Data Analysis of Middle Distance Running Strategy Based on Binary Discrete Choice Model

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Abstract. Through video analysis, this paper establishes the database of the pace strategy of distance runners in the 2008–2019 World Championships and the final of the Olympic Games. Combined with the econometric binary discrete selection model, this paper analyzes the differences between the self pace strategy, team strategy, the pace strategy of award-winning athletes and non award-winning athletes, and the pace strategy of male and female athletes. The results show that: 1) In the middle distance running, high-level athletes prefer to adopt the leading running strategy, whether there is team cooperation or not. 2) In 1500 m, athletes with 4–2 tactics (the speed ratio of the last 400 m is the highest and the speed ratio of the second 400 m is the lowest) are more likely to win medals; but athletes who adopt 1–2 tactics (the speed ratio of the first 400 m is the highest and the speed ratio of the second 400 m is the lowest) are more likely to win the medals in 800 m; 3) In the 1500 m events, the overall pace of male athletes is more even than female athletes.

Keywords: middle-distance running · pace strategy · binary discrete selection model

1 Introduction

The pace is the process of the human body's active distribution and use of energy [1]. Its purpose is to reasonably allocate energy, delay fatigue and maintain a high level of competitive state. Most of the research on pace strategies focuses on swimming [2], short track speed skating [3], and other projects. Based on the existing research on running pace strategy, it is found that the main research focuses on the pace strategy research of long-distance events such as marathon [4], while there is less research on the pace strategy of weaker middle-distance running projects. The academic circles believe that the 800 m race pace strategy shows the characteristics of high in front and low in back [5]. Yang Feng [6] also found that there is a secondary high at last 100 m of 800 m. The main views on the characteristics of the 1500 m running pace strategy research are uniform speed distribution, the speed of the first half is fast and the speed of the second half is slow [7], the speed of the first half is slow and the speed of the second half is fast [8] and the speed of the middle stage determines the final result [9].

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Based on the above research, it can be seen that the current research on the pace strategy of medium-distance running still has the following problems: (1) The sample size is not enough, and the conclusion is accidental, so its reference significance is limited. Most of the analysis is limited to the results of a certain race, and the results of a single race will be affected by many unexpected factors, which is not very illustrative; (2) There are many articles on the long-distance speed strategy and the speed strategy of swimming, short track speed skating, cycling and other projects, but there is insufficient research on the speed strategy of medium-distance running; (3) The 800 m pace strategy only analyzes the comparison of different lap speeds, and there is less analysis on the differences between athletes of different levels and different genders; (4) There are still great disputes about the 1500 m pace strategy, which cannot clarify the pace of athletes in 1500 m running. Therefore, on the basis of further expanding the research sample, this paper studies the strategies of high-level athletes themselves, the differences in pace strategies of athletes of different sex, and the differences in pace strategies of award-winning and unwinning athletes.

2 Research Method

2.1 Data Collection

This paper collects the total results and segmented results of the men's 800 m final, the women's 800 m final, the men's 1500 m final and the women's 1500 m final in the 2009–2019 World Championships and the 2008, 2012 and 2016 Olympic Games from official website of the Joint International Athletics Committee. Based on the actual race data, on the one hand, the data are real and easy to obtain and the sample size is relatively rich; on the other hand, athletes will not be interfered by research, and the study of high-level race data helps to truly analyze the rhythm difference of athletes in sports. According to the finals video, the pace strategy of different athletes is reviewed, and a speed strategy database is established.

2.2 Data Analysis Method

Tactical Collection
In order to further verify this problem, this paper calculates the ratio of each athlete's speed per lap to the average speed of all participants in this race, thus defining the serial numbers of the fastest and slowest laps per athlete. Use 1, 2, 3 and 4 to represent the serial numbers of the first lap to the fourth lap in the 1500-m running respectively, so that there can be a combination of 12 possible pace strategies, which can be expressed in the form of a matrix. For example, 1–2 represents the highest speed ratio of the first lap of the athlete and the lowest speed ratio of the second lap. In addition, 800 m is only divided into 1 and 2 laps, so there are only 1–2, 2–1 tactics.

