9%), 17-s group (running: 57.0%, hurdling: 43.0%), and 18-s group (running: 57.9%, hurdling: 42.1%). No significant differences were observed between the seven groups.

Table 2. Mean and standard deviation for each section from start to finish for each group.

Interval	12-s	13-s	14-s	15-s	16-s	17-s	18-s
S-H1	2.57 ± 0.04	2.70 ± 0.04	2.78 ± 0.05	2.88 ± 0.07	2.97 ± 0.09	3.06 ± 0.09	3.11 ± 0.07
H1-2	1.02 ± 0.02	1.07 ± 0.03	1.14 ± 0.03	**1.20 ± 0.03**	**1.28 ± 0.04**	**1.33 ± 0.05**	**1.40 ± 0.07**
H2-3	0.98 ± 0.03	1.06 ± 0.03	**1.13 ± 0.03**	1.20 ± 0.03	1.29 ± 0.06	1.35 ± 0.04	1.43 ± 0.05
H3-4	0.97 ± 0.03	1.05 ± 0.03	1.13 ± 0.04	1.21 ± 0.03	1.30 ± 0.05	1.39 ± 0.05	1.50 ± 0.07
H4-5	**0.96 ± 0.03**	**1.04 ± 0.03**	1.13 ± 0.03	1.21 ± 0.03	1.31 ± 0.05	1.39 ± 0.05	1.54 ± 0.07
H5-6	0.97 ± 0.04	1.04 ± 0.03	1.13 ± 0.03	1.24 ± 0.04	1.33 ± 0.04	1.42 ± 0.04	1.55 ± 0.06
H6-7	0.98 ± 0.05	1.06 ± 0.03	1.16 ± 0.04	1.24 ± 0.04	1.34 ± 0.04	1.44 ± 0.06	1.57 ± 0.06
H7-8	0.98 ± 0.06	1.07 ± 0.03	1.17 ± 0.04	1.27 ± 0.04	1.36 ± 0.05	1.49 ± 0.06	1.58 ± 0.07
H8-9	0.99 ± 0.07	1.09 ± 0.03	1.19 ± 0.03	1.30 ± 0.06	1.40 ± 0.04	1.53 ± 0.09	1.58 ± 0.06
H9-10	1.02 ± 0.08	1.11 ± 0.02	1.22 ± 0.05	1.33 ± 0.05	1.44 ± 0.08	1.55 ± 0.07	1.62 ± 0.06
H10-G	1.09 ± 0.05	1.20 ± 0.04	1.31 ± 0.07	1.41 ± 0.06	1.52 ± 0.16	1.61 ± 0.21	1.61 ± 0.08

Note. The bold in the table represent the fastest interval time in all hurdle section for each group.

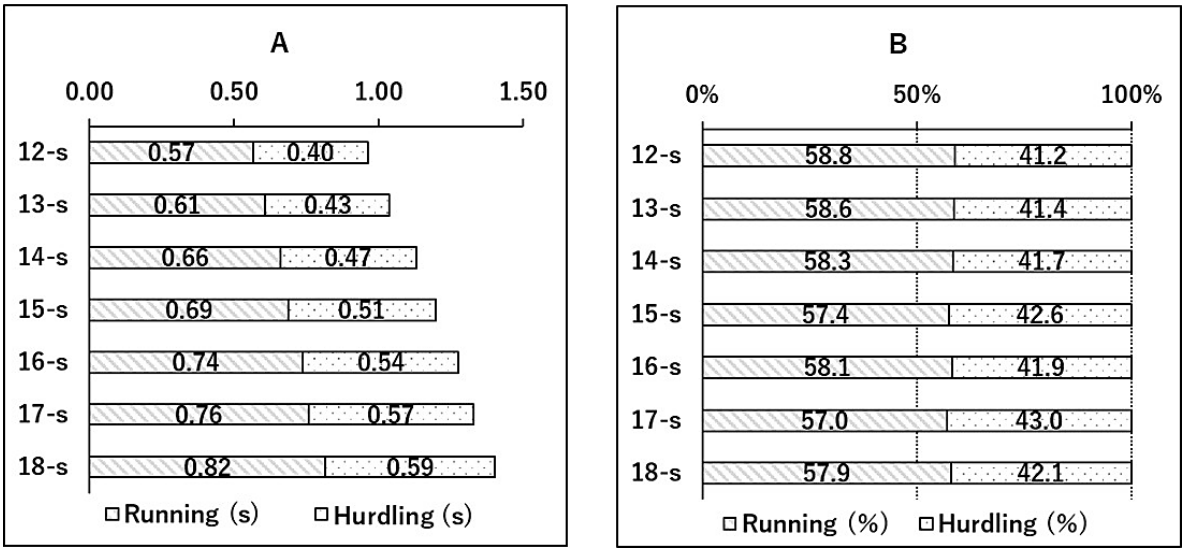

Figure 2. Running time and hurdling time in the shortest-time section.

