

## INTRODUCTION

The 400 m hurdles race is a rhythmic sprinting event. Speed and speed endurance are basic requirements, but the ability to express these in a rhythmic pattern is more important. Then, race distribution and rhythmic structure are essential for a successful in this event (1). There have been numerous studies of the 400 m hurdles over the last few years. However, the 400 m hurdles race is an athletic discipline rarely subjected to official individual biomechanical study at World Championships or Olympic Games (2, 3, 4).

## RESULTS

Related to the stride patterns or rhythmic structures, uniformity is non-existent and most patterns are individual (one-person). Most of the athletes do not repeat stride patterns from one round to the next. This may be due to the use of different strategies according to the necessities of each race, or because the stride pattern is not yet assumed. And only one athlete of the finalists (Sydney McLaughlin) repeats rhythmic structure in the three races she disputed.

24 different rhythmic structures have been found in heats, 15 in the semi-finals (including 7 new ones) and 6 in the final (including 1 new one). Only one athlete of the finalists (Sydney McLaughlin) repeats rhythmic structure in the three races she disputed. Moreover, the athletes who ran the fewest steps in the total race achieved better results ( $R_{xy} .643$ ,  $p < .001$ ).

All the athletes execute at least one change of stride pattern during the race. As usual in women races of 400 m hurdles, the first change is mostly carried out at the 6<sup>th</sup> hurdle. Although among the finalist, the first change is preferably delayed to the last 8<sup>th</sup> or 9<sup>th</sup> hurdles.

Although it is preferable to lead with the left leg at hurdles on a curve (hurdles 1, 2, 6, 7 and 8), only 1 athlete from the final attack those 5 five hurdles with their left leg, and the winner (Dalilah Mohammad) attacks all with their right. In the total sample, the percentage of number of curved hurdles attacked with the left leg is 51.94 %.

Related to the distribution of the effort, the best athletes are the ones with the lowest speed losses after the eighth hurdle, have the smallest time difference between fastest and slowest interval, and less time wasted before the change of rhythmic structure in each section. The loss of speed in the second part of the race correlates with the final time ( $R_{xy} .890$ ,  $p < .001$  and  $R_{xy} .956$ ,  $p < .001$  in the final), much more than in the men's races of this World Championships. A correlation curve between the time between hurdles and the final time has been found in the total of the sample, being the highest in the eight rhythmic unit, between hurdles 8 and 9 ( $R_{xy} .807$ ,  $p < .001$  and  $R_{xy} .904$ ,  $p < .001$  in the final).

