

Eight steps' paradigm shift in men's 110 metres hurdles: an 89 years retrospective study

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Abstract

Men's 110 metres hurdles is one of the oldest disciplines in the Olympic Games and yet scarce anecdotal reports are found to pinpoint technical elements indicators of success. The approach technique to the hurdles has been raised by coaches as a potential element of success however it seems that the approach strategies undertaken to the first hurdle have not been investigated to the current date. Therefore, this study aimed to examine the employment of the seven and eight steps strategy until the first hurdle in the 110 m discipline among the Olympic Games and World Championships in Athletics' finalists. Public domain videos of the events in the period between 1924 and 2013 were assessed. An international level sprint and hurdles' coach, using the Dartfish software, assessed the number of steps taken until the first hurdle. A left-tailed one sample sign test showed that although the seven steps strategy adoption seems to have begun in 1960 it was only in 2011 that it was considered a dominant tactic. Due to determination of factors that influence the choice of strategy or their respective influence on performance falling outside the scope of this study, future research is needed in this area. Notwithstanding, the success by the hurdlers that adopt the seven steps strategy, evidenced by the number of medals won, allowed to pinpoint the approach strategy to the first hurdle as a potential performance variable to be investigated.

KEYWORDS: Athletics; Hurdler; Olympic Games; World Championships in Athletics.

Introduction

The 110 m hurdle is one of the oldest disciplines in the Olympic Games (OG), being present in that event's first edition, in the year of 1896¹. Although the rules and characteristics of this discipline have not undergone major changes, important alterations have been shown in hurdlers' strategies to overcome the 110 metres. All athletes employed the eight steps strategy when approaching the first hurdle until the appearance of the seven steps strategy in the 1960 OG. In 2008, the first seven steps strategy hurdler won the OG finals while establishing a world record.

The recent success of the seven steps strategy has raised doubts among the coaches and athletes about the effectiveness of the eight steps strategy^{2,3}. Indeed, without a single scientific discussion about the subject it was observed that between 2011 and 2013 only 5 out of 24 finalists used the eight steps strategy. The adoption for one of the two approaching strategies has profound implications in the athletes' performance namely in the block exit technique, in the hurdle approach technique and in step length and frequency in the first 13.72 meters.

According to Schmolinsky⁴ the preference for one of the two strategies would have a performance non-deterministic consequence. The author refers that the chosen strategy may improve speed development, i.e. enhance acceleration, until the third hurdle. This speed enhancement from start to third hurdle may prove to be valuable due to the decay in velocity globally observed from the third hurdle to the finish line^{4,5}.

A proper running technique between hurdles is considered one of the determining factors for the hurdlers' success⁶. In the initial 13.72 m, the option for one of the two approach strategies determines the relation between step frequency and step length. Even though there is no consensus regarding the contribution of step frequency and step length to determine the speed^{7,8,9}, finding the optimal relation between those factors is capital^{10,11} because of its subject-dependent nature¹².

Anecdotal reports from the discipline's coaches state that in assuming the eight steps strategy the hurdler places his lead leg (the leg that strikes the hurdle) in the back block at the starting line. This condition leaves his power leg (supposedly, the strongest) in the front block allowing to develop a higher initial velocity and to minimize the reaction

time after the starting shot. When an athlete changes his approach strategy and assumes the seven steps approach to the first hurdle he must invert his feet in the starting blocks. It is believed that this alteration leads to a speed decrease in the initial meters despite the increase in step length, making the hurdlers' adaptation to this new condition a prolonged process. Although it may exert significant influence on the performance, to the best of our knowledge, no studies have examined the option of the number of steps to the first hurdle, displaying a scientific gap in this field.

The breaking of the 2008 and 2012 world records by hurdlers that used the seven steps strategy emphasizes the relevance of the topic, raising several questions such as: is the employment of the seven steps adopted in these last events an inedited strategy? And have there been other moments in which this strategy was successfully used by event finalists? Therefore, the purpose of the present study was to analyze retrospectively the approach technique to the first hurdle in men's 110 m in the Olympic Games and the World Championships in Athletics finals. Our hypothesis was that the majority of hurdlers utilize the seven steps approach to the first hurdle, constituting a current trend.

