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Study on Technical Standards of Different Speed Ranges of Man's Junior Race Walkers

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Abstract: Race walking technique is closely related to speed, and the technical standards based on the relationship between speed and technique is more reasonable and practical. In this study, literature method, expert survey method, biomechanical test method, mathematical statistics method, etc. are adopted, by constructing the evaluation indicator system of men's junior athletes' walking technique, 14 key indicators of 4 category of swing type, support type, flight type and speed rhythm type were selected, among which the swing type indicators had the highest contribution rate; Combining the correlation between each indicator and the speed, it can be divided into stable type and sensitive type; According to the principle of the race walking technique again, the indicators are classified into 3 types of high-excellent type, medium-excellent type and low-excellent type; Finally, the percentile method was used to grade and assign the technical indicators of each speed range, and the technical standards of race walking for men's junior in different speed ranges were established to provide reference for training.

1. Introduction

Junior walkers' technical fouls in the competition are frequent, but there is little research on it. At present, there are two problems in the research on race walking technique, one is that the selected technical indicators are obviously differentiated, the number of indicators is too large, and there is a lack of evaluation standards. Second, most studies simply compare technical indicators under different speed states, while ignoring the intrinsic relationship between speed and techniques [1-3]. Obviously, this is not conducive to the efficiency of technical evaluation [4]. Race walking techniques at different speeds have different internal structures and external performance. Changes in speed are closely related to changes in techniques [5-9]. This has also been confirmed by our team's previous research [10]. Some studies indicate the state of velocity when analyzing technique, but do not analyze the relationship between speed and technique [4][11], or the analysis content is not systematic enough [7-9]. Therefore, based on the relationship between speed and technique, this study establishes the technical standards of men's junior race walkers in different speed ranges to provide reference for training.

2. Subject and Methods of study

2.1. Subject of Study

The subject of the study was men's junior race walking technique. The test subjects were 41 Chinese elite junior walkers (see Table 1).

Table 1: Basic information of subjects (average ±standard deviation)

Sex	Age (years)	Height (m)	Weight (kg)	10km Score (min)	Athlete Level
MEN'S	18.5 ±1.0	1.75 ±0.60	59.82 ±4.684	41.47 ±1.26	National first level

2.2. Methods of study

2.2.1. Questionnaire Survey Method.

The questionnaire "Survey on Key Technical Indicators of Junior Race Walking Athletes" was designed, and coaches and researchers were invited to conduct five-level quantitative scoring of the preliminary selection indicators and screen the key indicators. Fifteen questionnaires were distributed and 15 were recovered, with a recovery rate of 100%. Screened questionnaire results, retaining the indicator with a mean score of ≥4 as a check indicator.

2.2.2. Biomechanical Test Method

Video testing of men's junior race walkers (all top 8) in seven international and domestic race walking competitions, such as the 2014 Nanjing Youth Olympic Games. Test methodology.

1) Select 3 shooting positions and place a scale bar with a length of 2.5 meters in the playing field, the scale calibration line is parallel to the motion plane and perpendicular to the main optical axis of the camera, and the distance between the two calibration lines is 0.5 meters (see Fig. 1 and 2). Set up CASIO-FH25 high-speed camera. The main optical axis of the camera is perpendicular to the plane of motion, the shooting range is 4-5 meters, and the shooting distance is about 12.5 meters. The camera is 1.10 meters high, the shooting frequency is 120Hz, and the exposure time is 1/1000s.

2) Use a camera to film all racers walking through the calibration area each lap.

3) Use Dartfish 6.5 to perform two-dimensional kinematic analysis of the completed technical video and obtain the check indicator data. In this paper, a total of 238 double-step techniques were analyzed, for a total of 476 single-step techniques.

