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Women's 1000m speed skating technical development features research based on analytic hierarchy process

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ABSTRACT

Take women's 1000m speed skating as entry point, it makes research on 21st Olympic Winter Games women's 1000m speed skating competition performance, and utilizes analytic hierarchy process to analyze Chinese women skaters performances influence factors, and gets Chinese women skaters performances main influence factors are athlete's speed and endurance. To these two points, it carries out research on Chinese women skaters' training methods, and makes improvement suggestions on coaches' training methods are as following: to athletes' different physical qualities, select proper bicycle training method to train them; reduce skateboard training's training time; during training period, select different ways' speed endurance running to train athletes corresponding to different training purposes; utilize speed skating wind resistance trainer to train athletes; with healthy diet and keep healthy psychology.

KEYWORDS

Analytic hierarchy process;
Weight analysis
Women speed skating;
Speed and endurance;
Olympic winter games.

INTRODUCTION

Speed skating was first listed as formal competition event in Chamonix, France in 1924, till Sochi Olympic Winter Games, speed skating always were an important competition event. China first participated in Olympic Winter Games in 1980 and since participating and up to Sochi Olympic Winter Games this year; Chinese speed skating always took higher world level. However, in women's speed skating 1000m competition, Chinese performance was not ideal. Chinese women's speed skating only won historical first gold medal till Sochi Olympic Winter Games this year. In order to maintain Chinese women's speed skating 1000m excellent performance, it carries out research on women's speed skating 1000m athlete training method. In previous winter sports meetings, Chinese athletes have never achieved excellent performance in women's speed skating 1000m competition event. Women's speed skating main influence factors include technique, psychology, competition state and other multiple aspects. Athlete's psychology and competition state are mainly up to athletes' their psychological quality adjustment.

To effective improve athlete performance, it firstly needs to find out Chinese athletes shortcomings in competition process compared to world top athletes; and to these shortcomings, it proposes corresponding improvement suggestions. Domestic partial scholars have ever researched on speed skating. Yao Do-Wei etc[1]. makes use of regression analysis, variance analysis and other methods, to intermittent hypoxia training form, it makes research on athletes' physiology and immune systems. Other most parts of researches are researches on speed skating athletes' motions techniques. However, by researching athletes' shortcomings, documents that propose corresponding solutions on these shortcomings are very little.

The paper takes previous Olympic Games as examples, by researching competition performance; it discusses on athletes' loss points in competitions. And find out main reasons that hinder skaters' performance progress, and provide practical suggestions to help Chinese women's speed skating athlete's performance further improvement.

COMPETITION PERFORMANCE ANALYTIC HIERARCHY PROCESS

In the past, Chinese speed skating team's performances were in the bottleneck period. Until to Vancouver Olympic Winter Games in 2010, Chinese speed skating performance was not very ideal. Till to Sochi Olympic Winter Games in 2014, Chinese speed skating team achieved remarkable performance. In 2014 Olympic Games, Chinese woman skater Zhang Hong event won the champion of 1000m speed skating that got first gold medal in Chinese Olympic Games speed skating history.

Take 21st Olympic Winter Games as entry point. By researching 21st women's 1000m speed skating

TABLE 1 : The 21st Olympic Winter Games women's speed skating 1000m competition performance analysis table

Rank	Name	Country	200m	200-600m (X1)	600-1000m (X2)	Time difference X2 and X1	1000m
1	Christine Nesbitt	CAN	18.36	28.11	30.09	+1.98	1:16.56
2	Annette Gerritsen	NED	17.89	28.04	29.65	+2.61	1:16.58
3	Laurine van Riessen	NED	18.08	28.16	30.48	+2.32	1:16.72
18	Jin Peiyu	CHN	18.27	28.38	31.32	+2.94	1:17.97
24	Wang Beixing	CHN	17.88	28.01	32.41	+4.40	1:18.30
32	Yu Jing	CHN	18.63	29.12	31.38	+2.26	1:19.13
33	Ren Hui	CHN	18.70	28.60	31.88	+3.28	1:19.18

