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Original Article

Technique characteristics of 13–15-year-old female athletes specializing in race walking at the stage of preliminary basic preparation

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Abstract:
Analysis of the technique of competitive exercise performance by 13–15-year-old female athletes specializing in race walking is the basis for further improvement of the training process, both at the stage of preliminary basic preparation and subsequent stages of long-term preparation. *Objective*: to determine the main kinematic characteristics of the techniques of female athletes specializing in race walking at the stage of preliminary basic preparation. *Material*: technique kinematic characteristics of 19 athletes (13.9 ± 1.07 years old) at a distance of 2 km at the 2016 and 2017 Championships of Ukraine, as well as those of two of these athletes at the stage of specialized basic preparation at the Championship of the Association of Balkan Athletics Federations in 2020 and the Championship of Ukraine in 2021 at 5 and 10 km distances, were analyzed. *Results:* to achieve at a distance of 2 km the level of results equal to $\bar{x}$ = 9:57 (S = 0:17), the average speed at that distance should be 3.35 m·s^{-1} (S = 0.10), stride length – 1.07 m (S = 0.03), stride frequency – 3.14 stride·s^{-1} (S = 0.08), duration of the support phase – 0.298 s (S = 0.011), that of flight – 0.021 (S = 0.005), angle of foot placement on the ground – 70.43° (S = 2.15), and take-off angle – 59.96° (S = 1.91). *Conclusions*: the values of technique biomechanical characteristics of 13–15-year old female athletes at the stage of preliminary basic preparation reach high indices and approach those of adult athletes of the high national level at distances of 20 and 50 km. The age of 13–15 years is important for athletes specializing in race walking for the formation of the basic elements of technique (i.e., stride length and frequency) and should be taken into account when designing the training process and long-term training strategy.
Keywords: stage of preliminary basic preparation, female athletes, race walking, technique kinematic characteristics

Introduction

The level of sports results and competing in women's race walking is constantly increasing. At the same time, the analysis of the competitive activity of outstanding athletes in the world shows that at the major world forums at a distance of 20 km, they use a tactical option with a gradual speed increase to 3.95–4.03 m·s^{-1} in the second part of the distance, and especially during the last 4–5 km. Such speed indices exceed the average speed required to set a world record (Pupiš, Spišiak, Tóth, 2017; Sovenko et al., 2018).

Race walking is the only track and field event with strict demands placed on the technique by the competition rules, the control of compliance with which is performed by the appropriate referees. According to the competition rules, in race walking there should be no phase of flight visible to the human eye, and the forward (support) leg must be fully extended at the knee joint from the first contact with the ground until passing the vertical (Competition rules, 2020; Pavlović, Petrović, Vrcić, 2021).

The increase of race walking speed along with the duration of flight to critical limits in the world best athletes pose important challenges not only for the technology of judging, but for the coaches in the process of technical preparation (Taborri, Palermo, Rossi, 2019; Caporaso and Grazioso, 2020).

Similarly, the requirements for athletes' fitness level are increasing, which requires a detailed analysis of competitive activity as a basis for further training process improvement of not only highly skilled athletes at the stages of preparation for higher achievements, a maximum realization of individual capacities, and preservation of higher sportsmanship, but also athletes at the basic stages of long-term preparation (Matveyev, 2010; Platonov, 2015; Czakova, Pupiš, Líška, 2019).

VB Zelichonok (2018), who has many years of experience in monitoring the methods of training track and field athletes at different stages of long-term preparation, argues that the training process of young track and field athletes is mainly focused on the development of physical qualities (speed–strength and speed), whereas insufficient attention is paid to training techniques and the development of flexibility. These shortcomings further negatively affect the quality of performed special and competitive exercises, often lead to injuries, and do not allow to reveal the young athlete's potential. The author is convinced that it is extremely important to lay the proper foundation of exercise performance techniques at the very beginning. It is well-known that after a wrong

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skill is formed, it is much more difficult to relearn it than to learn it correctly to begin with (Matveyev, 2010; Bauersfeld, Schroter, 2015).