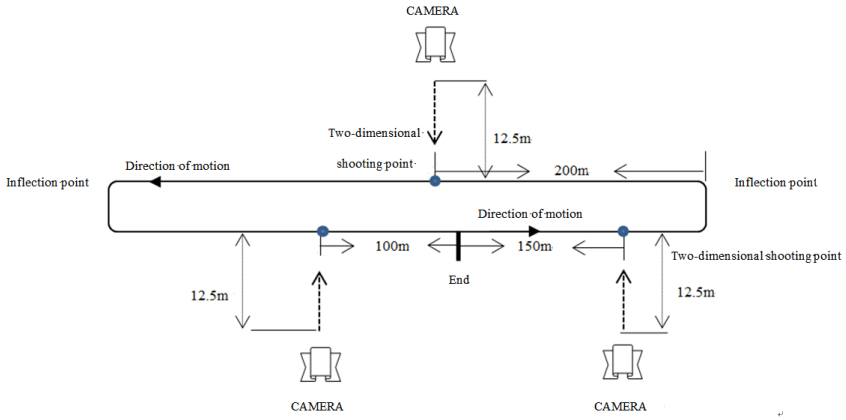

Figure 1: Schematic diagram of scene shooting layout

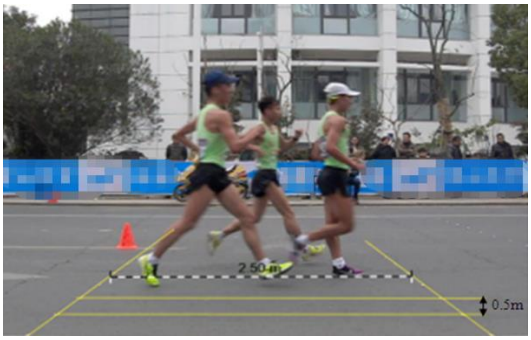

Figure 2: Schematic diagram of calibration of two-dimensional plane scale

2.2.3. Mathematical Statistics Method

Principal component analysis and correlation analysis were performed using SPSS 22.0.

3. Results and Analysis

3.1. Screening of Key Indicators

Table 2: Principal Component Classification and Factor Nomenclature of Technical Indicators

Principal factor	Naming	Contribution rate (%)	High load indicator
1	Swing action factor	31.25	Knee angle when two thighs overlap
			Knee angle before leaving the ground
			Angle between legs above the ground
			Elbow joint angle of swing forward when off the ground
			Rear swing angle of upper arm off the ground
2	Supporting action factor	22.23	Back pedaling distance off the ground
			Back pedaling off ground angle
			Support distance before landing
			Angle of elevation of landing sole
			Angle of inclination of landing torso
3	Flight action factor	14.21	Time of flight
			Head vertical undulation height
4	Speed rhythm factor	11.04	Stride length
			Cadence

Note: Back pedaling distance off the ground, Support distance before landing and the step size refer to the ratio of the actual distance to the height.

Using the Delphi method, 21 were selected from 50 indicators. Through principal component analysis, 4 factors with characteristic values greater than 1 were selected as common factors, and 14 indicators with load values greater than 0.7 were selected (see Table 2). The contribution rate of the swing action factor is the highest, which is more consistent with the view of “promoting pedaling with pendulum” in previous studies [12].

3.2. Classification of Indicators

3.2.1. Classification of Stable and Sensitive Indicators

The single-step speed of race walking is 3.76-4.55 m/s, and the average is 3.93 m/s. The results of the Shapiro-Wilk normal distribution test for all indicators show a P>0.05, which indicates that the normal distribution of the above results is consistent and the Pearson correlation coefficient can be used for correlation analysis (see Table 3).

The type 1 indicators show a corresponding numerical increase trend when the speed increases, the change trend of the type 2 indicators is the opposite, and the type 3 indicators remain relatively stable when the speed changes. Therefore, the type 1 and 2 indicators are defined as sensitive indicators, which refer to indicators that have a certain obvious change law in the speed change; Type 3 indicators are defined as stable indicators. They refer to indicators that remain relatively stable in the face of speed changes. For the latter, they can be evaluated and analysed without distinguishing speed. For the former, they need to be analyzed after distinguishing the speed difference.

Table 3: Correlation between Competition Speed and Key Technical Indicators

Indicator (Unit)	Average ± SD	Correlation
Stride length (%)	0.67±0.03	r=0.841,P=0.000**
Cadence (Hz)	3.37±0.12	r=0.658,P=0.000**
Back pedaling distance off the ground (%)	0.25±0.02	r=0.499,P=0.000**
Back pedaling off ground angle (°)	62.54±1.86	r=-0.470,P=0.000**
Support distance before landing (%)	0.13±0.02	r=0.131,P=0.000**
Angle of elevation of landing sole (°)	24.40±3.35	r=0.103,P=0.000**
Angle of inclination of landing torso (°)	0.71±1.33	r=0.018,P=0.032*
Knee angle when two thighs overlap (°)	103.11±4.81	r=-0.095,P=0.024*
Knee angle before leaving the ground (°)	163.02±5.62	r=-0.380,P=0.008**
Angle between two legs off the ground (°)	48.75±2.83	r=0.601,P=0.005**
Elbow joint angle of swing forward when off the ground (°)	65.76±10.83	r=-0.013,P=0.041*
Rear swing angle of upper arm off the ground (°)	59.83±7.13	r=0.011,P=0.019*
Flight time (s)	0.057±0.012	r=0.565,P=0.000**
Head vertical undulation height (m)	0.058±0.014	r=0.401,P=0.003**

Note: **stands for extremely significant correlation (P<0.01) and * stands for significant correlation (P<0.05)

3.2.2. Classification of Indicators of High-excellent Type, Medium-excellent Type and Low-excellent Type

The high-excellent type refers to the indicator that the higher the value is, the better the technique is under the same speed condition; the low-excellent type is the opposite. Medium-excellent type refers to the better technical indicator when the numerical value is in the appropriate middle range under the same speed condition.

