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New Studies in Athletics

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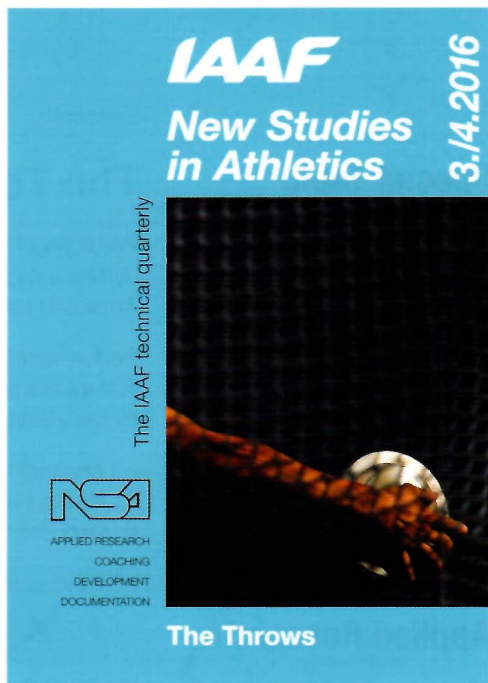
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Technique and Tactics of Elite Male Race Walkers

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by Sergey Sovenko

ABSTRACT

Performance level and overall competitiveness in the men's 20km race walk have both increased in recent years. The demands on athletes aspiring to top-level success are also increasing, necessitating in-depth analysis of the event as the basis for further improvement. The paper presents data on the variants of tactics used by the world's elite and the biomechanical characteristics of the top athletes at 2014-2016 Ukrainian national championships. The author's findings include that major championship medallists cover the second half of the race at high velocity (4.26–4.38 m·s⁻¹) and performance improves due to increases in stride length and frequency and a decrease in absorption time. He concludes that the following methodical approaches should be developed: a) optimum expansion of the volume of race walking at competitive and higher velocity with an accentuation on stride length increase, 2) use of race walking at varying velocities aimed at developing the ability for gradual and sharp velocity increases in the last segments of the race, 3) searching for and using the most efficient special and auxiliary means (of strength, speed-strength, coordination direction, etc.) aimed at a more effective take-off and enhanced hip joint mobility.

AUTHOR

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Introduction

The world record for the men's 20km race walk was lowered twice in 2015, first to 1:17:02 by Yohann Diniz (FRA) and then to 1:16:36 by Yusuke Suzuki (JPN), a performance spike that was accompanied by increased competitiveness in the event at major competitions. For instance, at the 2016 Olympic Games in Rio de Janeiro, at the 18km mark the lead group still comprised five athletes and, in the end, winner Zhen Wan (CHN) was only 12 seconds ahead of the runner-up Cai Zelin (CHN).

This situation means that the demands placed on athletes aspiring to top-level success are increasing, necessitating in-depth analysis as the basis for further improvement^{1,2}. Taking into account the fact that the competition exercise of race walking^{3,4,5} performed within different intensity zones is the major means used in the training process, the consideration of various other preparation aspects – technical,

tactical and, above all, physical – is of tremendous importance. Methodical approaches to the improvement of technico-tactical skills and physical fitness should be substantiated on the basis of analysis of the practice of highly skilled athletes. This will permit coaches to make informed and rational selection of the most effective training means and decide on their distribution within the annual preparation structure.

There are few studies^{6,7,8,9,10} aimed at preferential analysis of the technique and tactics of elite male 20km race walkers that give us a basis for addressing this challenge. This is at least partially due to the fact that the attention of the researchers has been mostly focused on the identification and establishment of specific regularities and their determining characteristics, and only to a lesser extent on finding ways to put them into practice in the training process. This indicates the need for further study².

This study, which was conducted in parallel with a previously published study of female walkers¹², identifies and discusses two areas of concentration for athletes and their coaches wishing to improve performance in the men's 20km race walk: a) pacing and tactics and b) stride length and frequency. It is based on analysis of competition data on the world's top performers and the top Ukrainian athletes.

Methods

Analysis of pacing and tactical variants was made on the basis of statistical materials available on the websites of the International Association of Athletics Federations (IAAF) and the Ukrainian Athletic Federation (UAF).