The stage of specialized basic training is the most studied among the basic stages, especially from the perspective of the technique of competitive exercise performance; this stage includes 16-19-year-old athletes and lays the foundation of technical and special physical fitness, which in the future will become the basis for sports improvement of athletes (Korolev, 2005; Fruktov & Travin, 1989; Tucker, Hanley, 2017; Vinogradova, Sovenko, 2020). For example, the analysis of competitive activity technique of junior race walkers of the high world and national levels (Hanley, Bissas, Drake, 2014; Sovenko, Danilyuk, 2017) indicates that at a similar speed at 10 km distance, they reach almost the same parameters of stride length and frequency as adult athletes at 20 km distance (Amara, Mkaouer, 2020; Hanley, Bissas, Drake, 2011). Therefore, most outstanding athletes dominated in junior competitions.

The stage of preliminary basic preparation, which includes 13–15-year-old female athletes, is the least studied stage from the standpoint of the technique of competitive exercise performance and just as important in the structure of long-term training of race walkers. Though the amount of general training still prevails over special one, during this stage a significant increase in strength occurs and the foundation for further acquisition of sports skills (including technical ones in a selected track and field event) is laid owing to the widespread use of special preparatory exercises (Track and Field, 2017). Therefore, a detailed analysis of the technique of competitive exercise performance of this contingent of athletes is the basis for further improvement of the training process, both at the stage of preliminary basic preparation and subsequent stages of long-term training.

Materials and methods

Participants

Biomechanical analysis of the technique of competitive exercise performance by 19 female athletes (age = 13.9 years; S = 1.07) was based on the findings obtained as a result of our video recording of the 2016 and 2017 Championships of Ukraine in race walking at a distance of 2 km held in the city of Ivano-Frankivsk. One athlete participated in both starts; therefore there were a total of 20 sports results. In addition, the analysis of the technique of the best two athletes three to five years later in 2020 and 2021 at the Championship of the Association of Balkan Athletics Federations held in Ivano-Frankivsk and Championship of Ukraine held in the city of Lutsk during their transition to other age categories at 5 and 10 km distances was performed along with respective comparative analysis.

Instruments

The “Lumax” hardware and software complex was used for video image analysis, the main technical characteristics and capabilities of which are presented in detail in the publications of developers (Ostrovskyi, 2003). The body positions of athletes during the competitive exercise performance were recorded by "Sony HDR-PJ50E" video camera at a speed of 50 frames per second. During the studies, all metrological requirements were taken into account, which allowed proper placement of the camera and minimization of systematic and accidental errors. A model of the human body consisting of 20 points plotted in a clear sequence was used to digitize the motion of athletes' biolinks.

Statistical analysis

Licensed MS Excel software was used to analyze the obtained data. Descriptive statistics indices were determined: arithmetic mean ($\bar{x}$), standard deviation (S), and variation coefficient (V). The significance of differences between groups was assessed by the Statistica-10 (StatSoft, USA) program, using the non-parametric Mann–Whitney test for independent samples (U) at the significance level of p = 0.05.

Results

Female athletes were divided into two groups, each of which was homogeneous in terms of the level of results, age, growth rates, and basic biomechanical characteristics, as evidenced by the value of the variation coefficient, which did not exceed 10% (Table 1).

Table 1. Biomechanical characteristics of the technique of female athletes specializing in 2 km race walking at the stage of preliminary basic preparation (n = 20)

Index		Group						U	p*
		I (n = 9)			II (n = 11)				
		$\bar{x}$	S	V	$\bar{x}$	S	V		
Result		9:57	0:17	2.8	10:49	0:14	2.2	0	**p < 0.01**
Age, years		14.00	1.12	8.0	13.82	1.08	7.8	44.5	p > 0.05
Height, m		1.64	0.06	3.4	1.59	0.06	4.0	32	p > 0.05
Body mass, kg		46.67	6.32	13.6	46.00	5.67	12.3	47.5	p > 0.05
Average speed	$m \cdot s^{-1}$	3.35	0.10	2.9	3.08	0.07	2.2	0	**p < 0.01**
	$km \cdot h^{-1}$	12.07	0.34		11.10	0.25			
Stride length, m		1.07	0.03	2.4	1.01	0.03	3.4	6	**p < 0.01**
Rear stride length, m		0.37	0.03	7.1	0.38	0.03	9.2	49	p > 0.05
Flight length, m		0.18	0.04	21.8	0.14	0.05	33.5	17	**p < 0.05**

