Improving technical fitness of race walkers on the basis of special exercises to focus on key parameters of movements

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Author contribution: A – study design; B – data collection; C – statistical analysis; D – manuscript preparation; E – fundrising

Abstract

Purpose: In race walking, the reliability of competitive activity, the risks of disqualification are determined by athlete's stable control of the key motion characteristics at a distance, especially in the face of fatigue. Therefore, the formation of specialized sensations in an athlete to control these movements is an important condition for sports technique improvement. Hypothesis of study: the use of special exercises to increase the analytical perception of motion key parameters will increase the effectiveness of race walking technique, control for fatigue development. Objective of study: to show the possibilities of increasing special fitness in race walking through the use of special exercises, improvement of the analytical perception of motion key parameters.

Material: 10 athletes aged 17-20 years and engaged in sports training for 4-6 years participated in the study. Special exercises, assessment of race walking technique (video shooting) before and after their performance within three weeks (10 sessions) were used.

Results: it is shown that the targeted use of special exercises with the analysis of subjective sensations creates conditions for the activation in the athlete of specialized perceptions for the basic sports technique elements. After the use of special exercises, the increase in speed was due to an increase in the stride length - 1.14 m (S = 0.04), relative to the initial one - 1.09 m (S = 0.03) ($p < 0.01$). The stride length increase in athletes occurred at the expense of the length of the "rear" stride ($\bar{x}$ = 0.43 м; S = 0.02) at statistically significant differences from the initial indices. This created the prerequisites for improving athletic performance.

Conclusions: Special exercises focusing on key parameters of movements contribute to increase of technical fitness of race walkers. The proposed approach creates the prerequisites for further research on the formation of the motor composition of the skill of body position accuracy, the development of sensations of free movement, inertia, liberation from excessive degrees of freedom in the parts of the body with account for the functional state of the athlete.

Keywords: race walking technique, fatigue, specialized sensations, work capacity increase.

Introduction

An important aspect of race walking training is associated with the improvement of specialized sensations. The characteristics of movement, the formation of skill motor composition during fatigue development are scarcely presented in special literature. Professional sport means early specialization. Much attention is paid during the initial training at motion technical elements. In modern sport, the level of development of specific sensorimotor qualities is the mainstay of sports and technical mastery. Their indices hold the important place in the complex system of functional diagnostics. Race walking is the sports event, which requires a high level of functional preparation, a delicate "muscle sense" and developed "motor memory". Of great importance are the individual feature of the distinctive sensitivity of the main kinematic and dynamic parameters of movement, operative thinking and attention [1].

Considerable attention was paid to the study of psychomotor system in sport. In recent years, there has been an increased interest in the scientific development of diagnostics and formation of psychomotor capacities in highly skilled athletes. It has been demonstrated that "sports" talent is a combination of intellectual and psychomotor capacities that gives a person the opportunity to successfully, independently and originally perform and create in complex sports motor activity [2]. Some works partially reveal the problem of the methods of directional correcting the race walking technique [3]. Studies of the coordination structure and its changes in respect of other informative indices of athletes' fitness are presented; the spatio-temporal organization of movements of skilled race walkers is shown [4]. The educational process involving psychomotor system is sometimes presented as the formation of "motor skills", which requires attention already at the initial stages [1]. Then ensues the cognitive phase of motor skill training with demonstration and gestures, followed by the associative phase. It is long, practical, fixing and autonomous for unconscious realization according to the classification of P. Fitts [5]. There are known methods, in which psychomotor training is demonstrated by physical skills: coordination, dexterity, manipulation, grace, strength, speed and includes educational goals: perception - the ability to use sensory signals to control motor activity; readiness to act - mental, physical and emotional affirmations; guided response - the early stages of learning a complex skill; it includes