Method

Experimental approach to the problem

The finals of the main events since 1896 that best represent the athletic performance in the 110 m hurdles were assessed: the Olympic Games (OG) and the World Championships in Athletics (WCA). Public domain videos that provided acceptable analysis conditions were included in the study (TABLE 1). Therefore, all the data that allowed correct identification of the hurdlers' approach strategy were accepted. That is, the lead leg and the power leg in the starting block and the number of steps taken until the first hurdle. The athletes' approach to the first hurdle was evaluated by an International Association of Athletics Federations (IAAF) level three sprint and hurdles coach using the Dartfish Connect 7.1.1 software¹³. The athletes were classified according to the number of steps taken until the first hurdle: seven or eight steps. The event official

results (podium) were obtained from the IAAF site¹⁴. A similar methodological approach was taken by Lipps et al.¹⁵, Haugen et al.¹⁶ and Salo et al.¹² While in the first study, public domain data was obtained from an internet database in the latter cases, video analyzes were conducted either viewing the footage in a slow motion¹² or with a specific software¹⁶. In the present study, Dartfish was used to monitor the first 13.72 m of the competition of each athlete in a frame by frame manner attempting to identify the approach strategy to the first hurdle. In this way, each step performed by each hurdler was counted. This software has been used by many sports (i.e. badminton, fencing, football/soccer, gymnastics, handball, hockey, judo, karate, roller, rugby, ski and snowboard, swimming, table tennis, taekwondo, tennis, volleyball, weightlifting and wrestling¹³ and similar analysis (i.e. frame by frame) was previously performed in track and field athletes¹⁶.

TABLE 1 – Electronic sites of the videos by event category (Olympic Games – OG; World Championships in Athletics – WCA), city and year.

Year	City	Event	Site
1896	Athens	OG	Video not found
1900	Paris	OG	Video not found
1904	St. Louis	OG	http://goo.gl/PJi2tv
1908	London	OG	https://www.youtube.com/watch?v=1A7IxdhuzhU
1912	Stockholm	OG	Video not found
1916	...	OG	Olympic Games were not held due to World War I
1920	Antwerp	OG	https://www.youtube.com/watch?v=QNzxrWI_e40
1924	Paris	OG	https://www.youtube.com/watch?v=yxqYvTviA2A
1928	Amsterdam	OG	http://youtu.be/PYneUv1WIPc
1932	Los Angeles	OG	https://www.youtube.com/watch?v=nHTtBddfowc
1936	Berlin	OG	https://www.youtube.com/watch?v=LKsG-s-Fgkk
1940	...	OG	Olympic Games were not held due to World War II
1944	...	OG	Olympic Games were not held due to World War II
1948	London	OG	https://www.youtube.com/watch?v=-pPHZQF4v_E
1952	Helsinki	OG	https://www.youtube.com/watch?v=xF-K7ybd9fA
1956	Melbourne	OG	https://www.youtube.com/watch?v=6Xf12yoD9Ow
1960	Rome	OG	https://www.youtube.com/watch?v=V-ulCVCFFi0
1964	Tokyo	OG	https://www.youtube.com/watch?v=5h7GWUDR8wU
1968	Mexico City	OG	http://youtu.be/SFhGJVxF3kY
1972	Munich	OG	https://www.youtube.com/watch?v=UPwZ4ZrI5po
1976	Montreal	OG	https://www.youtube.com/watch?v=UVFJo6zil94
1980	Moscow	OG	https://www.youtube.com/watch?v=aY60--Hc5KA
1983	Helsinki	WCA	https://www.youtube.com/watch?v=gcIA6cynX-U
1984	Los Angeles	OG	https://www.youtube.com/watch?v=hrwcWys4Um4
1987	Rome	WCA	https://www.youtube.com/watch?v=HRsW9w7tKKY
1988	Seoul	OG	https://www.youtube.com/watch?v=X8Kr8CM52LU
1991	Tokyo	WCA	https://www.youtube.com/watch?v=Tc2n5m5g1ec
1992	Barcelona	OG	https://www.youtube.com/watch?v=5H29xejpZPc
1993	Stuttgart	WCA	https://www.youtube.com/watch?v=QQBF913pJh0
1995	Gothenburg	WCA	https://www.youtube.com/watch?v=WlUFHtGi5h4
1996	Atlanta	OG	https://www.youtube.com/watch?v=9rri4TWLtmc
1997	Athens	WCA	https://www.youtube.com/watch?v=vvnS-hv1oYg
1999	Seville	WCA	https://www.youtube.com/watch?v=kYUvsNMLXH0
2000	Sydney	OG	https://www.youtube.com/watch?v=OSCv7ugfy58
2001	Edmonton	WCA	https://www.youtube.com/watch?v=e8W-o5Dgg54
2003	Paris Saint-Denis	WCA	https://www.youtube.com/watch?v=fV9NVPn-uU4
2004	Athens	OG	https://www.youtube.com/watch?v=V09H08Q0UQA
2005	Helsinki	WCA	https://www.youtube.com/watch?v=507b-MQ67oI
2007	Osaka	WCA	https://www.youtube.com/watch?v=_FUzTMVIdl0
2008	Beijing	OG	https://www.youtube.com/watch?v=2prWa2jwgpY