Front stride length, m	0.26	0.04	14.2	0.24	0.03	11.0	31	p > 0.05
Length of support transition, m	0.26	0.01	4.3	0.25	0.02	7.0	41	p > 0.05
Stride frequency, stride·s^{-1}	3.14	0.08	2.5	3.06	0.11	3.4	30	p > 0.05
Duration of one stride, s	0.319	0.008	2.5	0.327	0.011	3.5	30	p > 0.05
Single support duration, s	0.298	0.011	3.7	0.311	0.015	4.8	26	p > 0.05
Duration of absorption in single support phase, s	0.140	0.005	3.3	0.149	0.008	5.6	17.5	**p < 0.05**
Flight duration, s	0.021	0.005	25.2	0.016	0.012	73.8	38	p > 0.05
Foot placement angle, degrees	70.43	2.15	3.1	70.37	1.22	1.7	43	p > 0.05
Take-off angle, degrees	59.96	1.91	3.2	59.84	1.92	3.2	48	p > 0.05
Knee joint angle during foot placement on support, degrees	178.54	1.26	0.7	178.73	0.70	0.4	49	p > 0.05
K_a	0.65	0.03	4.1	0.63	0.03	5.3	27	p > 0.05

* Mann–Whitney criterion was used

The level of sports results of each group of athletes differed in the range of approximately 52 s at statistically significant differences ($p < 0.01$) and were as follows: the first group (athletes of the first category) – $\bar{x}$ = 9:57 (S = 0:17), the second group (athletes of the second category) – $\bar{x}$ = 10:49 (S = 0:14). Of note, the athletes of both groups did not differ in age, height, and body mass ($p > 0.05$).

The result in race walking or the average speed of movement depends on stride length and frequency, which are fundamental characteristics in assessing the technique of athletes (Broďani, Šelinger, Vavak, 2011; Hoga-miura, Hirokawa, Sugita, 2017; Caporaso, and Grazioso, 2020).

Table 1 shows that the average indices of stride length in the athletes of the first group were 1.07 m (S = 0.03), which is much higher than that in the athletes of the second group – 1.01 m (S = 0.03) ($p < 0.01$).

At the same time, no significant differences were found in the values of stride frequency, which in the first and second groups were 3.14 and 3.06 stride·s^{-1}, respectively ($p > 0.05$).

Let us consider which components contribute to stride length increase (Fig. 1).

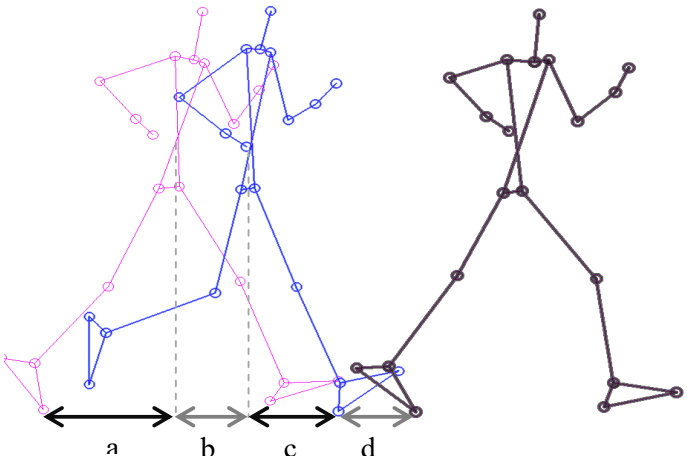

Figure 1. Measurement of stride length constituents: a – rear stride; b – flight distance; c – front stride; d – support transition (foot length)

