TECHNIQUE CHARACTERISTICS OF ATHLETES AGED 13–15 YEARS SPECIALIZED IN RACE WALKING AT THE STAGE OF PRELIMINARY BASIC PREPARATION

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Abstract. The analysis of the technique of performing a competitive exercise by athletes aged 13–15 years, who specialize in race walking at the stage of preliminary basic training is the basis for further optimization of technical training, both at this and the following stages of long-term improvement. *The objective* of the study was to determine the main kinematic characteristics of the technique of athletes specialized in race walking at the stage of preliminary basic training. *Methods*. The kinematic characteristics of the technique of 31 athletes (age – 14,68 years; S = 0,65) at a distance of 3 km at the championships of Ukraine in race walking 2016–2021, as well as the individual dynamics of these indices in two athletes at the stage of specialized basic preparation at a 10 km distance were analyzed. *Results*. To achieve the level of results at a distance of 3 km – 14:11 (S = 0:22), the average speed at the distance constitutes 3,53 m·s^{-1} (S = 0,09), stride length – 1,13 m (S = 0,05), stride frequency – 3,13 stride·s^{-1} (S = 0,12), the duration of the support phase – 0,289 s (S = 0,016), and that of flight – 0,032 s (S = 0,010). The knee joint angle during foot placement on support constituted 179,70º (S = 1,59), the angle of foot placement on support – 69.99º (S = 1,48), and the take-off angle – 60,78º (S = 1–34). *Conclusions*. The values of technique biomechanical characteristics of athletes aged 13–15 years at the stage of preliminary basic preparation reach high indices and approach those of junior and adult athletes of high national level at distances of 10 and 20 km, respectively. The age of 13–15 years for athletes who specialize in race walking is important for the formation of the basic elements of technique, namely the stride length and frequency and the main kinematic characteristics that affect their values, and should be taken into account when designing their process of technical preparation and long-term improvement strategy in general.

Keywords: stage of preliminary basic preparation, athletes specializing in race walking, kinematic characteristics of technique.

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ХАРАКТЕРИСТИКИ ТЕХНІКИ СПОРТСМЕНІВ 13-15 РОКІВ, ЯКІ СПЕЦІАЛІЗУЮТЬСЯ У СПОРТИВНІЙ ХОДЬБІ, НА ЕТАПІ ПОПЕРЕДНЬОЇ БАЗОВОЇ ПІДГОТОВКИ

Анотація. Аналіз техніки виконання змагальної вправи спортсменів віком 13–15 років, які спеціалізуються у спортивній ходьбі, на етапі попередньої базової підготовки є основою для подальшої оптимізації технічної підготовки, як на цьому, так і на наступних етапах багаторічного вдосконалення. *Мета* – визначити основні кінематичні характеристики техніки спортсменів, які спеціалізуються у спортивній ходьбі, на етапі попередньої базової підготовки. *Методи*. Проаналізовано кінематичні характеристики техніки 31 спортсмена (вік – 14,68 року; S = 0,65) на дистанції 3 кілометри на чемпіонатах України зі спортивної ходьби 2016–2021 років, а також індивідуальна динаміка цих показників у двох спортсменів на етапі спеціалізованої базової підготовки на дистанції 10 кілометрів. *Результати*. Для досягнення рівня результатів на дистанції 3 кілометри – $\bar{x}$ = 14:11 (S = 0:22), середня швидкість на дистанції становить 3,53 м·с$^{-1}$ (S = 0,09), довжина кроку – 1,13 м (S = 0,05), частота кроків – 3,13 крок.·с$^{-1}$ (S = 0,12), тривалість фази опори – 0,289 с (S = 0,016), польоту – 0,032 с (S = 0,010). Величина кута в колінному суглобі в момент постановки ноги на опору становила 179,70º (S = 1,59), кута постановки ноги на опору – 69,99º (S = 1,48), кута відштовхування – 60,78º (S = 1,34). *Висновки*. Величини біомеханічних характеристик техніки спортсменів віком 13–15 років на етапі попередньої базової підготовки досягають високих показників і наближаються до величин спортсменів-юніорів і дорослих атлетів високого національного рівня на дистанціях 10 та 20 кілометрів відповідно. Вік 13–15 років для спортсменів, які спеціалізуються у спортивній ходьбі, є важливим для формування основних елементів техніки, а саме довжини та частоти кроків і основних кінематичних характеристик, що впливають на їх величини, і має враховуватись під час побудови процесу їхньої технічної підготовки та стратегії багаторічного вдосконалення загалом.