Binary Discrete Selection Model
In this paper, Logit model and Probit model of binary discrete selection model are used to analyze whether athletes with outstanding results prefer to choose the leading tactics rather than the following running strategy. Among them, the interpreted variable

is whether the athlete adopts a leading running tactic, which is measured by the 0–1 variable. 1 means yes and 0 means no. The explained variable is the athlete's results, using the best score (PBS) of the first year before the competition, the average score (AS) of the year before the competition, and whether the competition is obtained. Medals (FS), standard speed (FLS) for the last lap of this competition (1500 m using the standard speed of the last 300 m) are measured, and the control variables are gender (GEN), distance (DIS), whether to enter the last Olympic or World Championship final (LFS), and whether there are teammates in this competition (LFF).

Single-Factor Variance Analysis
In order to analyze the differences in athletes' speed strategies at different distances of 800 m and 1500 m, this paper uses a single-factor variance analysis to compare and analyze the lap speed difference between medalists and other ranking athletes, and male and female athletes.

3 Results

3.1 Tactical Collection of All Athletes in 800 m and 1500 m

Table 1 is the tactical aggregation table of 800 m and 1500 m athletes. In this paper, 800 m and 1500 m middle distance running are divided into two and four stages respectively according to 400 m. What tactics are adopted by athletes in each distance interval are compared and recorded. For example, the 4–1 tactics of 1500 m is that the athlete's pace ratio is the fastest in the last 400 m of 1500 m, and the athlete's pace ratio is the slowest

Table 1. Tactics Collection of All 800 m and 1500 m Athletes

Project	Tactics	1	2	3	4	5	6	7	8	9	10	11	12	Total	Proportion
800 m	1–2	9	9	10	10	11	10	9	8					**76**	71.03%
	2–1	5	5	4	4	3	4	4	2					**31**	28.97%
1500 m	1–2													**0**	0
	1–3							1						**1**	1.05%
	1–4											1	1	**2**	2.11%
	2–1									1				**1**	1.05%
	2–3													**0**	0
	2–4								1	1	1	1	1	**5**	5.26%
	3–1	1	1	2	2	2	3	1	1	1	1	1	1	**17**	17.89%
	3–2												2	**2**	2.11%
	3–4							1					1	**2**	2.11%
	4–1	3	3	1	3	2	3	2	1	3	3	2	1	**27**	28.42%
	4–2	4	4	5	3	3	2	3	5	2	2	3		**36**	37.89%
	4–3					1					1			**2**	2.11%

in the first 400 m. As it can be seen from Table 1, the number of athletes using 4–2 tactics in the 1500 m distance is the largest, accounting for 37.89% of the total number of athletes in the statistics, and the athletes who use this tactics also have the largest proportion of the first place winners, and the proportion of medal winners is also the largest. Secondly, 28.42% of athletes use 4–1 tactics. 76 athletes in the 800 m distance race all adopted 1–2 tactic, that is, a fast-start strategy to occupy the inner track, which is as high as 71.03 percent.

3.2 Test Results of Leading Pace Strategy Selection

Table 2 is the result of the binary discrete selection model test, which can be used to explain the reasons that affect athletes to adopt the leading tactics. Model 1 to Model 4 selects the personal best score of the year before the competition, the average score of individuals of the year before the competition, whether this competition has won a medal, and the standard speed of the last lap of the competition as different indicators to measure personal results. The P value of the LR statistics of model 1 to model 4 is less than 0.01, which shows that the combined significance of all coefficients (except constant terms) of the whole equation is better. The probability ratios of the main explanatory variables are 3.8361, 3.1833, 2.297, 2.0504 respectively, and they are all significant at a level of 1%, which means that for every second increase in personal best results in the year before the competition, the probability of athletes using leading running increases by 3.8361 times; for every second increase in the average score of individuals in the year before the competition, the probability of athletes taking the lead increases by 3.1833 times; athletes who win medals in this competition are 2.9297 times the probability of other ranking athletes; for every second increase in the standard speed of the last lap of this competition, the probability that the athletes taking the leading running tactic has increased by 2.0504 times.