Biomechanical analysis of the technique of 16 Ukrainian male 20km race walkers was made on the basis of data obtained from video recordings of Ukrainian championships held in Alushta in 2014, Sumy in 2015 and Ivano-Frankovsk in 2016. Most of the athletes participated in more than one of the competitions, which gave us total of 31 performances to analyse.

The body positions of the athletes during the 2014 and 2015 competitions were recorded by "Sony DCR-SR 65" video camera at a rate of 25 frames per second and then separated into 50 half-frames. In 2016 a "Sony HDR-PJ50E" camera recording at a rate of 50 frames per second was used. The biomechanical characteristics of the studied athletes during the competitions in 2014 were determined at three distance points: 2, 10 and 18km and during competitions held in 2015 and 2016 they were determined at four points: 5, 10, 14 and 18km. This study took into account all the metrological requirements, which made it possible to place the camera correctly and to minimise systematic and random errors.

The video images were analysed using "Lumax" hardware and software complex, the main technical characteristics of which are presented in detail in the publications of the developers¹¹. A 20-link model of the human body was used to digitise the kinematics of the athletes' bio-links. It should be noted that the points were plotted in a distinct sequence.

Results and Discussion

Pacing and tactics

Performance in race walking depends on the degree of special endurance manifestation, which is determined by the ability to maintain balance between oxygen demand and uptake for a long period. This has a direct impact on the quality of the athlete's technique at any given moment.

It is known that in endurance events, the achievement of maximum possible performance depends on the maintenance of the highest average velocity for the whole distance³. However, as practice shows, this tactical variant is rarely used by male race walkers at the major international competitions (Figure 1).

It is obvious that in order to achieve a medal or win at a major international competition, athletes should be ready for any tactical variant. As seen in Figure 1, the tactical variant of

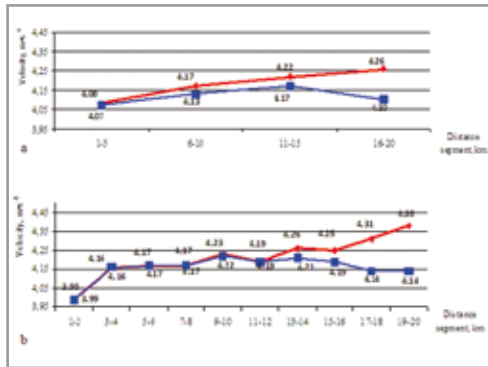


Figure 1: Dynamics of the velocity in the men's 20km race walk ($n=70$) (a – the 2013, 2015, 2016 World Championships in Athletics and the 2012 and 2014 IAAF World Race Walking Cups; b – the 2012 and 2016 Olympic Games);

- Medallists (mean result: IAAF World Championships and Cups – 1:19:44, Olympic Games 1:19:14);
- Athletes who placed 4-10 (mean result: IAAF World Championships and Cups – 1:20:57, Olympic Games 1:20:10)

a consistent pace with a slight drop off after 15-16 kilometres is characteristic for athletes placing from fourth through 10th, but the variant of a relatively slow pace at the beginning of the race and a gradual increase through to the end is common for the world's very top male race walkers. The ability to cover the second half of the distance, and in particular, the last 5km, at a velocity close to 4.26–4.38 m·s⁻¹ is the most distinctive feature of the medallists of the IAAF World Championships in Athletics, the World Cups and the Olympic Games.

Another tactical variant is to draw away in the first kilometres or the middle of the race and then maintain or vary (increase or decrease) the velocity at subsequent distance segments. This approach is rarely seen at the major competitions of recent years although two Chinese female athletes successfully used this tactic at 2015 World Championships in Athletics win-