Increasing the stride length and increasing the cadence is an ideal strategy for increasing the speed of race walking. However, the increase in stride length will increase the body's exercise load, and the acceleration of cadence is limited by the ability of neuromuscular synergy. Therefore,

simply increasing the stride length or increasing the cadence is not practical. It can be seen from the current high-level competition that the stride length and cadence are moderate to create results. Therefore, stride length and cadence are both medium-excellent indicators.

In race walking, both feet should not be human visible lifted off the ground at the same time, and the front legs should be kept straight from the moment of touching the ground to the vertical of the body [13]. The problem of off the ground in high-speed races is difficult to avoid, and the imaging of the ground off-ground action in human vision can only be avoided by perfecting the technique. Shortening the time and height off the ground is an important way. Therefore, the altitude of the abnormal ground time and the vertical undulation height of the head are low-excellent indicators.

According to the principle of "composite moving pendulum movement" of race walking technique, when the support foot lands on the ground, a "near fixed positive moving pendulum motion" is formed with the hip joint on one side of the supporting leg as the rotation fulcrum and the distance from the center of mass of the swinging leg to the fulcrum as the radius, and the "far fixed inverted moving pendulum motion" is formed with the landing support point as the rotation fulcrum and the distance from the body's center of gravity to the fulcrum as the radius. When the swing radius is positive, increasing the radius of the center of mass of the swing leg can shorten the swing period, and when the swing radius is negative. Reducing the radius of the center of mass of the swinging leg shortens the swing period [12]. Under the premise of relaxation, the speed of swinging of the swinging leg is the key to improving technical performance. Knee angle when two thighs overlap, Knee angle before leaving the ground, Angle between two legs off the ground, back pedaling off ground angle all reflect the swing leg swing effect. After the support leg hits the ground, only when the posterior muscles are relaxed can the swinging leg continue to show a large knee angle during the support. Therefore, Knee angle when two thighs overlap and Knee angle before leaving the ground, Angle between two legs off the ground are both high-excellent indicators. It is precisely because the swinging leg can relax the swing in the support stage, the body can complete the "far fixed inverted pendulum movement" with a small radius, which is conducive to athletes to obtain better forward movement when leaving the ground, forming a smaller "throwing angle". It can be seen that the back pedaling off ground angle is a low-excellent indicator.

Swing leg swing relaxation creates a larger Support distance before landing at the end of the swing and into the support phase. Support distance before landing the larger it is, the better it is to form an open stride. Therefore, Support distance before landing is a high-excellent indicator. In addition, when the combination of pedaling and pendulum is good, increasing the pedaling distance after the support leg can accelerate the speed of the center of gravity when pedaling off the ground, which is conducive to obtaining the ideal horizontal displacement off the ground and forming an ideal stride length. Therefore, the back pedaling distance off the ground is a high-excellent indicator. The human trunk should also be stabilized during accelerated movements [14-15], which requires a full swing of the upper arm and a proper forward swing elbow angle. In this way, the purpose of strong back swing and relaxed front swing can be achieved. Therefore, Rear swing angle of upper arm off the ground and Elbow joint angle of swing forward when off the ground are high-excellent and medium-excellent indicators, respectively. At the moment of landing, the dorsiflexion action of the ankle joint is conducive to controlling the freedom of movement of the ankle joint, and creating conditions for the improvement of the swing effect of "far fixed inverted pendulum movement" after landing. Increasing the amplitude of ankle dorsiflexion is a good technical performance. Therefore, Angle of elevation of landing sole is a high-excellent indicator.

3.3. Establishment of Technical Standards for Race Walking in Different Speed Ranges

Using the percentile method, the indicators in the ranges of 3.846-4.000m/s and 4.000-4.167m/s

were graded, and technical standards were established (see Tables 4 and 5). According to the standards, the Youth Competition of 2017 Tianjin National Games was analyzed, and the evaluation results were consistent with the penalty of the competition, which verified the rationality of the established technical standards.