Ключові слова: етап попередньої базової підготовки, спортсмени, які спеціалізуються у спортивній ходьбі, кінематичні характеристики техніки.

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Introduction. The level of sports results and competition at the world's major race walking competitions are constantly increasing. For instance, four of the five all-time best results in race walking, including the world record at a distance of 20 km, were shown in the last nine years.

The competitive activity analysis of the world's best athletes shows that at the Olympic Games and World Championships at a distance of 20 km, they tend to use a tactical variant with a gradual increase in speed up to 4,24–4,38 $m \cdot s^{-1}$ (15,26–15,77 $km \cdot h^{-1}$) in the second part of the distance, especially in the last 4–5 km. These indices are close to the average speed required to set a world record [5; 9].

Along with that, there are requirements for the technique of race walking, the compliance of which is monitored by the respective judges [15]. According to the competition rules, there should be no flight phase visible to the human eye, or, in other words, there should always be contact with the support, and the forward (support) leg should be fully extended at the knee joint from the moment of first contact with the ground to passing the vertical [7; 17].

The increase in the speed of race walking in the world's best athletes, and thus the duration of the flight to its critical limits, which can result in disqualification during the competition, pose today important challenges not only before the technology of judging [8; 10; 20; 21] but the coaches in the process of technical preparation as well [11; 16; 24].

At the same time, the requirements for the level of fitness of not only elite race walkers in the second phase of long-term preparation, primarily at the stages of maximum realization of individual capacities and maintenance of higher sportsmanship, but athletes who are in the first phase at the basic stages of long-term preparation as well, are increasing. However, practice shows that during the preparation of young athletes the main attention is often paid to the development of physical qualities, whereas insufficient attention is focused on the training of technique. It should be stressed that it is during this period that the foundation of technical preparation and the correct basics of the technique of performing a competitive exercise is laid. After all, it is reliably known that when the wrong skill is formed, it is much more difficult to retrain it than to teach all over again [2; 4; 6].

Therefore, the study of the technique of competitive exercise performance by race walkers at the stages of the first phase of long-term preparation will allow creating prerequisites for improving the process of technical training in the system of long-term improvement of athletes [19].

One of the most studied stages of the first phase of long-term preparation of race walkers in terms of the technique of performing a competitive exercise is the stage of specialized basic preparation, which involves athletes aged 16–19 years. Studies [12; 14; 23] demonstrate that at a similar speed of covering the distance of 10 km they reach almost the same parameters of stride length and frequency as adult athletes at a distance of 20 km [5; 13]. This indicates that during this period the basis of special technical and physical fitness is laid, which in the future will become the basis for further sports improvement of athletes [19].

The least studied among the stages of the first phase of long-term improvement from the angle of the technique of competitive exercise performance by race walkers remains to be the stage of preliminary basic preparation, which involves athletes aged 13–15 years. Despite the fact that the volume of general preparation means still prevails over the special one, it is at this time that a significant increase in strength occurs and the basis for further improvement of technical skills is laid due to the widespread use of special preparatory exercises [2]. Therefore, a detailed analysis of the technique of competitive exercise performance by this contingent of athletes will become the basis for further improvement of technical preparation and the training process in general, both at the stage of preliminary basic training and the next stages of long-term preparation.

The objective of the study was to determine the main kinematic characteristics of the technique of athletes specialized in race walking at the stage of preliminary basic training.

Methods. Analysis of scientific and methodological literature, video recording with computer analysis of athletes' motor actions, and methods of mathematical statistics were used to solve the set objective.

Biomechanical analysis of the technique of competitive exercise performance by 21 athletes from Ukraine, Hungary, and the Republic of Belarus (age – 14,68 years; S = 0,65) was carried out on the basis of data obtained as a result of our video recording of the Ukrainian Race Walking Championships 2016–2021 at a distance of 3 km, held in the cities of Ivano-Frankivsk and Lutsk, as well as the International Race Walking Competition "Cup "Evening Ivano-Frankivsk"". Some athletes participated in several races, therefore the total number of sports results constituted 31.