## METHODS

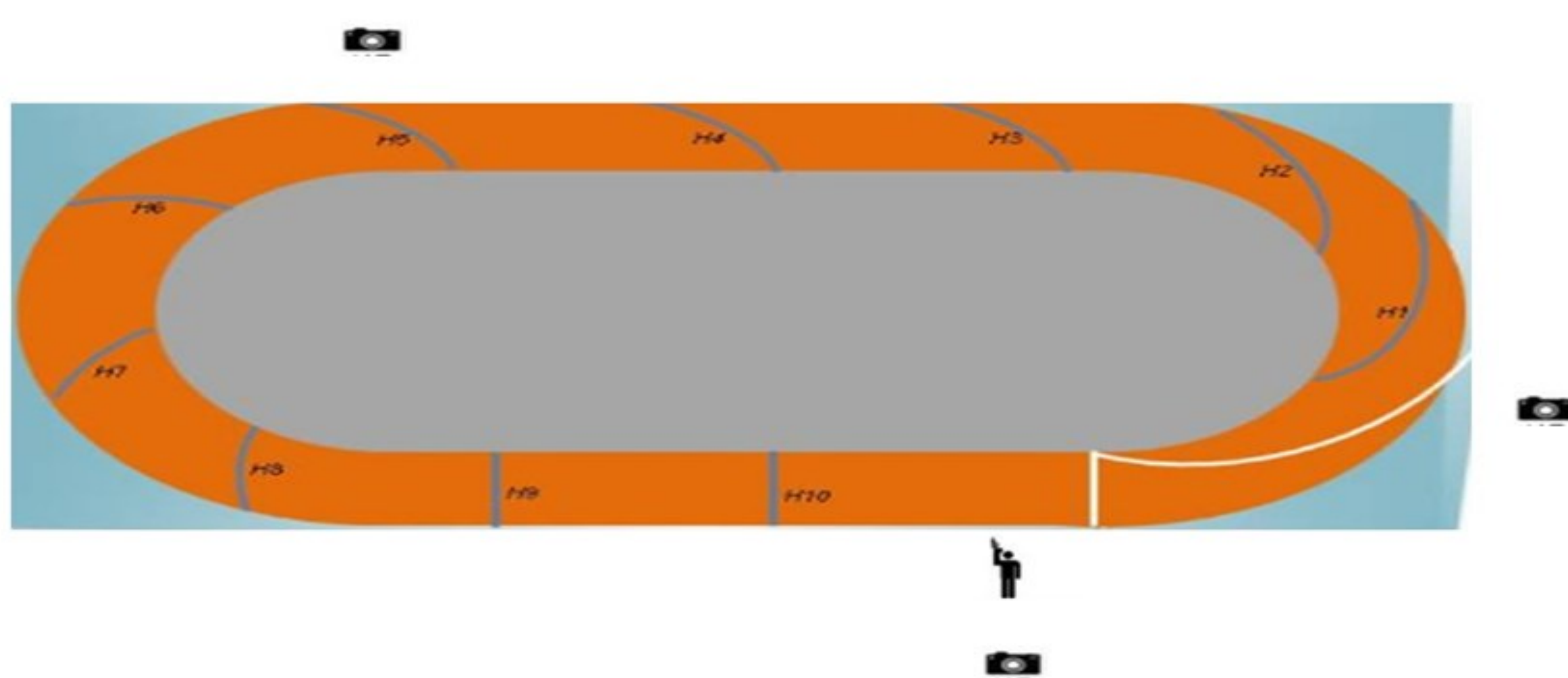


Figure 1: Location of the 3 cameras in the stadium stands. All of them took the reference from the start of the race (gun) and, from the first hurdle, they kept all participants in the framing throughout the race.

The rhythmic structure and effort distribution of the nine women's 400m hurdles races of the IAAF World Athletics Championships Doha 2019 have been analysed: 5 heats (35 athletes), 3 semi-finals (24 athletes) and 1 final (8 athletes). Then, 67 individual performances have been analysed. 87 variables of each athlete by race were analysed, 19 qualitative and 68 quantitative (including spatial, temporal and spatio-temporal parameters), related to the rhythmic structure and effort distribution. All races were recorded by 3 cameras (2 Casio Ex-F1 and 1 Sony A9) placed in different positions of the stand of the Khalifa Stadium, permanently recording all the participants in each race and also recording the output trigger signal. The images were analysed using Kinovea (v.0.8.15) software.

Table 1: Rhythmic structures found in heats, semi-finals and final and number of athletes who carried them out.

Rhythmic structure	Heats	Semi-finals	Final	Total
15 to 7th, 16 to 10th	2	6	2	10
14 to 5th, 15 to 10th	1	2	1	4
15 to 5th, 16 to 8th, 17 to 10th	1	1		2
15 to 7th, 16 to 9th, 17 to 10th	2	2	1	5
16 to 3th, 17 to 7th, 18 to 10th	1			1
14 to 5th, 15 to 9th, 16 to 10th	1		1	2
15 to 6th, 16 to 9th, 17 to 10th	1			1
16 to 7th, 17 to 9th, 18 to 10th	1			1
16 to 5th, 17 to 10th	2			2
15 to 6th, 17 to 10th	1			1
15 to 4th, 16 to 7th, 17 to 10th	1			1
16 to 7th, 17 to 10th	1	2		3
15 to 8th, 16 to 10th	4	1	2	7
15 to 5th, 16 to 7th, 17 to 10th	4			4
15 to 6th, 16 to 8th, 17 to 10th	3	1		4
15 to 5th, 16 to 7th, 18 to 10th	1			1
14 to 4th, 15 to 7th, 16 to 10th	1			1
15 to 5th, 16 to 7th, 17 to 9th, 18 to 10th	1			1
15 to 3th, 16 to 4th, 17 to 7th, 18 to 9th, 19 to 10th	1			1
15 to 5th, 16 to 10th	1			1
16 to 5th, 17 to 8th, 18 to 10th	1			1
15 to 5th, 16 to 9th, 17 to 10th	1	1		2
15 to 5th, 16 to 6th, 17 to 10th	1			1
16 to 3th, 15 to 5th, 16 to 8th, 17 to 10th	1			1
15 to 6th, 16 to 10th		2		2
16 to 5th, 17 to 7th, 18 to 8th, 19 to 10th		1		1
15 to 4th, 16 to 5th, 17 to 10th		1		1
16 to 4th, 17 to 10th		1		1
15 to 5th, 17 to 9th, 18 to 10th		1		1
15 to 6th, 17 to 8th, 17 to 10th		1		1
15 to 3th, 14 to 4th, 15 to 6th, 16 to 9th, 17 to 10th		1		1
15 to 6th, 16 to 7th, 15 to 8th, 16 to 10th			1	1



Figure 2: Dalilah Muhammad, of United States (lane 6), in the passage of the last hurdle in the final, where he won with a world record of 52"16.

## CONCLUSION

A correct distribution of effort and a more stable rhythmic structure are determining factors to obtain the best results in the women's 400m hurdles event.

Numerous and clearly differentiated stride patterns appear in this World Championship. Uniformity is non-existent and more rhythmic structures are individual (one-person)

## REFERENCES

- Schiffer, J. (2012) The 400m Hurdles, *New Studies in Athletics*, 1-2 (9-24)
- López, J.L. et al. (2012) Analysis of the Choice of the Predominant Lead Leg in the 400m Hurdles at the 13<sup>th</sup> World Athletics Championships Daegu 2011. *Apunts. Educación Física y Deportes*, 110, 4 (70-77)
- Guex, K. (2012) Kinematic Analysis of the Women's 400m Hurdles, *New Studies in Athletics*, 1-2 (41-51)
- Behm, J.J. (2007) 400 haies: 1900-2006. *Histoire de quatrache* (44-47).