To be continued

TABLE 1 – Electronic sites of the videos by event category (Olympic Games – OG; World Championships in Athletics – WCA), city and year.

Year	City	Event	Site
2009	Berlin	WCA	https://www.youtube.com/watch?v=-Vcecsb4GH4
2011	Daegu	WCA	https://www.youtube.com/watch?v=6bsQuifkRSU
2012	London	OG	https://www.youtube.com/watch?v=2snLA3j1Sis
2013	Moscow	WCA	https://www.youtube.com/watch?v=wTyO4jgNLpI

Sample

A total of 33 events were analyzed summing 250 trials (145 hurdlers). Being a retrospective study that deals with public domain data without referring the subjects’ names, the approval from the Research Ethics Committee was not required. All the men’s 110 m hurdles finals, since the broadcast on television (early in the 1930s), were assessed. Available videos prior to that date were also analyzed, however, only one race in 1924 permitted clear identification of the variables of interest. The video data from the Olympic Games of 1896, 1900 and 1912 were not found. Videos from 1904, 1908, 1920, 1928 and 1976 were found but their poor quality did not allow proper analysis. All the WCA public domain videos, since his first edition in 1983, were in perfect analysis condition. All the athletes that did not start the race were excluded from the sample.

Statistics

Being the number of steps a dichotomous variable, a left-tailed One Sample Sign Test was used to test the null hypothesis that the athletes of an event final used eight steps to the first hurdle against the alternative hypothesis that only seven steps were employed. A statistical significant level of 0.05 was assumed. To quantify the differences’ magnitude between the two medians Cliff’s Delta (δ), a nonparametric effect size, was calculated as well as the corresponding 99% confidence intervals¹⁷. This statistics was obtained using the following expression: $\delta = [\#X_i < 8_2] / mn$; where X_i is a vector representing the number of steps taken by the athletes until the first hurdle, $\#(X_i < 8_2)$ represents the counting of the event finalists’ approaching strategy that was under eight steps, 8_2 is a 2x1 matrix of value 8 for the comparison, m indicates the number of athletes in such event and n the number of elements in

vector 8_2 . The obtained value in this dominance matrix refers to the degree of overlap between the two vectors, which can assume any number in a close interval of [-1,1]. For graphical purposes, when the X_i vector median was 7 steps the δ was given by $-1\delta - 1$, fixing the close interval in [-2,0]. When the X_i vector median was 8 steps the δ was given by $\delta + 1$, fixing the close interval in [0,2] and when the median assumed 7.5 steps the δ returned zero with a close interval [-1,1]. Therefore, when δ is close to -2 the majority of athletes in that event approach the first hurdle with 7 steps; when δ assumes values close to 2 they do it with 8 steps; and when $\delta = 0$ it means that there are the same number of subjects whose approach technique is 7 or 8 steps. Hence, δ equals -2 or +2 when all athletes ran with a seven or eight steps strategy, respectively. A 99% confidence interval for the statistics was calculated by the following expression:

$$\delta Cl_{99} = \frac{\delta - \delta^3 \pm Z_{\alpha/2} \sigma_{\delta c} \sqrt{[(1 - \delta^2)^2 + Z_{\alpha/2}^2 \sigma_{\delta c}^2]}}{1 - \delta^2 + Z_{\alpha/2}^2 \sigma_{\delta c}^2}$$