In addition, the technique of two athletes was analyzed three and four years later in 2021 at the Ukrainian Championships in Lutsk at a distance of 10 km when they moved to other age categories and a corresponding comparative analysis was made.

The "Lumax" hardware and software complex was used for the analysis of video images, the main technical characteristics and possibilities of which are presented in detail in the publications of the developers [3].

Registration of athletes' body positions during the performance of competitive exercises was made by "Sony HDR-PJ50E" video camera at a speed of 50 frames per second.

In the course of studies, all metrological requirements were taken into account, which allowed correctly placing the camera and minimizing systematic and random errors. To digitize the movements of athletes' biolinks, a human body model consisting of 20 points was used, with a clear sequence of plotting points.

Data on the age and anthropometric characteristics of athletes (height and body mass) were obtained from the official website of the Athletics Federation of Ukraine, as well as during the survey at the competitions.

Statistical analysis. According to the level of results, kinematic characteristics of the technique, age, and anthropometric data, indices of descriptive statistics were determined: arithmetic mean ($\bar{x}$), standard deviation (S) and coefficient of variation (V). Licensed MS Excel software was used for the analysis. The significance of differences between the groups according to the data obtained was assessed

using the non-parametric Mann–Whitney test for independent samples (U) at the significance level of p = 0,05. Statistical processing was performed using Statistica 14.0.0.15 software (TIBCO Software, USA).

Results. The technique of 21 race walkers was analyzed, while the number of sports results constituted 31. In general, the average level of athletes' results was 14:45 (S = 00:38), height 1,69 m (S = 0,08), and body mass 54,19 kg (S = 7,04).

In the course of the study, the athletes were conventionally divided into two groups, each of which was homogeneous in terms of results, age, height, and almost all biomechanical characteristics, as evidenced by the value of the coefficient of variation, which did not exceed 10%. The only exceptions were the characteristics of the length and duration of the flight in both groups, and the body mass in the second group (Table 1).

The level of sports results of each group of race walkers differed in the range of about 1 min 3 s with statistically significant differences (p < 0,01) and constituted – $\bar{x}$ = 14:11 (S = 00:22) and – $\bar{x}$ = 15:14 (S = 00:21) in the first and the second group, respectively. It is important to note that athletes of both groups did not differ in height (p > 0,05). A slight difference was observed in age – 15 and 14,41 years in the first and second groups, respectively. There was a significant difference in body weight: in athletes of the first group it was 5,25 kg more, which is quite typical for boys of this age category (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 evaluating athletes' technique [2].

As seen in Table 1, the average stride length in athletes of the first group was 1,13 m (S = 0,05), which is significantly higher than in those of the second group – 1,05 m (S = 0,04) (p < 0,01). Along with that, there were no differences in the values of stride frequency, which in the first and second groups were 3,13 and 3,14 stride-s^{-1}, respectively (p > 0,05).

Thus, more skilled race walkers of the first group achieve higher indices of the speed of covering the distance and sports results at the expense of increased stride length. At the same time, the values of the coefficient of use of anthropometric data Ka (the ratio of stride length and height) in athletes of the first group are also at a higher level in relation to representatives of the second group $\bar{x}$ = 0,66 (S = 0,02) and $\bar{x}$ = 0,63 (S = 0,03), respectively at statistically significant differences (p < 0,05).

Let's consider due to which components that make up the stride length the sports result mainly increased (Fig. 1).

We can observe from Table 1 that stride length increase in the first group athletes occurs mainly at the expense of the length of rear stride and flight at statistically significant

Table 1

Biomechanical characteristics of the technique of athletes specialized in race walking at the stage of preliminary basic training at a distance of 3 km (n = 31)