DISCUSSION

Insights from time allocation in the shortest interval section

The ratio of running to hurdling time in the shortest interval section showed no significant differences among the seven groups, remaining consistently at approximately 60% for the running phase and 40% for the hurdling phase (Figure 2). This suggests that the ratio is a general characteristic of the 100-m hurdles interval. The ratio of running to hurdling distances is also a factor, showing a similar 60:40 distribution based on data from the 44th Spanish Indoor Championship and the 12th IAAF World Indoor Championship (2008) 60 m Hurdle events (González-Frutos et al., 2020).

These results clearly show that the time allocation ratio in the shortest interval phase of the 100-m hurdles is consistent, even when performance levels vary significantly from a world-class record to the 18-s range.

Relationship between competition level and race patterns

Analysing the race patterns of the 100-m hurdles in this study revealed that the shortest time for the 15–18-s group occurred in the H1–2 section (Table 2). This pattern is a fundamental characteristic of 100-m hurdle running (Tsiokanos et al., 2017). Specifically, acceleration from the start to each hurdle is important, and preventing subsequent increases in time is crucial (McArdle et al., 1991; Hücklekemkes, 1990). In contrast, for the 12- and 13-s groups, the shortest times were observed in the H4–5 section (38.5–47.0 m), consistent with previous findings (Tsiokanos et al., 2017; Hücklekemkes, 1990). The 14-s group showed an intermediate race pattern. One interpretation is that, while a time reduction occurred in the hurdle intervals as performance improved compared with the characteristics of the 15-s and slower groups, the 14-s group did not reach the race pattern of the 12- and 13-s groups. This suggests that this group can be considered to be in a transition from a hurdling-dominant race pattern to a sprint-dominant one.

Furthermore, the 12- and 13-s groups achieved their maximum velocity at approximately the same point as athletes in the women's 100-m sprint (Slawinski, et al., 2017). These groups also had a high ability to reach and maintain their highest velocity in the middle of the race. This is believed to be because their running and hurdling techniques are highly advanced, ensuring stability and speed maintenance(Hücklekemkes, 1990).

Relationship between step count and race time

Figure 3 shows the relationship between the total number of steps from the start to the 10th hurdle and the race time. In the 12–14-s groups, all athletes ran 35 steps. In contrast, in the 15-s group and slower, athletes individually chose to run the interval phase with only three steps or more, as the step count varied starting from a time of 15.72 s.

It is inferred that athletes with a total step count exceeding 35 steps up to the 10th hurdle can only achieve a performance in the high 15-s range. Based on these findings, further detailed research on the choice of step count and the location of its occurrence is necessary to determine the factors influencing this choice.

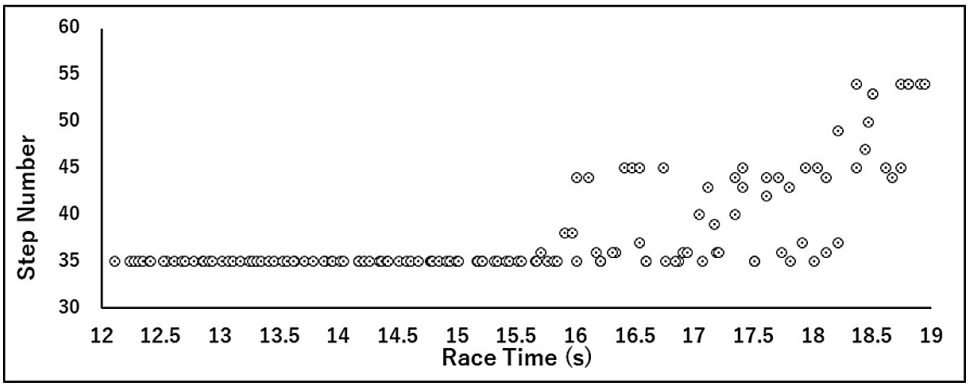

Figure 3. Trends in step number and race time.

CONCLUSIONS

This study was conducted to clarify the temporal characteristics of women's 100-m hurdles across a wide range of competition levels (12–18 s). The 12- and 13-s groups showed a high ability to maintain velocity,

while those in the 14-s group tended to decelerate. Among those with the shortest hurdle interval time, the 60%–40% ratio of running to hurdling time was consistent across groups, regardless of the competition level, suggesting that running ability is what differentiates the competition levels. The increase in step count observed in the 15-s and slower groups was associated with a decrease in interval running velocity, leading to inefficient running characteristics. Specifically, athletes with a total step count exceeding 35 steps were limited to a performance ceiling in the high 15-s range.

Overall, this study shows that, within the common framework of consistent running and hurdling time allocation, diverse race patterns unfold according to the competition level. Further investigations are required to examine factors contributing to the formation of these patterns and their relationship with training.

AUTHOR CONTRIBUTIONS

KK: conceptualization, methodology, data curation, formal analysis, writing – original draft preparation. KS: writing – reviewing and editing. IM: writing – reviewing and editing. SH: writing – reviewing and editing. GK: writing – reviewing and editing. YG: methodology, writing – reviewing and editing. SI: supervision, writing – reviewing and editing. All authors approved the final version of the manuscript.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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