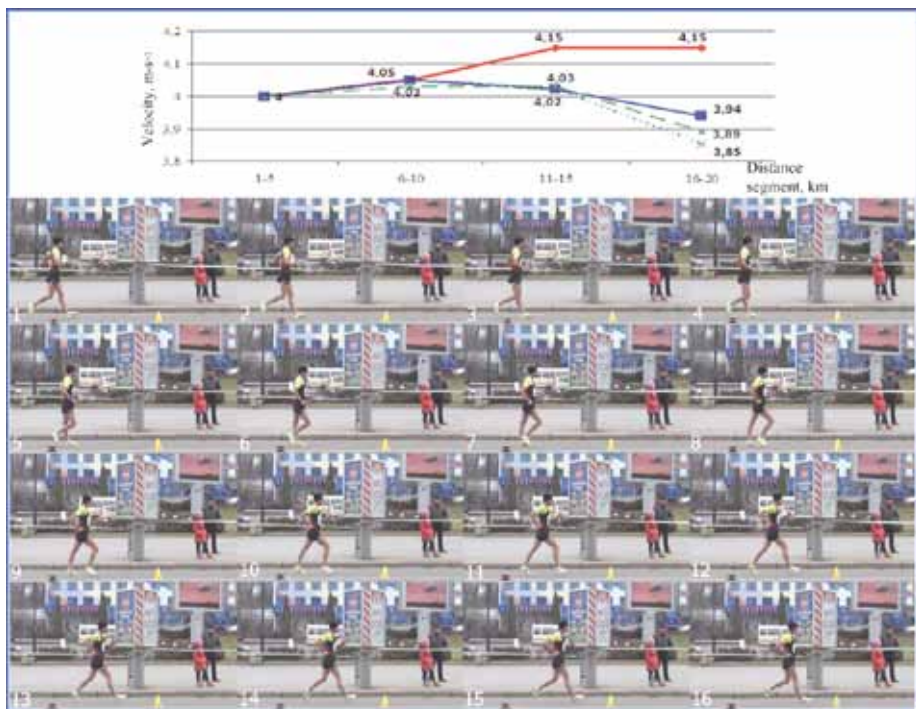


Figure 2: Velocity dynamics of the of the top four athletes in the 20km at the 2016 Ukrainian national championship in Ivano-Frankivsk

- 1st place (result 1:21:31); – 2nd place (result 1:23:17); – 3rd place (result 1:23:32); –X- 4th place (result 1:23:45)

ning the gold and the silver medals. We can speculate that perhaps, the use of this variant is related to estimation of the potentials of the other competitors before the event¹².

Velocity variation may also be selected as a tactical option on the basis of the assessment of the rivals' fitness during the course of competition, with the aim of taking a particular place rather than achieving a maximum possible performance. The victory in the 2016 Ukrainian national championship by Rulsan Dmytrenko, one of the world best athletes, at may illustrate this point (Figure 2). With a lead of about 40 seconds in the 10 to 15km segment and keeping the pace in the last 5km of the distance Dmytrenko managed to increase this advantage more than twice, due to the lack of competition. At the same time, the fight for the second place began at 15km.

Stride length and frequency

Let us now consider the technique characteristics of the best male Ukrainian race walkers at recent national competitions. As seen in Table 1, we divided the athletes into two groups based on their level of their performance - Group I (n=6) – International Masters of Sport - and Group II (n=25) - National Masters of Sport, whose level of performance was lower at statistically significant differences ($p < 0.05$). Both groups were homogeneous in terms of results, anthropometric measurements and the main biomechanical characteristics (stride length and frequency, above all) as evidenced by the value of the coefficient of variation, which did not exceed 10%.

Performance in race walking is directly proportional to the average velocity, which, in turn, depends on stride length and stride frequency. Therefore, identification of these characteristics as well as their ratio represents the basis for evaluation of the technique of race walking. In order to achieve world level results in the men's 20km, the indices of stride length and stride frequency should be in the range of 1.23 to 1.26m and 3.35 to 3.53 strides·s⁻¹, respectively^{6,7,9}. These indices and their ratios will vary in the athletes depending on body height and

foot length as well as the degree of technical and physical fitness¹². In this regard, it should be noted that athletes of both groups did not differ significantly in the main anthropometric indices – body height and mass ($p > 0.05$).

As Table 1 shows, the average stride length in the more accomplished athletes of Group I was 1.22m ($S = 0.02$), significantly exceeding that of Group II – 1.18m ($S = 0.03$) ($p < 0.01$). The values of the coefficient of utilisation of anthropometric data (ratio of stride length and body height) in the Group I athletes were significantly higher ($p < 0.01$) and corresponded to those of the world's best race walkers: $K_a = 0.69$ ($S = 0.01$). Stride frequency in Group I was higher than in Group II – 3.40 strides·s⁻¹ ($S = 0.03$) and 3.29 strides·s⁻¹ ($S = 0.08$), respectively ($S=0.08$) ($p > 0.01$).