Index		Group						U*	p
		I (n = 14)			II (n = 17)				
		$\bar{x}$	S	V	$\bar{x}$	S	V		
Result		14:11	00:22	2,5	15:14	00:21	2,3	0	**p < 0,01**
Age, years		15,00	0,00	0	14,41	0,80	5,5	63	**p < 0,05**
Height, m		1,72	0,06	3,5	1,67	0,09	5,2	75	p > 0,05
Body mass, kg		57,07	5,03	8,8	51,82	7,68	14,8	65	**p < 0,05**
Average speed	$m \cdot s^{-1}$	3,53	0,09	2.6	3,28	0,07	2,3	0	**p < 0,01**
	$km \cdot h^{-1}$	12,70	0,33		11,82	0,27			
Stride length, m		1,13	0,05	4,5	1,05	0,04	4,3	19	**p < 0,01**
Rear stride length, m		0,39	0,03	8,1	0,37	0,03	9,2	67	**p < 0,05**
Flight length, m		0,19	0,04	19,9	0,14	0,07	48,1	48	**p < 0,01**
Front stride length, m		0,27	0,02	8,7	0,26	0,05	18,8	108	p > 0,05
Length of support transition, m		0,28	0,02	5,4	0,28	0,02	6,9	91	p > 0,05
Stride frequency, $stride \cdot s^{-1}$		3,13	0,12	3,8	3,14	0,12	4,0	115	p > 0,05
Duration of single support phase, s		0,289	0,016	5,4	0,298	0,021	7,1	83	p > 0,05
Duration of absorption in support phase, s		0,129	0,008	6,0	0,137	0,013	9,3	76	p > 0,05
Duration of realization in support phase, s		0,159	0,015	9,4	0,161	0,012	7,6	108	p > 0,05
Flight duration, s		0,032	0,010	31,8	0,021	0,014	64,4	67	**p < 0,05**
Foot placement angle, degrees		69,99	1,48	2,1	70,82	1,90	2,7	90	p > 0,05
Take-off angle, degrees		60,78	1,34	2,2	61,68	1,76	2,8	99	p > 0,05
Knee joint angle during foot placement on support, degrees		179,70	1,59	0,9	179,71	1,40	0,8	114	p > 0,05
Knee joint angle at the moment of vertical, degr.		182,09	1,66	0,9	181,95	1,67	0,9	115	p > 0,05
Ka		0,66	0,02	3,5	0,63	0,03	5,0	58	**p < 0,05**

*Note: * – Mann – Whitney test.*

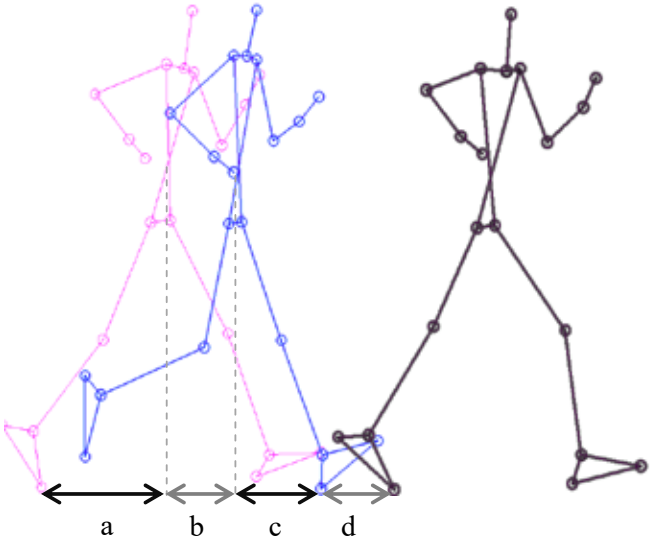

Fig. 1. Measurement of stride length constituents: a – rear stride; b – flight distance; c – front stride; d – support transition (foot length)

differences $p < 0,05$ and $p < 0,01$, respectively. For instance, the indices of rear stride and the flight in athletes of the first group are 2 cm and 5 cm higher than in athletes of the second group. It is noteworthy that the duration of the flight in more highly skilled athletes averaged 0,032 s (S = 0,01), whereas in the second group – 0,021 s (S = 0,014) at statistically significant differences ($p < 0,05$). It should be underscored that the duration of the flight does not reach the critical values of 0,04–0,05 s, and the indices of the knee joint angles during foot placement on the support and at the moment of vertical in athletes of both groups, which were close to 180–181° and 184–185°, respectively, corresponded to the competition rules.

The angles of foot placement on the support and the take-off in athletes of both groups constituted about 70 and 60°, respectively, and had no significant differences.