doi:10.15561/26649837.2020.0208

imitation, trial and error method [6]. The next method - computer assisted instruction (CAI) is used in educational technology [7]. Today, modern computer assisted instruction of psychomotor skills is used in sports. The development of e-sports educational programs can provide a positive impact on the study of psychomotor skills, assist in finding young sports talents, in track and field included [5]. Such technologies should be used in sports more often [8]. The psychomotor aspects of improving and teaching race walking technique are insufficiently represented in special literature. Activation of psychomotor abilities of athletes is not fully implemented; elaborations for improving the technique of race walking and training are scarcely represented [9]. This area of studies is quite actual, since the IAAF Council decided (March 2019, Doha) to introduce technology (RWECS) to assist judges in identifying athletes who have lost contact with the ground. The trials on the introduction and distribution of chips in the insoles of athletic shoes of athletes competing in race walking are near completion.

Hypothesis of study: special exercises tend to activate the athlete's analytical perception of motion key parameters. This increases the efficiency of race walking technique. The determinants of the "sense of differentiation and presentation" of the motion temporal characteristics are specified: duration, pace, rhythm, speed, time sequence of movements. *Objective of study*: to show the possibility of increasing special fitness in race walking while using special exercises, improving the athlete's analytical perception of motion key parameters.

Material and methods

Participants

The study involved 10 athletes aged 17-20 years (males) and engaged in sports training for 4-6 years: one Candidate Master of Sports, six first-rate and three second-rate athletes.

All athletes agreed to participate in the experiment.

Organization of study.

Video shooting was used. The "Lumax" hardware-software complex was used for video content analysis, the main technical characteristics and capabilities of which are detailed in the publications of the developers [10]. The registration of the body positions of athletes during competitive exercise performance was carried out by "Sony HDR-PJ50E" video camera at a speed of 50 frames per second. All metrological requirements, the placement of the camera were taken into account, which minimized systematic and random errors. A 20-link model of human body was used to digitize the kinematics of athletes' biolinks. Point interpolation had a standard sequence. The result in race walking is directly proportional to the average speed of movement and depends on stride length and frequency. These parameters and their ratios are the main characteristics for assessment of race walking technique [4, 9].

Fig. 1 illustrates the main constituents of stride length in race walking.

Realization of the study objectives required elaboration of exercises for the development of specialized sensations in race walkers. They are focused on improving the analytical perception of motion key technical parameters in this sports event.

During three weeks of the preparatory period of training, three technical, specially targeted sessions per week have been conducted (10 sessions every other day)

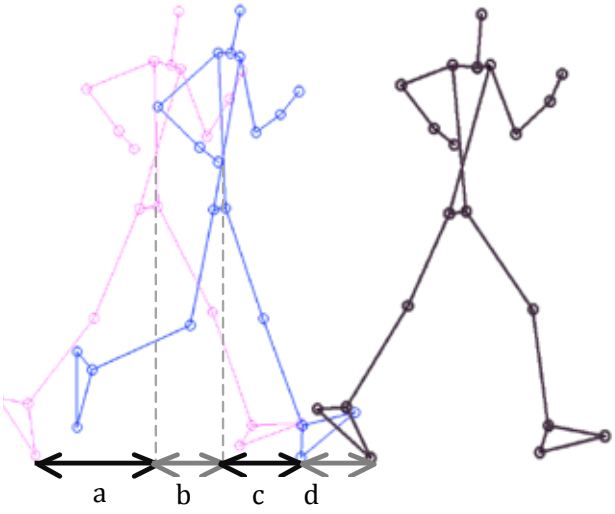

Fig. 1. Characteristics of stride length constituents in race walking: a - rear stride; b - flight distance; c - front stride; d - support transition (foot length) [9].

The exercise program presented below to improve race walking technique was used without changing the general direction of preparation. Race walking technique was evaluated (video shooting, frame-by-frame analysis of the technique) before experimental 3-week period and after its completion in the course of covering a 10 km distance in its final part at a stadium.

The basics of classical instruction in race walking technique are presented in special literature [9, 11, 12]. Exercises are performed in the form of covering 100 m interval segments to work out the rhythm structure and accentuate technical parameters [13]. They are presented, with minor differences, by the following tasks: 1. To create an idea of race walking technique. 2. To teach the correct leg movements during race walking. 3. To teach the pelvis motions while walking. 4. To teach the arm and shoulder movements while walking. 5. Complex improvement of race walking technique.