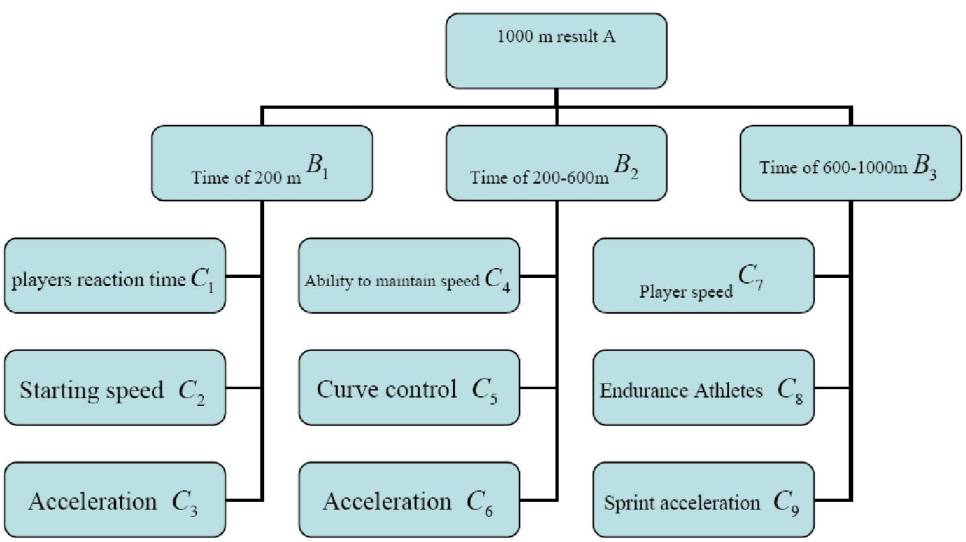

Figure 1: Women's speed skating 1000m competition performance influence relational graph

competition performances, it researches on Chinese women's skaters' main influence reasons. The 21st Olympic Winter Games women's speed skating 1000m partial competition performance is as TABLE 1 show.

Make researches and analysis of TABLE 1, it finds out that Chinese athletes' former200m and 200-600m consumed time has no big difference with world excellent athletes. Consumed time in 600-1000m is longer than that of world excellent athletes. Competition total consumed time is longer than world excellent athletes.

By analyzing, it gets athletes completing former 200m consumed time main influence reasons are majorly in three points, which include athletes reaction time that lets body move forward after listening to starting gun ; in the beginning of competition, athletes' skating starting speed; athletes' body accelerated speed after starting.

Between 200-600m, athlete completion time main influence reasons have following points: between 200-600m, it needs athlete to continue to accelerate, meanwhile it maintains forepart speed. Therefore, athletes' speed maintaining abilities affect athletes' completion time. The course has two curves, when in curves; it needs athletes accelerating to surpass front athletes. However when accelerates in curve, athletes are prone to fall down due to poorly controlling. Therefore athletes' curve controlling ability and accelerate speed, it is also very important for athletes whether can arrive at larger speed and surpass other athletes.

600-1000m is competition final phase that directly relative to competition final performance. In final course, athlete body are already very fatigue. Whether athlete can still keep high speed and even accelerate skating in final phase is crucial to competition result. Final phase athlete endurance and speed affect athlete final performance. Except for that, competition final phase the scenes that athletes utilize final spurt to change their fates are common. Final phase spurt can shorten competition consumed time to great extent. Final phase spurt acceleration also affects competition performance.

Draw relational graph on competition performance each influence factor, as Figure 1 show.

Construct judgment matrix

Hierarchical structure can clearly reflect relations among elements, but a criterion hierarchy's every criteria weight in target measuring is not always the same. When one factor has more influence factors, directly consider how influence degree that each factor affects the factors, it will appear importance inconsistent data and cause errors. This paper adopts comparison between two factors and establishes paired comparison matrix to factor B. Which takes two factors B_i and B_j every time, use a_{ij} to express the influence ratio that B_i and B_j cover A, all comparison results use matrix $M=\left(a_{ij}\right)_{n\times n}$ to express. Call M is paired comparison judgment matrix between $A-B$, it is called judgment matrix for short. It is clear if B_i and B_j to A influence ratio is a_{ij}, and then B_j and B_i to A influence ratio should be: $a_{ji}=\frac{1}{a_{ij}}$. Adopt same method comparing each C factor, and establish $B-C$ comparison matrix. According to consulted information and data, make comparison on each factor and can get judgment matrix as following show (list out in table):

Women1000m skaters performance A and influence factors former 200m consumed time B_1, 200-600m consumed time B_2, 600-1000m consumed time B_3 comparison matrix $A-B$ is as following TABLE 2 show:

Establish former 200m consumed time B_1 and influence factors athletes' reaction time C_1, starting speed C_2, accelerated speed C_3 comparison matrix B_1-C is as following TABLE 3show:

Establish 200-600m consumed time B_2 and

TABLE 2: Comparison matrix $A-B$

A	B_1	B_2	B_4
B_1	1	$\frac{2}{3}$	$\frac{1}{3}$
B_2	$\frac{3}{2}$	1	$\frac{1}{2}$
B_3	3	2	1

influence factors speed maintaining ability C_4, curve control ability C_5, accelerated speed C_6 comparison matrix B_2-C is as following TABLE 4 show:

Establish 600-1000m consumed time B_3 and influence factors speed C_7, endurance C_8, spurt accelerated speed C_9 comparison matrix B_3-C is as following TABLE 5 show:

TABLE 3: comparison matrix B_1-C

B_1	C_1	C_2	C_3
C_1	1	$\frac{2}{3}$	$\frac{5}{2}$
C_2	$\frac{3}{2}$	1	$\frac{3}{5}$
C_3	$\frac{5}{2}$	$\frac{5}{3}$	1

TABLE 4: Comparison matrix B_2-C

B_2	C_4	C_5	C_6
C_4	1	$\frac{2}{3}$	$\frac{4}{3}$
C_5	$\frac{3}{2}$	1	2
C_6	$\frac{4}{3}$	$\frac{1}{2}$	1

TABLE 5 : comparison matrix B_3-C

B_3	C_7	C_8	C_9
C_7	1	$\frac{6}{7}$	$\frac{3}{2}$
C_8	$\frac{7}{6}$	1	$\frac{7}{4}$
C_9	$\frac{2}{3}$	$\frac{4}{7}$	1

TABLE 6 : Random consistency indicator RI

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Hierarchical single arrangement and consistency test

Judgment matrix corresponding maximum feature value $\lambda_{\max}$ feature vector W, it is the priority weight of same hierarchy corresponding elements relative importance to last hierarchy some element after normalization, the process is called hierarchical single arrangement. Consistency indicator:

$$\mathbf{CI}=\frac{\boldsymbol{\lambda}-\mathbf{n}}{\mathbf{n}-\mathbf{1}} \tag{1}$$

When $CI=0$, C is consistency matrix, CI gets bigger C inconsistency degree gets more serious. Random consistency indicator RI value is as TABLE 6 show:

To $n\geq 3$ paired comparison matrix M, call its consistency indicator and same order(refer to n is the same)random consistency indicator RI ratio is consistency rate CR, when formula(2)thinks M inconsistency degree within tolerance range, it can use its feature vector as weight vector.

$$\mathbf{CR}=\frac{\mathbf{CI}}{\mathbf{RI}}<\mathbf{0.1} \tag{2}$$

Use Matlab to calculate every matrix maximum feature value $\lambda_{\max}$ and CI, and judge whether consistency passes or not, result is as TABLE 7 show.

From TABLE 7, each judgment matrix maximum feature is the same as its matrix order number, and its consistency indicator CI value is 0, which indicates each judgment matrix is consistency matrix so it passes consistency test. According to random consistency indicator RI values, calculate and get consistency rate CR value is 0, because $0<0.1$, so it thinks M inconsistency degree within tolerance range, it can use its feature vector as weight vector.

Hierarchical total arrangement and consistency test

In above test, we achieved is a group element to its previous layer one element weight vector, in order to get every factor to women's 1000m speed skating performance influence weight, it should compound bottom layer every element weight with previous layer

TABLE 7 : Consistency test result

Judgment matrix	Weight vector W	Maximum feature value	CI	RI	CR
$A-B$	$(0.1818\ 0.2727, 0.5455)$	3	0	0.58	0
B_1-C	$(0.2, 0.3, 0.5)$	3	0	0.58	0
B_2-C	$(0.3077, 0.4615, 0.2308)$	3	0	0.58	0
B_3-C	$(0.3529, 0.4118, 0.2353)$	3	0	0.58	0

factor to top level efficiency weight.