Let's consider using the example of the two best athletes of Ukraine among juniors of 2021 (K-yi and R-ak), what changes took place in their technique at the end of the specialized basic training stage at the age of 18–19 years old, in comparison with similar data at the end of the stage of preliminary basic training at the age of 15 years (Table 2).

As Table 2 shows, at the end of the stage of the preliminary basic preparation the race walkers K-yi and R-ak at the age of 15 years reached rather high indices of stride length – 1,16 and 1,12 m, while their values of the coefficient of use of anthropometric data corresponded to the level of the best adult athletes of Ukraine and constituted 0,67 and 0,68.

During the next stage of specialized basic preparation, while improving both stride length and frequency, it was possible to achieve higher results already at a longer distance of 10 km: the average speed of the distance covering improved from 3,53 to 3.83 $m \cdot s^{-1}$ in K-yi and from 3,60 to 3,82 $m \cdot s^{-1}$ in R-ak.

The increase in stride length to 1,18 and 1,14 m mainly occurred at the expense of flight length increase to 0,26 and 0,24 m. At the same time, if the duration of the flight 0,04 s did not change in R-ak, then in K-yi it increased from 0,035 s to the critical mark of 0,048 s, which can be the basis for violation of the competition rules. Indices of the coefficient of use of anthropometric data in athletes remained at a high level, while their height increased by 5 cm.

The improvement of stride frequency was characterized by a decrease in the duration of the single support phase from 0,295 to 0,260 s in K-yi and from 0,270 to 0,258 s in R-ak.

Discussion. Studies [1; 4; 22] demonstrate that the formation and improvement of technical skills of athletes is one of the priority directions for optimizing the process of long-term preparation of athletes in various sports events. At the same time, the prerequisites for improving the training process and technical preparation, in particular, are created on the basis of knowledge about the technique of athletes' competitive activity.

Along with that, the analysis of special scientific and methodical literature [12; 13; 23] showed that research on the technique of performance of race walking are mainly focused on the study of characteristics of juniors and adult athletes. At the same time one of the least studied from this position in the structure of long-term preparation of athletes specializing in race walking, is the stage of the preliminary basic preparation, which involves athletes aged 13–15 years.

As a result of our studies, an analysis of the competitive activity technique of athletes who specialize in race walking at the stage of preliminary basic preparation was made according to the main kinematic characteristics. This expanded the understanding of the technique of competitive exercise performance by this contingent of athletes and created the prerequisites for improving their training process and the strategy of long-term preparation in general.

Thus, a detailed analysis of the technique of competitive exercise performance by athletes aged 13–15 years showed that the best athletes covering a distance of 3 km at an average speed of 3,50–3,74 $m \cdot s^{1}$ achieve higher results due to high values of stride length 1,13–1,20 m, with stride frequency close to 3,10–3,30 $stride \cdot s^{-1}$. At the same time, the coefficient of use of anthropometric data (the ratio of stride length and height) reaches high values – Ka = 0,65–0,68.

Comparing the characteristics of the technique with athletes of higher skill levels at the next stages of long-term

Table 2

Individual dynamics of the technique kinematic characteristics of athletes specializing in race walking at the basic stages of long-term preparation

Index		Athlete, age years, distance			
		K-yi		R-ak	
		15	19	15	18
		3 km	10 km	3 km	10 km
Result		0:14:10	0:43:28	0:13:53	0:43:41
Height, m		1,73	1,78	1,65	1,70
Body mass, kg		60	68	59	69
Average speed	$m \cdot s^{-1}$	3,53	3,83	3,60	3,82
	$km \cdot h^{-1}$	12,71	13,80	12,97	13,74
Stride length, m		1,16	1,18	1,12	1,14
Rear stride length, m		0,40	0,38	0,40	0,37
Flight length, m		0,22	0,26	0,20	0,24
Front stride length, m		0,27	0,25	0,24	0,25
Length of support transition, m		0,27	0,29	0,28	0,28
Stride frequency, $stride \cdot s^{-1}$		3,03	3,24	3,23	3,35
Duration of single support phase, s		0,295	0,260	0,270	0,258
Duration of absorption in support phase, s		0,125	0,120	0,120	0,120
Duration of realization in support phase, s		0,170	0,140	0,150	0,138
Flight duration, s		0,035	0,048	0,040	0,040
Foot placement angle, degrees		67,68	69,06	68,53	69,59
Take-off angle, degrees		59,37	60,89	61,25	60,52
Knee joint angle during foot placement on support, degrees		179,67	180,77	181,57	179,97
Knee joint angle at the moment of vertical, degr.		184,23	183,67	185,24	185,34
Ka		0,67	0,66	0,68	0,67

preparation, it was found that the stage of preliminary basic training is an important period of formation of the basics of the technique of athletes specializing in race walking during which its key elements are laid.