Table 1 shows that the stride length increase in athletes of the first group mainly occurs at the expense of the flight length, which is 4 cm more than in athletes with lower sports results at statistically significant differences ($p < 0.05$). Of note, the flight duration in more highly qualified athletes averaged 0.021 s (S = 0.005), whereas in the second group it was 0.016 s (S = 0.012) at no statistically significant differences in this index ($p > 0.05$). The same is true for the indices of the angles of foot placement on the ground and take-off, which in athletes of both groups are approximately 70° and 60°, respectively. These data indicate that the athletes of the first group achieve a longer stride length owing to more active forward motion and rotation in the hip joint. Thus, the examined athletes of higher qualification at the age of 13–15 years achieve a longer stride length mainly owing to more efficient technique rather than an advantage in the level of physical capacity development.

Let us consider the prospects of improving the level of results of the first group athletes by comparing their technique characteristics with those of the athletes of higher qualification at the following stages of long-term preparation. For example, the leading juniors of Ukraine, who have the results of the highest world level at the age of 18–19 years at the stage of specialized basic training at a 10 km distance, achieve high results at a slightly higher average speed owing to the same stride length of 1.07–1.08 m at the same value of the coefficient of anthropometric data usage (ratio of stride length and height) of 0.65 but much higher frequency, i.e., close to

3.25–3.30 stride·s^{-1} (Sovenko, Danilyuk, 2017). In the world best juniors, these indices are approximately 1.10 m and 3.40 stride·s^{-1} (Hanley, Bissas, Drake, 2014), respectively, which correspond to the high world level of adult athletes covering twice as long distance – 20 km. The winners of the major world forums reach the indices of 1.14–1.19 m and 3.40–3.47 stride·s^{-1}, which depend on the individual characteristics of athletes (Hanley, Bissas, Drake, 2011).

Let us consider what changes have occurred in the technique of the two best Ukrainian athletes who were at the stage of preliminary basic preparation three to five years later at the next stage of long-term training. The first athlete (Sh-ka) at the age of 13, 16, and 17 (i.e., her age corresponded to the beginning of the stages of preliminary basic and specialized basic preparation) competed at the distances of 2, 5, and 10 km, respectively, setting a new record of Ukraine for girls – 46:09. The second athlete (K-yan) at the age of 14 and 18, i.e., the age corresponded to the middle of the stages of preliminary basic and specialized basic preparation. The athlete competed in distances of 2 and 10 km, respectively (Table 2).

Table 2. Dynamics of the technique biomechanical characteristics of female athletes specializing in race walking at the basic stages of long-term training

Index		Athlete, age (years), distance				
		Sh-ka			K-yan	
		13	16	17	14	18
		2 km	5 km	10 km	2 km	10 km
Result		09:27	23:22	46:09	09:39	47:39
Height, m		1.62	1.68	1.70	1.6	1.69
Body mass, kg		40	50	52	41	50
Average speed	m·s^{-1}	3.53	3.57	3.61	3.45	3.50
	km·h^{-1}	12.70	12.84	13.00	12.44	12.59
Stride length, m		1.08	1.07	1.07	1.06	1.08
Rear stride length, m		0.33	0.38	0.40	0.39	0.37
Flight length, m		0.23	0.18	0.20	0.14	0.18
Front stride length, m		0.27	0.27	0.20	0.28	0.27
Length of support transition, m		0.25	0.25	0.26	0.25	0.27
Stride frequency, stride·s^{-1}		3.28	3.33	3.39	3.25	3.23
Duration of one stride, s		0.31	0.30	0.30	0.31	0.31
Single support duration, s		0.28	0.27	0.26	0.29	0.28
Duration of absorption in single support phase, s		0.14	0.12	0.12	0.14	0.12
Flight duration, s		0.03	0.04	0.04	0.02	0.03
Foot placement angle, degrees		71.54	68.62	71.07	65.82	69.66
Take-off angle, degrees		60.88	61.46	57.56	57.85	59.91
Knee joint angle during foot placement on support, degrees		178.50	179.06	179.25	175.89	178.30
K_a		0.66	0.64	0.63	0.66	0.64