From the perspective of control variables, gender, distance, whether the last Olympic and World Championships have reached the finals, and whether there are teammates participating in this competition will also affect the strategic choices of athletes. The probability of sex is less than 0.01, which is significant at a level of 1%, indicating that female athletes are more likely to take the leading running tactic than male athletes. The distance probability is less than 0.05 compared with the corresponding P value, that is, at a significant level of 5%, which shows that athletes participating in 800 m are more likely to take the leading running tactic than 1500 m athletes. The probability of winning medals at the last Olympic Games or World Championships is less than 0.10, that is, at a level of 10% (5% for model 4) and a slightly lower level of remarkability, but the probability ratios can still indicate that athletes who can win medals at the last Olympic Games or World Championships before participating in this competition are more than those who have not reached the finals have a higher probability of adopting or trying to adopt a leading tactics; the P value of whether team members participate in this competition is less than 0.01, that is, at a significant level of 1%, and the probability ratio is relatively high. The probability ratio of this item in Model 1 to Model 4 is: 3.8999 3.9954, 4.2626, 4.5946 respectively, all about four times, which means that if team members participate together in the competition, the probability of athletes taking the leading running tactic is about four times higher than athletes who have no teammates.

Table 2. Test Results of Binary Discrete Selection Model

Project	Subdivision variable	model 1	model 2	model 3	model 4
Main explanatory variables	PBS	3.8367 (0.009)			
	AS		3.1833 (0.008)		
	FS			2.9297 (0.002)	
	FLS				2.0504 (0.003)
Control variable	GEN	1.5706 (0.008)	1.4016 (0.008)	1.2535 (0.006)	1.2106 (0.009)
	DIS	0.0407 (0.031)	0.0410 (0.029)	0.6284 (0.021)	0.6385 (0.030)
	LS	1.8745 (0.052)	1.7648 (0.083)	1.8646 (0.057)	2.1461 (0.016)
	LFF	3.8999 (0.001)	3.9954 (0).001	46.262 (0.001)	4.5956 (0.000)
sample number N		201	201	201	201
The estimation method, Model		Logit model	Logit model	Probit model	Probit model
Quasi R2		0.1735	0.1704	0.1691	0.1554
LR statistics		31.14	30.59	30.35	27.89
P value		0.0000	0.0000	0.0000	0.0000

a. Note: The corresponding value of the variable is the odds ratio, and the value in parentheses is the P value.

3.3 Test Results of Pace Strategy Under Award-Winning and Gender Differences of Athletes

The results of the difference between medalists and other ranking athletes show that there is a significant difference in the standard speed of the last lap of 1500 m medalists and other ranking athletes (P value is 0.0367), which shows the last 300 m sprint ability of the winners in 1500 m is more important. The speed difference between 800 m medalists and other ranking athletes is significant (P value is 0.0195 and 0.0236 respectively), which shows that the absolute speed of 800 m medalists is crucial throughout the race.

The results of the difference between male athletes and female athletes show that the significant difference of 1,500 m in the male and female groups exists in the second and third laps (P value is 0.0063 and 0.0001 respectively). The speed of female athletes in the second lap is significantly reduced, and there is a peak in the third lap. Generally speaking, for the athletes in the men's group, the pace of the body is more even and the sprint ability is stronger. There is no significant difference in the standard speed of

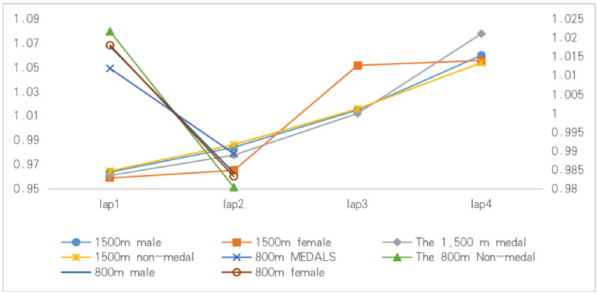

Fig. 1. The Difference of Standard Speed Distribution Between Different Genders and Ranks in 1500 m and 800 m