Where $Z_{\alpha/2}$ is the normal deviate corresponding to the $(1-\alpha/2)^{th}$ percentile of the normal distribution and $\sigma_{\delta c}^2$ represents a δ consistent estimate of variance, where $\sigma_{\delta c}^2 = [(m-1)\sigma_{\delta i}^2 + (n-1)\sigma_{\delta j}^2 + \sigma_{\delta ij}^2] / m$. For this δ variance calculus first one needs to obtain the variance of the marginal values of the rows in the dominance matrix ($\sigma_{\delta i}^2$), the variance of the marginal values of the columns ($\sigma_{\delta j}^2$) in the dominance matrix and the variance of all elements in the dominance matrix ($\sigma_{\delta ij}^2$). The following expressions were used to calculate such parameters:

$$\begin{aligned} \sigma_{\delta i}^2 &= \sum (\delta_i - \delta)^2 / (m - 1) \\ \sigma_{\delta j}^2 &= \sum (\delta_j - \delta)^2 / (n - 1) \\ \sigma_{\delta ij}^2 &= \sum \sum (\delta_{ij} - \delta)^2 / [(m - 1) (n - 1)] \end{aligned}$$

where δ_i represents the marginal value of row i , δ_j is the column marginal value of column j and δ_{ij} is the value of element ij in the dominance matrix. These asymmetric confidence intervals provide visual information about the median uncertainty and magnitude as well as a complementary analysis for the corresponding hypothesis testing. Therefore, when the δ confidence limits are between $[-2, -1[$ or $]1, 2]$

it can be inferred that a statistical significant majority of athletes uses the seven or eight steps strategy, respectively. On the other hand, when the δ confidence limits crosses $X=-1$ or $X=1$ no definitive conclusions can be made about that final predominant step strategy. All statistical procedures were conducted in the Statistical Analysis System (SAS/STAT 9.3, SAS Institute).

Results

The main results of this study are presented in TABLE 2. Note that until 1960 the OG 110 m finals had only six athletes.

The retrospective analysis revealed that the eight steps strategy has been widely employed by these events' finalists (FIGURE 1; Panel A). However, since 2011 it has been seen a tactical change favoring

the use of seven steps until the first hurdle ($P \leq 0.016$). The retrospective analysis of the podium places in that events showed that between 1924 and 2007 only three hurdlers who used the seven steps strategy made it to the podium. However, between 2008 and 2013 there were eight hurdlers that reached the podium (FIGURE 1; Panel B).

TABLE 2 – The number of athletes who ran with a 7 or 8 steps strategy to the first hurdle by year, event category (Olympic Games – OG; World Championships in Athletics – WCA), city and the p-value (P) associated with the left-tailed One Sample Sign Test.

Year	City	Event	APPROACH STRATEGY		P
			7 Steps	8 Steps	
1924	Paris	OG	0	6	1.000
1932	Los Angeles	OG	0	6	1.000
1936	Berlin	OG	0	6	1.000
1948	London	OG	0	6	1.000
1952	Helsinki	OG	0	6	1.000
1956	Melbourne	OG	0	6	1.000
1960	Rome	OG	1	5	0.500
1964	Tokyo	OG	1	7	0.500
1968	Mexico City	OG	0	8	1.000
1972	Munich	OG	0	8	0.500
1980	Moscow	OG	4	4	0.063
1983	Helsinki	WCA	4	4	0.063
1984	Los Angeles	OG	2	6	0.250
1987	Rome	WCA	0	7	1.000
1988	Seoul	OG	2	6	0.250
1991	Tokyo	WCA	3	5	0.125
1992	Barcelona	OG	1	7	0.500
1993	Stuttgart	WCA	1	7	0.500
1995	Gothenburg	WCA	0	8	1.000
1996	Atlanta	OG	1	7	0.500
1997	Athens	WCA	1	6	0.500
1999	Seville	WCA	1	7	0.500

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TABLE 2 – The number of athletes who ran with a 7 or 8 steps strategy to the first hurdle by year, event category (Olympic Games – OG; World Championships in Athletics – WCA), city and the p-value (P) associated with the left-tailed One Sample Sign Test.