The above may be confirmed by characteristics of Andrii Kovenko's technique in achieving different levels of performances (see Table 1 - next page; marked with blue).

Turning to Figure 3 and the main constituents of stride length, Table 1 shows that the increase of stride length in the athletes of Group I



Figure 3: Measurement of stride length constituents: a – rear stride; b – flight distance; c – front stride; d – support transition (foot length) (Projection of the body's centre of mass is marked with the dotted line.)

occurs because of increase of rear stride length ($\bar{X} = 0.44\text{m}$; $S = 0.02$) and flight ($\bar{X} = 0.25\text{m}$; $S = 0.01$) with statistically significant differences to the same indices of athletes of Group II ($p < 0.05$). The increase in these indices depends, to a great extent, on the efficiency of the take-off. More efficient take-off execution by the athletes of Group I is confirmed by the index of its duration $\bar{X} = 0.257\text{ sec}$ ($S = 0.003$), being on the average 0.015 sec better than the athletes of Group II. An important point is that the decrease of take-off time in the Group I athletes mainly occurs because they reduce the time of absorption during single support phase to 0.096 sec as compared to 0.106 sec ($p < 0.01$) in Group II. This is indicative of a higher efficiency of force interaction, with the support conditioned by respective manifestation of speed-strength capacities and special endurance.

Stride length is also influenced by flight duration. The rules of race walking forbid a "visible (to the human eye) loss of contact" with the ground, but for most walkers there is a very brief moment in each stride where contact is lost that can only be seen using video recordings. In the more skilled athletes of Group I this flight phase of each stride is 0.005 sec longer than we see in Group II, which provides an advantage of about 2.0cm in stride length at the average competition velocity. This tendency, however, has no potential for development, as any further increase of the flight phase will result in visual detection by the judges and thus disqualification. Therefore, future studies should consider the hip joint mobility characteristics that also influence the stride length¹⁰.

Looking at the individual indices of Ukrainian athletes in different distance segments we can see that the decrease of velocity as the race progresses in some athletes is mainly a result of stride length reduction, whereas in others it is a consequence of decrease of both stride length and frequency (Table 2).

Conclusions

Employment of the tactical variant of a relatively slow pace at the beginning of the race and gradually increasing velocity by the end is a characteristic of the world's elite male 20km race walkers. The ability to cover the second half of the distance with a velocity of 4.26–4.38 $\text{m}\cdot\text{s}^{-1}$ is a distinctive feature of the medallists at the IAAF World Championships in Athletics, the IAAF World Race Walking Cup and the Olympic Games. Athletes aspiring to world-class must be prepared for this approach to racing.

Increase in the performance of male 20km race walkers to the world level (from 1:26:10 { $S = 0:01:48$ } to 1:20:29 { $S = 0:0:055$ }) occurs with a stride length increase to 1.22m ($S = 0.02$) and a stride frequency increase to 3.40 stride $\cdot\text{s}^{-1}$ ($S = 0.03$), statistically significant differences in these indicators between the more skilled Group I athletes and those athletes (Group II) with lesser performances ($p < 0.01$) in Ukraine. Stride length increase occurs because of increases in rear stride length – $\bar{X} = 0.44\text{m}$; $S = 0.02$ and flight length – $\bar{X} = 0.25\text{m}$; $S = 0.01$ ($p < 0.05$). These are conditioned by a more efficient take-off, which is characterised in Group I athletes by a reduced duration of the single support phase ($\bar{X} = 0.257\text{ c}$; $S = 0.003$), mainly because of a 0.096 sec shorter absorption time.

From these findings we can conclude that the principal task for further improvement of race walkers' technical skills is the determination of the characteristics of force interaction with support, with due account for individual peculiarities of athletes, and the search for the most efficient special and auxiliary means aimed at stride length increase, while maintaining or increasing stride frequency in the last quarter of the distance.