Table 4: Technical Standards of 4.000-4.167m/s Speed Range

	Indicator	High-class	Medium-to-high class	Medium class	Medium-to-inferior class	Inferior class
Swing technique	Knee angle when two thighs overlap (°)	109.4↑	106.5-109.4	98.5-106.5	95.4-98.5	95.4↓
	Knee angle before leaving the ground (°)	168.1↑	165.6-168.1	158.3-165.6	154.4-158.3	154.4↓
	Angle between two legs off the ground (°)	52.5↑	51.0-52.5	47.0-51.0	45.5-47.0	45.5↓
	Elbow joint angle of swing forward when off the ground (°)	64.9-68.0	62.7-64.9	52.2-62.7	48.5-52.2	48.5↓
			68.0-69.5	69.5-78.9	78.9-83.8	83.8↑
	Rear swing angle of upper arm off the ground (°)	68.9↑	64.9-68.9	55.2-64.9	51.5-55.2	51.5↓
Support technique	Back pedaling distance off the ground (%)	27.22↑	26.26-27.22	24.09-26.26	23.43-24.09	23.43↓
	Back pedaling off ground angle (°)	60↓	60-60.9	60.9-63	63-63.8	63.8↑
	Support distance before landing (%)	14.97↑	13.83-14.97	11.52-13.83	10.66-11.52	10.66↓
	Angle of elevation of landing sole (°)	26.3↑	23.7-26.3	20.5-23.7	18.6-20.5	18.6↓
	Angle of inclination of landing torso (°)	-0.2-0.6	-0.8-(-0.2)	-1.5-(-0.8)	-1.5(-2.2)	-2.2↓
			0.6-1.2	1.2-2.4	2.4-3.1	3.1↑
Fight technique	Flight time (s)	0.042↓	0.042-0.050	0.050-0.067	0.067-0.072	0.072↑
	Head vertical undulation height (%)	0.03↓	0.03-0.04	0.04-0.06	0.06-0.08	0.08↑
Speed rhythm	Relative stride length (%)	68.08-68.90	67.34-68.08	66.67-67.34	66.20-66.67	66.20↓
			68.90-69.19	69.19-70.89	70.89-71.27	71.27↑
	Cadence (Hz)	3.367-3.400	3.333-3.400	3.283-3.333	3.250-3.283	3.250↓
			3.400-3.433	3.433-3.483	3.483-3.533	3.533↑

Table 5: Technical standard for 3.846-4.000m/s speed range for men

	Indicator	High-class	Medium-to-high class	Medium class	Medium-to-inferior class	Inferior class
Swing technique	Knee angle when two thighs overlap (°)	109.4↑	106.5-109.4	98.5-106.5	95.4-98.5	95.4↓
	Knee angle before leaving the ground (°)	169.2↑	166.8-169.2	159.4-166.8	155.7-159.4	155.7↓
	Angle between two legs off the ground (°)	51.6↑	50.6-51.6	46.4-50.6	44.8-46.4	44.8↓
	Elbow joint angle of swing forward when off the ground (°)	64.9-68.0	62.7-64.9	52.2-62.7	48.5-52.2	48.5↓
			68.0-69.5	69.5-78.9	78.9-83.8	83.8↑
	Rear swing angle of upper arm off the ground (°)	68.9↑	64.9-68.9	55.2-64.9	51.5-55.2	51.5↓
Support technique	Back pedaling distance off the ground (%)	26.40↑	25.59-26.40	23.81-25.59	22.62-23.81	23.81↓
	Back pedaling off ground angle (°)	60.6↓	60.6-61.4	61.4-63.9	63.9-64.6	64.6↑
	Support distance before landing (%)	14.97↑	13.83-14.97	11.52-13.83	10.66-11.52	10.66↓
	Angle of elevation of landing sole (°)	26.3↑	23.7-26.3	20.5-23.7	18.6-20.5	18.6↓
	Angle of inclination of landing torso (°)	-0.2-0.6	-0.8-(-0.2)	-1.5-(-0.8)	-1.5(-2.2)	-2.2↓
			0.6-1.2	1.2-2.4	2.4-3.1	3.1↑
Fight technique	Flight time (s)	0.042↓	0.042-0.050	0.050-0.067	0.067-0.072	0.072↑
	Head vertical undulation height (%)	0.03↓	0.03-0.04	0.04-0.06	0.06-0.08	0.08↑
Speed rhythm	Relative stride length (%)	66.79-67.86	65.97-66.79	64.49-65.97	63.61-64.69	63.61↓
			67.86-68.36	68.36-69.55	69.55-70.13	70.13↑
	Cadence (Hz)	3.333-3.367	3.300-3.333	3.250-3.300	3.200-3.250	3.200↓
			3.367-3.400	3.400-3.450	3.450-3.483	3.483↑

4. Conclusion

Men's junior race walking athlete evaluation technical indicator system includes a total of 14 indicators, which are divided into swing, support, flight, speed and rhythm, and the swing indicator has the highest contribution rate. According to the correlation between each indicator and speed, the indicator is divided into two categories: stable type and sensitive type; According to the principle of race walking technique, the indicators can be divided into high excellent type, medium excellent type, and low excellent type. Using the percentile method, the technical standards for race walking for Men's junior athletes in different speed ranges were established. The established standards are reasonable.

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