Year	City	Event	APPROACH STRATEGY		P
			7 Steps	8 Steps	
2000	Sydney	OG	1	7	0.500
2001	Edmonton	WCA	2	6	0.250
2003	Paris Saint-Denis	WCA	0	8	1.000
2004	Athens	OG	0	8	1.000
2005	Helsinki	WCA	0	8	1.000
2007	Osaka	WCA	1	7	0.500
2008	Beijing	OG	1	7	0.500
2009	Berlin	WCA	1	7	0.500
2011	Daegu	WCA	6	2	0.016
2012	London	OG	6	2	0.016
2013	Moscow	WCA	7	1	0.008

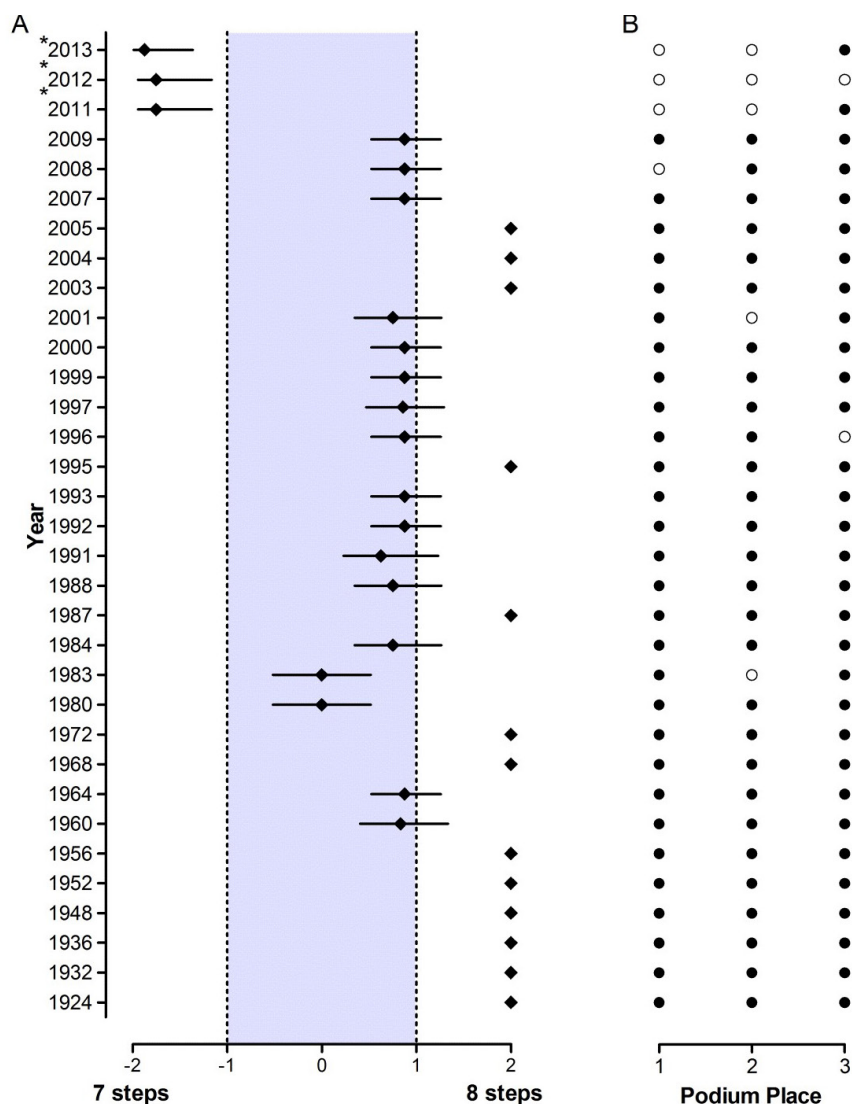


FIGURE 1 – Panel A – Forest plot showing Cliff's Delta (δ) effect size and the respective 99% confidence intervals, since 1924 until 2013, representing the approach technique to the first hurdle by the