Therefore, the results of the above analysis afford ground for giving high priority to the development of the following methodical approaches to the process of special fitness improvement for the men's 20km race walk:

Table 1: Physical and technique characteristics of highly skilled Ukrainian male 20km walkers (n=31)

Athlete, group	Index																	
	Performance	Height (m)	Body mass (kg)	Average velocity (m·s ⁻¹)	Stride length (m)	Rear stride length (m)	Flight length (m)	Front stride length (m)	Length of support transition (m)	Stride frequency (strides·s ⁻¹)	Duration of one stride (sec)	Single support duration (sec)	Duration of absorption in single support phase (sec)	Flight duration (sec)	Foot placement angle (degrees)	Take-off angle (degrees)	Knee joint angle during foot placement on support (degrees)	K _a
L. I.	1:19:33	1.77	70	4.19	1.22	0.44	0.26	0.24	0.28	3.43	0.29	0.26	0.10	0.03	70.05	58.65	179.07	0.69
K. N.	1:19:46	1.78	69	4.18	1.23	0.47	0.25	0.23	0.28	3.41	0.29	0.25	0.10	0.04	69.65	57.49	179.24	0.69
L. I.	1:20:01	1.81	74	4.17	1.23	0.45	0.24	0.26	0.28	3.39	0.30	0.26	0.10	0.04	71.60	56.77	179.58	0.68
P. K.	1:20:12	1.75	63	4.16	1.24	0.45	0.25	0.27	0.27	3.35	0.30	0.26	0.10	0.04	69.44	57.85	179.15	0.71
K. A.	1:20:20	1.74	68	4.15	1.22	0.42	0.25	0.27	0.28	3.41	0.29	0.26	0.09	0.04	70.86	56.43	179.57	0.70
D. R.	1:21:31	1.81	67	4.09	1.21	0.42	0.24	0.25	0.29	3.39	0.30	0.26	0.10	0.04	69.73	58.48	179.72	0.67
K. A.	1:22:00	1.74	68	4.07	1.19	0.43	0.25	0.21	0.28	3.43	0.29	0.26	0.09	0.04	72.50	56.99	179.35	0.68
I (n=6)	1:20:29	1.77	68.43	4.14	1.22	0.44	0.25	0.25	0.28	3.40	0.294	0.257	0.096	0.037	70.55	57.52	179.38	0.69
S	0:0:55	0.03	3.31	0.05	0.02	0.02	0.01	0.02	0.01	0.03	0.002	0.003	0.002	0.004	1.15	0.85	0.25	0.01
V	1.1	1.7	4.8	1.1	1.4	4.0	2.6	8.5	2.3	0.8	0.8	1.3	2.5	9.6	1.6	1.5	0.1	2.0
K. N.	1:23:17	1.78	69	4.00	1.22	0.40	0.25	0.29	0.28	3.28	0.31	0.27	0.12	0.03	72.17	59.82	179.12	0.69
L. I.	1:23:32	1.77	69	3.99	1.21	0.43	0.21	0.29	0.28	3.29	0.30	0.27	0.11	0.03	71.73	57.80	179.24	0.68
K. N.	1:23:35	1.78	69	3.99	1.21	0.42	0.21	0.30	0.28	3.29	0.30	0.28	0.11	0.03	71.28	58.17	178.46	0.68
K. A.	1:23:45	1.74	68	3.98	1.18	0.38	0.26	0.27	0.28	3.36	0.30	0.27	0.11	0.03	72.57	59.85	178.34	0.68
G. A.	1:24:15	1.75	53	3.96	1.16	0.44	0.26	0.19	0.27	3.40	0.29	0.25	0.10	0.04	74.89	62.37	179.49	0.66
K. A.	1:24:16	1.74	68	3.96	1.17	0.42	0.20	0.28	0.28	3.38	0.30	0.27	0.11	0.03	72.60	59.23	178.99	0.67
S. I.	1:24:29	1.78	65	3.95	1.18	0.42	0.24	0.25	0.28	3.35	0.30	0.27	0.10	0.03	72.09	60.82	179.14	0.66
P. K.	1:24:45	1.75	63	3.93	1.17	0.43	0.24	0.22	0.27	3.38	0.30	0.26	0.11	0.03	72.77	62.44	177.89	0.67
P. K.	1:24:59	1.75	63	3.92	1.18	0.43	0.24	0.23	0.27	3.31	0.30	0.26	0.10	0.04	72.45	59.88	179.36	0.68
S. S.	1:26:05	1.71	61	3.87	1.16	0.40	0.26	0.23	0.27	3.33	0.30	0.26	0.10	0.04	73.40	59.33	177.82	0.68