B layer has B_1, B_2, B_3 three influence factors, their weights on A are respectively: 0.1818, 0.2727, 0.5455. C layer 9 factors to B layer weights are respectively:0.2, 0.3, 0.5, 0.3077, 0.4615, 0.2308, 0.3529, 0.4118, 0.2353(when C_i and B_j are uncorrelated, $c_{ij}=0$). Solve C layer each factor to women's speed skating 1000m performance A total weight, that is to solve C layer each factor total arrangement weight, make use of formula:

$$\mathbf{c_i = \sum_{j=1}^{m} c_{ij} b_j, i = 1,2,\cdots,14} \quad (3)$$

Utilize above formula(3)to solve C layer each factor weight value as TABLE 8 show :

Weight total arrangement consistency test:

C layer B_j relative factor established comparison judgment matrix passes consistency test in hierarchical single arrangement, and already solve consistency indicator $CI(j)$ and its corresponding random consistency indicator $RI(j)$, then C layer total arrangement random consistency proportion by formula(4)calculating and can get

$$\mathbf{CR} = \frac{\sum_{j=1}^{m} \mathbf{CI(j) b_j}}{\sum_{j=1}^{m} \mathbf{RI(j) b_j}} \quad (4)$$

When $CR < 0.10$, then hierarchical total arrangement result passes consistency test and result is relative correct.

By testing, C layer B_j relative factor achieved $CI(j)$ is 0, so hierarchical total arrangement random consistency CR passes test.

To sum up, we can get these factors corresponding weight value are respectively 0.038, 0.056, 0.094, 0.08, 0.013, 0.06, 0.19, 0.22, 0.13, by comparing data, it can get women's 1000m speed skating total consumed time larger influence factors are athlete's speed and endurance.

IMPROVEMENT METHODS

According to analytic hierarchy process concluded result, it can know that athlete's speed and endurance are women's speed skating 1000m athletes' performance main influence factors. Most direct and effective method to improve athlete's speed and endurance are gradually improving athletes' speed and endurance by daily training.

When human body takes speed and endurance movements, body energy metabolism features are non-oxygen energy supply major in lactic acid. Women's 1000m speed skating belongs to short track speed skating that major in sugar zymolysis energy-providing. Women's 1000m skaters' daily speed and endurance training, not only is to increase athletes their physical

TABLE 8 : Each factor to total consumed time total weight value

Factor	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
Weight	0.038	0.056	0.094	0.08	0.013	0.06	0.19	0.22	0.13

quality, but also to improve glycolysis ability. There are varieties of training methods in achieving purposes; select correct methods are beneficial to improve training efficiency so that get twice the result with half the efforts.

For Chinese women's 100m skaters speed and endurance training methods, there are many types that include bicycle, skateboard, bend walk, speed and endurance running, skidding, ski-jumping, strength, distance training and so on. Different training methods have different influences on speed and endurance; proportions that Chinese athletes adopt different methods are as TABLE 9 show:

According to TABLE 9 content, it is clear that Chinese coaches adopt more training methods of bicycle, skateboard, speed and endurance running to athletes, and bend walk as well as strength are the secondary. These methods are relative practical and effective, which widely spreads in daily training. Fewer coaches adopt skidding and ski-jumping method to train. Ice distance training event is indispensable. Different training methods have different glycol sis abilities improvements to athletes.

The article mainly researches on bicycle training, skateboard training, bend walk training, speed and endurance training, ice event distance training. Each training method to athletes' body influences are as TABLE 10 show:

Bicycle training method is speed training most common and widely used training method. Chinese and foreign coaches universal think that bicycle training moment used muscle group and body postures are very approximate to speed skating special features. It is effective path in land training; therefore it is widely adopted in training. Bicycle training intense is larger that belongs to speed and endurance training that majors in glycolysis metabolism type. According to TABLE 10 analysis, it is clear that after bicycle training, athletes' heart rate can arrive at 185~200 time/min, blood lactic acid value arrives at 11.26±1.04mmol/l. It can achieve the purpose of improving women's skaters' speed and endurance.

Skateboard is a training method that used for simulating straightaway techniques. It not only becomes method that improves athletes' speed and endurance training, but also can convert into ice technique to great extent. By long-term developing, skateboard training has become an important method in land training, is lots of athletes' non-ice period adopted training ways. In training progress, with training intense increasing, athlete heart rate and blood lactic acid concentration are gradually increasing. Blood lactic acid concentration generally can arrive at peak value in1~3 minutes. Blood lactic acid concentration is 12.80±1.21mmol/L; it can improve athlete's speed and endurance level in training process. When athlete carries out skateboard training, blood lactic acid concentration is lower than that during bicycle training. Skateboard is inferior to bicycle in the aspect of improving athlete speed and endurance. But skateboard training can simulate ice technique; it has irreplaceable position in non-ice period training. Therefore suggest coaches can properly reduce skateboard training time, increase bicycle training time so as to improve athletes' speed and endurance rapidly.