event finalists. (*) The median number of steps until the first hurdle taken by the athletes in the event is significantly different from 8 ($P \leq 0.016$), assessed by the left-tailed One Sample Sign Test. The shaded zone represents the area in which a contained confidence interval means the absence of a statistical significance. Panel B – Graphical representation of the podium places (1st, 2nd and 3rd) by the athletes who ran with seven (○) or eight (●) steps until the first hurdle.

Discussion

The results refute the coaches' belief that the seven steps approach is a recent strategy. Indeed, in 1960 one of the six finalists used seven steps to the first hurdle. Even though this seems to be the first change in the approach strategy, it was only in 1983 that a seven steps' hurdler reached the podium (silver medal). However, only since 2011 a significant change in this tactical element was seen. It was shown that in the events of 2011 and 2012 the majority of the finalists used the seven steps strategy and in 2013 almost all the athletes ran with this approach strategy. With this particular change the hurdlers who used the seven steps strategy achieve podium finishes.

The absence of a statistical significance until 2009 may be interpreted as a random occurrence, which did not happen in the last three events. The statistical significance found in the years of 2011, 2012 and 2013 may indicate that the employment of the seven steps strategy has a deterministic origin. This last statement suggests that unknown factors lead the top elite hurdlers to assume an approach strategy. Clarifying these factors should reveal relevant information for the hurdlers' coaches, though this was not the goal of the present study.

The transition to a new approach strategy taken by the events' finalists was not always translated in better results, i.e., the change in the approach to the first hurdle strategy should not be seen as a result determinant factor. Among the 145 hurdlers evaluated only eight changed their approach strategy over the analyzed events, obtaining distinct results. In the 2011 WCA event, the fifth place hurdler used the eight steps strategy change it and in the 2012 OG held in London he achieved the gold medal, establishing that year's world record². The Beijing bronze medalist also changed to the seven steps strategy, achieving the gold medal in the 2013 WCA event. However, the Olympic gold medalist in Sydney changed the eight steps approach strategy to the seven steps, obtaining the silver medal in the WCA held in Paris Saint-Denis. Similarly, the 2004 Olympic gold medalist and 2007 WCA champion

changed to the seven steps strategy obtaining the silver medal in the WCA held in Daegu.

Schmolinsky⁴ refers that the approach strategy selected may have profound implications on performance throughout the event, namely regarding the step frequency and the step length to overcome the initial 13.72 m as well as regarding the posture in the starting block and the starting technique. Thus, to overcome the same distance the eight steps strategy means higher step frequency and the seven steps strategy means higher step length. However, the step length seems to be determined by anthropometrics factors such as the athlete's height¹⁸. In this way, changing the number of steps could generate a non natural attitude towards unclear benefits. Furthermore, there is an effect of athlete's anthropometric characteristics (i.e. body height and leg length) on selecting the optimal running rhythm or hurdling technique¹⁹. To the best of our knowledge, few studies verified the anthropometric characteristics of 110m male hurdlers, however in a analysis of three best 100m performances ever; body height, leg length and liner body were considered the anthropometric characteristic advantages for top level sprinters²⁰.

This discipline's performance determinants are not yet properly listed, resulting in a paucity of scientific publication on the theme. Nevertheless, the transition towards the seven steps to the first hurdle highlighted by the results of this study suggests the approach strategy as a potential performance variable to be analyzed.