Athlete, group	Index																	K _a
	Performance	Height (m)	Body mass (kg)	Average velocity (m·s ⁻¹)	Stride length (m)	Rear stride length (m)	Flight length (m)	Front stride length (m)	Length of support transition (m)	Stride frequency (strides·s ⁻¹)	Duration of one stride (sec)	Single support duration (sec)	Duration of absorption in single support phase (sec)	Flight duration (sec)	Foot placement angle (degrees)	Take-off angle (degrees)	Knee joint angle during foot placement on support (degrees)	
L.V.	1:26:15	1.81	63	3.86	1.21	0.45	0.20	0.27	0.29	3.20	0.31	0.29	0.11	0.02	72.16	60.01	177.56	0.67
V.A.	1:26:29	1.83	70	3.85	1.16	0.42	0.23	0.21	0.29	3.33	0.30	0.26	0.11	0.04	73.87	62.33	178.53	0.63
V.V.A	1:26:33	1.83	59	3.85	1.16	0.39	0.24	0.24	0.30	3.33	0.30	0.28	0.11	0.02	72.21	62.56	177.03	0.63
V.V.A.	1:26:49	1.74	61	3.84	1.18	0.44	0.25	0.21	0.28	3.26	0.31	0.27	0.11	0.04	73.37	59.07	179.97	0.68
D.F.	1:27:08	1.76	73	3.83	1.15	0.38	0.23	0.25	0.29	3.31	0.30	0.27	0.11	0.03	69.43	60.13	178.67	0.66
S.S.D.	1:27:14	1.80	67	3.82	1.14	0.38	0.25	0.23	0.29	3.36	0.30	0.28	0.11	0.02	74.51	61.83	179.16	0.63
L.V.	1:27:31	1.81	63	3.81	1.19	0.44	0.17	0.29	0.29	3.21	0.31	0.29	0.11	0.02	71.11	58.93	177.74	0.66
L.V.	1:27:37	1.81	63	3.80	1.20	0.41	0.23	0.27	0.29	3.16	0.32	0.28	0.11	0.03	70.56	60.93	177.56	0.67
S.S.	1:27:38	1.71	55	3.80	1.14	0.41	0.23	0.23	0.27	3.33	0.30	0.26	0.10	0.04	72.15	59.95	178.03	0.67
V.V.A.	1:27:49	1.74	61	3.80	1.16	0.41	0.22	0.25	0.28	3.27	0.31	0.27	0.11	0.04	71.18	59.78	178.66	0.67
S.S.S.	1:28:16	1.71	55	3.78	1.13	0.42	0.21	0.22	0.27	3.35	0.30	0.26	0.10	0.04	73.76	62.41	179.65	0.66
B.O.	1:28:23	1.92	80	3.77	1.17	0.44	0.16	0.28	0.29	3.23	0.31	0.29	0.12	0.02	73.13	60.26	179.69	0.61
A.K.	1:28:25	1.84	73	3.77	1.23	0.46	0.23	0.23	0.29	3.08	0.33	0.29	0.10	0.04	73.05	59.58	179.11	0.67
A.K.	1:29:00	1.84	73	3.75	1.17	0.44	0.22	0.22	0.29	3.19	0.31	0.28	0.10	0.04	71.89	61.00	179.32	0.64
II (n=25)	1:26:10	1.78	65.17	3.87	1.18	0.42	0.23	0.25	0.28	3.29	0.304	0.272	0.106	0.032	72.43	60.35	178.69	0.66
S	0:01:49	0.05	6.46	0.08	0.03	0.02	0.03	0.03	0.01	0.08	0.008	0.010	0.006	0.007	1.24	1.38	0.79	0.02
V	2.1	2.9	9.9	2.1	2.3	5.7	11.9	12.4	3.3	2.4	2.5	3.7	5.6	21.2	1.7	2.3	0.4	3.0
p*	p<0.01	p>0.05	p>0.05	p<0.01	p<0.01	p<0.05	p<0.05	p>0.05	p>0.05	p<0.01	p<0.01	p<0.01	p<0.01	p>0.05	p<0.01	p<0.01	p>0.05	p>0.01