Table 3. Test Results of Difference in Lap Scores

Project	Subdivision variable	Statistics	Lap1	Lap2	Lap3	Lap4
1500 m	Winning and No Winning	F statistics	05.1	0.63	04.0	2.96
		P value	0.9272	0.5965	0.9897	.00367
	men and women	F statistics	0.36	7.81	18.04	0.26
		P value	0.5492	0.0063	0.0001	0.6146
800 m	Winning and No Winning	F statistics	5.63	4.04		
		P value	0.0195	0.0236		
	men and women	F statistics	0.03	0.04		
		P value	0.9498	0.8367		

800 m between male and female athletes, which shows that although there is a difference in absolute speed between male and female athletes, there is not much difference in the distribution of standard speed, and the initial speed is relatively high (Fig. 1 and Table 3).

4 Conclusions

4.1 Overview of Middle Distance Running Strategy

From the overall level, the average score of running 1500 m in the world has improved. The average total time of women's 1500 m in the 2019 World Championships was about 237.62 s, an increase of about 2.71 s compared with the average time in 2013; the average time of men's 1500 m in the 2019 World Championships was about 215.58 s, an increase of 3.14 s compared with 2013; Thus, the overall pace strategy of women's 1500 m has gradually changed from the back-range force in 2013 to the uniform parabolic type in 2019; the overall pace strategy of men's 1500 m has also changed from the post-range range in 2013 to "fast start—uniform speed—accelerate the sprint" transformation in 2019.

The average score of running 800 m in the world has not changed significantly. From 2013 to 2019, the average time of 800 m for women hovered between 119 and 120 s, while the time of 800 m for men hovered between 105 s and 106 s; the overall speed strategy of 800 m for men and women has not changed, and it is still basically started at high speed to get the opportunity, and won the race.

4.2 Reasons for Choosing a Leading Strategy

According to the results of Table 2, even if different indicators are used to measure personal results, top athletes will adopt the strategy of leading tactics or try to adopt the strategy of leading tactics. Therefore, although athletes will adjust their tactics based on the strength of their competitors in real competitions, for athletes with outstanding results, they use leading tactics rather than following tactics to occupy the most favorable position by mastering the initiative of the field to disrupt the opponent's pace strategy rather than letting other athletes disrupt their pace.

The conclusion that female athletes are more likely to take the lead than male athletes seems to subvert our general impression. Deaner et al. [10] found that female athletes are generally better able to maintain their original speed in sports than male athletes. Athletes participating in 800 m are more likely to take the lead than 1500 m athletes, because the distance of 800 m is shorter, and it is more important to quickly start the inner lane of runway.

Athletes who can win medals in the last Olympic Games or World Championships before participating in this competition are more likely to adopt or try to adopt a leading tactics than athletes who have not reached the finals. Entering the finals of the last Olympic Games or World Championships also proves the strength of athletes before participating in the competition.

If team members participate together in the competition, the probability of athletes taking the lead is about four times higher than that of athletes without teammates in the competition.

4.3 The Differences in Pace Strategies Between Award-Winning Athletes and Unwinning Athletes

The most significant difference between the 1500 m medal-winning athlete and the non-award athlete is in the fourth lap. Mytton [11] studied the difference in the pace of male athletes winning 1500 m and non-winning athletes, and proved that male medalists showed more obvious finish sprinting ability in the last 400 m of the competition than non-medal winners. It can be seen that athletes who win medals of 1500 m usually sacrifice the relative speed of part of the initial stage to ensure physical fitness in the last 300 m sprint stage, and finally ensure that they win medals.

There is a significant difference in speed between 800 m medalists and non-medal winners. Although the sprint ability of athletes in the 800 m race is equally important, the starting speed is more critical.

In the analysis of leading tactics strategies, this paper finds that female athletes are more likely to use leading tactics than male athletes, but from the perspective of the difference in the lap speed of male and female groups, the difference in the pace of 1500 m male and female athletes mainly occurs in the second and third laps. This is because women will lower their relative speed earlier than male athletes, thus ensuring their physical distribution throughout the stage. During the whole stage, their physical distribution fluctuates more than that of male athletes, and many female athletes even have two speed reduction processes. The difference in the lap speed of 800 m male and female athletes is small, which may be related to the segmentation of the competition schedule of this paper.

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