Research data [18] on the best juniors of Ukraine, who have high level results at the age of 18–19 years at the stage of specialized basic preparation and already cover a distance of 10 km, indicate that they achieve high results at a slightly higher average speed of 3, 80–3,94 $m \cdot s^{-1}$ at the expense of the same stride length 1,13–1,19 m with the same value of the coefficient of use of anthropometric data (the ratio of stride length and height) Ka = 0,65–0,66, but a higher frequency close to 3,20–3,50 $stride \cdot s^{-1}$. In adult athletes who already cover twice as long distance – 20 km, at a speed of 4,17–4,19 $m \cdot s^{1}$ these indices reach 1,22–1,23 m and 3,40–3,43 $stride \cdot s^{-1}$, Ka = 0,68–0,69.

The results of studies [12; 13] show that the best junior athletes of the world at a speed of 4,10–4,30 $m \cdot s^{-1}$ have a stride length and frequency of about 1,23–1,30 m and 3,13–3,55 $stride \cdot s^{-1}$, respectively, which correspond to the high world level of adult athletes, who at a similar speed reach the indices of 1,27–1,35 m and 3,03–3,35 $stride \cdot s^{-1}$.

Comparing the data of boys at a distance of 3 km with the previously published data of girls at a distance of 2 km [19], we note that the improvement of the level of results for both boys and girls is mainly due to the step length. At the same time, no difference in the steps length and frequency were found between boys and girls at the same speed of movement. The proportions of different parts of a step are the same: back, flight, front and transition of support, which in boys and girls are 34,5:16,8:23,9:24,8% and 34,6:16,8:24,3:24,3% respectively. However, a significant difference is observed in the length and weight of the body: for boys they are 1,72 m and 57,07 kg, respectively, and for girls – 1,64 m and 46,67 kg.

It should be noted that both in our studies and the researches of other authors, a rather considerable variation of stride length and frequency at different stages of long-term preparation is observed depending on individual peculiarities of athletes.

Conclusions. The main kinematic characteristics of the technique of athletes aged 13–15 years specialized in race walking at the stage of preliminary basic preparation were analyzed.

It was found that for the level of results at the distance of 3 km – 14:11 (S = 0:22), the average speed at the distance constituted 3,53 $m \cdot s^{-1}$ (S = 0,09). The average stride length and frequency constituted 1,13 m (S = 0,05) and 3,13 $stride \cdot s^{-1}$ (S = 0,12), respectively. The duration of the support phase was 0,289 s (S = 0,016), whereas that of flight – 0,032 s (S = 0,010). The value of the coefficient of use of anthropometric data was equal to 0,66 (S = 0,02). The value of the knee joint angle during foot placement on the support constituted 179,70° (S = 1,59), that of foot placement on the support – 69,99° (S = 1,48), and that of take-off – 60,78° (S = 1,34).

Comparing the biomechanical characteristics of the technique of athletes at the stage of preliminary basic training at the age of 13–15 years with those of athletes at the next stages of long-term preparation, it was found that they achieve high basic indices of the technique of competitive exercise performance, namely the stride length and frequency.

The achievement of a certain level of sports results by athletes at the age of 13–15 years old, who specialize in race walking, does not provide enough comprehensive information about the training process efficiency even for an experienced coach. Therefore, at this age, the tasks of achieving certain model indices of the technique of a competitive exercise performance, which at the next stages of long-term training, along with high physical loads, will become the basis for achieving high world-class sports results, should be put in the forefront.

The results of the analysis of race walkers' competitive activity, afford ground for the search and use of the most effective special and auxiliary means of technical preparation of race walkers at the stage of preliminary basic training.

Conflict of interest. The authors declare no conflict of interest.

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