* – Mann-Whitney criterion was used

Table 2: Kinematic characteristics of the technique of highly skilled Ukrainian male 20km walkers in different distance segments during the 2016 Ukrainian Championships in Ivano-Frankovsk

Place	Time (h:m:s)	Height (m)	Body mass, (kg)	Distance segment, (km)	Characteristics					
					Average velocity, (m·s ⁻¹)	Stride length (m)	Stride frequency, (strides·s ⁻¹)	Single- support duration (sec)	Absorption duration in support-phase (sec)	Flight duration, (sec)
1	1:21:31	67	1.81	1-5	4.00	1.18	3.39	0.26	0.11	0.04
				6-10	4.05	1.21	3.33	0.26	0.10	0.04
				11-15	4.15	1.20	3.45	0.26	0.09	0.04
				16-20	4.15	1.22	3.39	0.27	0.10	0.03
2	1:23:17	69	1.78	1-5	4.00	1.22	3.28	0.27	0.12	0.04
				6-10	4.05	1.21	3.33	0.26	0.11	0.04
				11-15	4.02	1.24	3.23	0.28	0.12	0.03
				16-20	3.94	1.20	3.28	0.28	0.12	0.03
3	1:23:32	69	1.77	1-5	4.00	1.22	3.28	0.27	0.11	0.04
				6-10	4.05	1.21	3.33	0.27	0.11	0.04
				11-15	4.02	1.22	3.28	0.28	0.10	0.03
				16-20	3.89	1.19	3.28	0.28	0.11	0.03
4	1:23:45	68	1.74	1-5	4.00	1.18	3.39	0.27	0.10	0.03
				6-10	4.03	1.23	3.28	0.27	0.11	0.04
				11-15	4.03	1.17	3.45	0.27	0.11	0.03
				16-20	3.85	1.15	3.33	0.28	0.11	0.03
5	1:24:15	53	1.75	1-5	3.94	1.16	3.39	0.26	0.11	0.04
				6-10	3.98	1.18	3.39	0.25	0.10	0.05
				11-15	3.91	1.17	3.33	0.25	0.10	0.05
				16-20	4.00	1.14	3.51	0.25	0.10	0.04
6	1:24:45	63	1.75	1-5	3.95	1.19	3.33	0.26	0.11	0.04
				6-10	3.97	1.17	3.39	0.27	0.11	0.03
				11-15	3.92	1.16	3.39	0.27	0.11	0.03
				16-20	3.89	1.15	3.39	0.27	0.12	0.03
7	1:26:05	61	1.71	1-5	3.85	1.15	3.33	0.27	0.11	0.04
				6-10	3.89	1.17	3.33	0.27	0.11	0.04
				11-15	3.88	1.16	3.33	0.26	0.11	0.04
				16-20	3.89	1.17	3.33	0.26	0.10	0.04
8	1:26:33	59	1.83	1-5	3.95	1.17	3.39	0.28	0.12	0.02
				6-10	3.82	1.16	3.28	0.28	0.12	0.03
				11-15	3.85	1.15	3.33	0.28	0.11	0.03
				16-20	3.80	1.14	3.33	0.28	0.11	0.02
9	1:27:14	67	1.8	1-5	3.86	1.14	3.39	0.28	0.11	0.02
				6-10	3.83	1.13	3.39	0.28	0.11	0.02
				11-15	3.82	1.15	3.33	0.28	0.11	0.02
				16-20	3.77	1.13	3.33	0.28	0.12	0.02

Notes. The last three places were corrected according to the results of athletes, who had competed among the youth

- Optimum expansion of the volume of race walking at competitive and higher velocity with accentuation of stride length increase;
- Use of race walking at varying velocities aimed at developing the ability for gradual and sharp increases in velocity in the last segments of the race;
- Searching for and using the most efficient special and auxiliary means (of strength, speed-strength, coordination direction,

etc.) aimed at a more effective take-off, enhanced hip joint mobility, etc.

These approaches should be further substantiated through future studies.

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