Table 2 shows that these athletes achieved high and quality indicators of stride length and frequency at the stage of preliminary basic preparation at the ages of 13 and 14 years old, respectively. In the next stage, along with a slight improvement of these characteristics (stride frequency in one athlete and stride length in the other) and much better physical fitness, they managed to achieve high-level results at longer distances of 5 and 10 km. At the same time, technical preparation did not stay static because the number of kinematic indices improved, the values of which are gradually approaching the technique of the world best athletes. For example, the duration of absorption in the support phase increased to 0.12 s in both athletes. The flight duration also increased to 0.03 and 0.04 s, respectively. Further improvement of this index may compromise race walking technique economy and become a basis for violation of competition rules (Gomez-Ezeiza et al., 2018). Athletes significantly improved the knee joint angle at the time of foot placement on the ground, which reached qualitatively new values of 179.25° and 178.30°.

Discussion

Previous studies (Matveyev, 1010; Pavei et al., 2014; Platonov, 2015) indicate that the formation and improvement of athletes' technical skills are the priority areas for optimizing the process of long-term training of athletes in various sports events. Of note, the prerequisites for improving the training process, and technical aspects in particular, are created based on knowledge about the technique of athletes' competitive activity.

In addition, the analysis of special scientific and methodological literature revealed (Amara, Mkaouer, 2020; Hanley, Bissas, Drake, 2014; Hoga-miura, Hirokawa, Sugita, 2017) that the stage of preliminary basic preparation, which includes 13–15-year-old female athletes, is the least studied stage from the standpoint of the technique of competitive exercise performance in the structure of long-term training of race walkers.

On the basis of conducted studies, an analysis of competitive activity technique of athletes specializing in race walking at the stage of preliminary basic preparation according to the basic kinematic characteristics was

made. This study expanded the knowledge about the technique of competitive exercise performance by this contingent of athletes and created the prerequisites for improving their training process and strategy of long-term preparation.

A detailed analysis of the technique of competitive exercise performance by 13–15year-old athletes showed that they reach significant values of stride length – approximately 1.07 m at 2 km distance. Of note, in terms of this measure, they are hardly inferior to adult athletes of high national level, competing at 20 km distance (Sovenko et al., 2018). Thus, the stage of preliminary basic preparation is an important period for the formation of the basics of the technique of athletes specializing in race walking during which its key elements are established.

Conclusions

The main kinematic characteristics of the technique of 13–15-year-old athletes specializing in race walking at the stage of preliminary basic preparation were analyzed.

It was determined that for the level of results at a distance of 2 km equal to $\bar{x}$ = 9:57 (S = 0:17), the average speed at that distance was 3.35 $m \cdot s^{-1}$ (S = 0.10), average stride length – 1.07 m (S = 0.03), stride frequency – 3.14 $stride \cdot s^{-1}$ (S = 0.08), duration of the support phase – 0.298 s (S = 0.011), that of flight – 0.021 (S = 0.005), angle of foot placement on the ground – 70.43° (S = 2.15), and that of take-off – 59.96° (S = 1.91).

Comparison of the technique biomechanical characteristics of these athletes with those in the subsequent stages of long-term training revealed that the athletes achieve high basic indices of technique at the age of 13–15 years at the stage of preliminary basic preparation. In the process of long-term improvement, the stride length and frequency are formed (but at shorter competitive distances from 2 to 10 km), which practically reach the values of adult athletes of the high national level at distances of 20 and 50 km.

Reaching a certain level of sports results by female race walkers at the age of 13–15 years old does not provide sufficient comprehensive information even for an experienced coach about the training process efficiency. Therefore, at this age, the task of achieving certain model indices of competitive exercise technique (which at the subsequent stages of long-term preparation along with high physical loads will become the basis for achieving sports results of high world level) should be the primary focus.

The results of the analysis of female athletes' competitive activity allow to identify and use the most effective special and auxiliary means of technical training of female athletes specializing in race walking at the stage of preliminary basic preparation.

Conflict of interest

The author declares that there is no conflict of interest.

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