Bend walk training's adoption rate is nearly

TABLE 9 : Chinese coaches' speed and endurance training adopted main methods

Method	Land							Ice event
	Bicycle	Skateboard	Bend walk	Speed and endurance running	Skidding	Ski-jumping	Strength	Distance training
Percentage(%)	77.14	74.29	62.86	71.43	5.71	14.29	57.14	100

TABLE 10: Each training method to athletes' body influence

Sports form	Bicycle	Skateboard	Bend walk	Speed and endurance running	Distance training
Influence	Heart rate185~200 time/min, blood lactic acid value11.45±1.24mmol/l	Heart rate above 180time/min, blood lactic acid value 12.80±1.21mmol/L	Heart rate above 180 time/min, blood lactic acid value 13.45±3.3mmol/l	Heart rate above 165 time/min, blood lactic acid value 12.35±3.0mmol/L	—

62.28%. Bend walk training has three forms: barehanded bend walk, slope loading bend walk, flat loading bend walk. When athlete takes bend walk training, blood lactic acid value arrives at 13.45±3.3mmol/l, heart rate is above 180 time/min. It can effective achieve purpose of training speed and endurance. However, it needs to pay attention to the training method has better effects in the middle and latter training period, and due to the training method causes larger loading on athletes, during training period, athletes required training interval time should not less than 20minutes.

Speed and endurance running is one of best training methods well recognized by coaches. Not only in speed skating, include swimming, gymnastics, basketball, football and athletics' most of events, coaches will select speed and endurance running to training athlete physical quality. On one hand, it is because speed and endurance running has little requirements on fields; meanwhile it is also because speed and endurance running can let athletes' multiple physical qualities get trained. When carries out the training, athletes' heart rate is above 165time/min, blood lactic acid value is 12.35±3.0mmol/L, which can achieve purpose of training speed and endurance. In speed skating competition event, athletes still need to maintain larger speed in latter half course. Speed and endurance running the latter half course also has spurting, which is similar to speed skating final spurt, the training method can achieve purpose of simulating speed skating to a certain degree.

Ice event distance training is most important, most prominent special training in speed skating training. Generally speaking, Chinese ice endurance training is divided into general endurance training, speed and endurance training and ice comprehensive training with general endurance and speed endurance features. Ice speed and endurance training features include large loading intense, medium continuous training time. Athlete improves non-oxygen energy providing abilities at faster skating speed in short time, and further improves respiratory system and circulatory system functions.

Except for that, with scientific and technological improvement and people puts more emphasis on sports event, training methods and trainers are gradually improving. Among them, speed skating wind resistance trainer is achievement that people researches on speed skating training.

In traditional training methods, athlete load and speed always are in inversely proportions. If it increases athletes' sports loads, sports speed will reduce. In this way, athlete speed will not get better trained. On the contrary, if it increases athletes' speed, athletes' loads bearable loads will be relative small, or they cannot train for long time. So that it cannot better train athletes' endurance. And speed skating wind resistance trainer can properly solve the problem; it can simultaneously train athletes' speed and endurance.

CONCLUSIONS

According to above research achievements, in order to let athletes more effective improve speed and endurance, now it makes suggestions on coaches and athletes as following: bicycle training can train athletes' speed and endurance to great extent. Therefore, it suggests coaches to increase bicycle training strength. To skateboard training, training speed and endurance effects are lower than that of bicycle training, but skateboard training can simulate ice technique that cannot cancel in non-ice period. So, it suggests coaches can properly shorten skateboard training time, increase bicycle training, and bend walk training and other high efficiency training speed and endurance training time. Bend walk training causes larger load to athlete, so it suggests in training period, athletes required training interval time should not less than 20 minutes. And the training method has better effects in middle and latter period. Speed and endurance running is common used training method to increase speed and endurance. It suggests coaches in the former period of training, use speed and endurance to let athletes adapt to train. In the medium period of training, it is used as speed and endurance increasing training method. In the latter period of sports, simulate speed skating spurt phase. By experience, it finds that athletes use speed skating wind resistance trainer to train and get better effects. It suggests coaches increase speed skating wind resistance trainer training. Except for that, healthy diet is crucial to athletes. Suggest that coaches should put athletes' diet in order. Suggest athletes to eat more food with high vitamin C, keep healthy physical state. Athletes psychological qualities also direct affect competition state and result. Athletes themselves should maintain a good attitude that is very important.

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