In addition to the changes in step frequency and step length, the two strategies impose major differences in the starting technique namely because the positioning of the feet positioning in the starting block also changes. In the eight steps strategy the leading leg rests on the rear support of the starting block allowing the approach to the first hurdle to be made by that same leg. In the seven steps strategy the hurdler needs to place his power leg in the rear support of the starting block so that he can approach the first hurdle with the other leg, his lead leg. Eikenberry et

al.²¹ showed that an immediate consequence of the strategy change was a technique alteration exiting the starting block which diminished the athletes' performance in whom the preferred leg was switched. Although the sample in that study was not composed by elite athletes, the similar results found when compared with amateurs suggest that the alterations seen in those who changes the approach strategy is not dependent on the level of the hurdlers.

Furthermore, Iskra & Čoh²² affirm that a consolidated performance determinant is the increasing velocity behavior until the third hurdle. Therefore, the hurdler should strive to develop maximum speed until the third hurdle, maintaining it as long as possible. Indeed, Schmolinsky⁴ and Ward-Smith⁵ mention that performance in the final stages of the event are closely related with this factor, especially when considering the velocity reduction will take place over the remaining course. Being the increasing acceleration until the third hurdle a performance determinant, the option for the seven or eight steps strategy is subject-dependent, i.e., the hurdler should choose the strategy that allows him to produce the higher velocity until the first three hurdles^{4,22,23}.

Therefore, investigating this discipline's subject-dependent determinant factors such as anthropometric characteristics, velocity, flexibility, hurdle-clearance techniques; is an inexorable research path^{5,6,22-25}. It should be noted that the purpose of the present study

was not to determine the influence of the performance factors or even the elements that should be accounted for when a decision on the approach strategy to the first hurdle must be taken. Nevertheless, it is highly suggested that future studies focus on confirming the factors pointed as potential determinants of the approach to the first hurdle strategy. Providing validity of these factors to coaches and athletes regarding changing the hurdlers approach strategy may bring about performance enhancement.

This study aimed to assess retrospectively the approach to the first hurdle strategy by the OG and WCA finalists in the 110 m discipline, as well as their classification. This study's main results showed that although the seven steps strategy has been used since 1960 only in the events since 2011 that seems to be dominant. A strategy transition from eight steps to seven steps has been confirmed by these results. Selecting an approach strategy seems to be a subject-dependent decision, and although some factors that should support that option were stated it was not this study's purpose evaluate its effectiveness. Thus, the present study pinpoints the approach strategy to the first hurdle as a performance determinant, emphasizing the urgency in obtaining insights about the underlying mechanisms that influence the hurdlers' choice. These next research steps should allow the athletes to choose an approach strategy that ensures a performance optimization.

Resumo

Mudança do paradigma dos oito passos nos 110 metros barreiras: um estudo retrospectivo

A prova de 110 metros barreiras é uma das mais antigas disciplinas dos Jogos Olímpicos, no entanto os elementos técnicos indicadores de sucesso têm sido apontados de forma empírica. A técnica de abordagem à barreira tem sido sugerida por treinadores como um potencial elemento de sucesso, contudo as estratégias de abordagem à primeira barreira não têm sido alvo de investigação. Desta forma, o presente estudo objetivou examinar a utilização da estratégia dos sete ou oito passos à primeira barreira entre os finalistas olímpicos bem como do campeonato mundial de atletismo na prova dos 110 m. Foram analisados vídeos de domínio público do período entre 1924 e 2013. Usando o software Dartfish, o número de passos dados até à primeira barreira foi avaliado por um treinador de atletismo de nível internacional. O teste de sinais, unicaudal à esquerda para uma amostra, revelou que embora em 1960 a estratégia dos sete passos tenha começado somente em 2011 foi considerada como uma tática dominante. A determinação dos fatores que influenciam a escolha da estratégia de abordagem ou o seu efeito no desempenho saí do escopo do presente estudo fazendo-se necessária pesquisa voltada à temática. Não obstante, o sucesso dos barreiristas que adotam a estratégia dos sete passos, evidenciada pelo número de medalhas ganhas, permite apontar a estratégia de abordagem à primeira barreira como uma potencial variável de desempenho a ser investigada.

PALAVRAS-CHAVE: Atletismo; Barreiras; Jogos Olímpicos; Campeonato Mundial de Atletismo.

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