In contrast to this method, athletes were offered walking at a slow, average, fast and competitive pace at distances of 30-50 meters in a straight line. The distance was covered in a certain sequence according to mastering the movements of walking. 5 special exercises were used. Athletes were trained in concentration and switching attention to the movements of the right and left sides of the body, so that to "liberate" the opposite body side for mental, automatic rational movement of the free links.

The appearance of *sensation 1* - "liberation of the body links" along the length of the kinematic chain of

pelvis – foot, determined the search for *sensation 2* - the inertia of free motion. Task solution followed by rest, HR recovery to 80-90 beats / min. The pause was considered as a factor of psychomotor stimulation.

During exercise performance, the construction of movements in race walking included determining semantic corrections:

- *objectives:* to feel the support reaction when the foot touches the surface in places of training, competition, its depreciation, "recoil";

- *tasks:* to focus on motor sensations, form the basic skill of take-off after a vertical with straight supporting leg in the wake of the "recoil" of the bearing surface after depreciation;

- *technical details:* to feel and use the action of reactive and ballistic forces in the direction of the foot-lower leg-thigh-pelvis-thigh-lower leg-foot of the other leg to correct the sensations of inertia of the "free motion" in the process of walking.

Special exercises for development of the sensations of the bearing surface during walking, the "feeling of the track" on which training or competitions are held.

Exercise 1. Walking at a slow pace, 2-3 × 40-50 meters in a straight line. A preliminary simulation is performed. Hand movements for walking, straight, bent, half-bent, search for a comfortable position. Apply walking with eyes closed and open; blocking the auditory analyzer.

Close the athlete's eyes, use ear plugs (SureFire EP10 Sonic Defenders® Ultra Max Large), and reduce the impact of environmental sound. Athlete "plunges into the inner body."

Athlete straightens legs in knee joints and visualizes pelvis movements from top to bottom and from back to front, along stretched forward elipsoid. This technique is quite effective for the formation of kinesthetic images of motions at the expense of activation of proprioreceptors [9]. Focus on the beginning of "movement in the sacral region, which should remain calm and firm, being the fundamental pillar" [14]. In each phase of the movement the equilibrium should be achieved. It is necessary to maintain focus on sensations in the area of the suggested center of gravity.

In case of center of gravity displacement, one should control the *sensation 3* - "fullness, profuseness" of the supporting leg and that part of the body on which the body weight is transferred, respectively, the *sensation 4* - "emptiness" in the opposite, support-free leg.

To control breathing: a calm rhythm, shoulders relaxed and lowered, neck muscles without tension, determine the head position.

To train the athlete to move at the expense of active movement of the" pelvis-thigh" link. The knees and feet are "off" to the extent of the level of development of individual coordination and do not enter into active movement.

Continue walking at a slow pace. 2-3 × 40-50 meters in a straight line. The athlete concentrates on the appearance of *sensation 5* - "pelvis-thigh", body forward orientation. Every 7-10 strides, after passing the vertical in the support phase, perform elastic movement in the knee joints, minimal in amplitude, feel depreciation.

Straight leg walking, concentration of attention shifts from the pelvis and thigh to the knees, athlete weight pressure on the support contributes to the depreciation of the surface coating, its "recoil". The next stage in the formation of new sensations begins to work when, after depreciation of the road pavement, the forefoot becomes involved. Focus on the *sensation of 6th* - link "thigh - knee - foot - forefoot".

Exercise 2. Walking at a slow pace 2-3 × 40-50 meters in a straight line. The exercise is performed by an athlete with eyes closed, an attempt is made to control the stride length by the symmetry of efforts. The coach is next to the athlete and corrects the movement in a straight line. Change the angle of foot bending by 5°, the athlete designates and remembers the springy movement of the pelvis, knee, middle part of the foot.

Muscle tension occurs, the athlete expects a "recoil" of the road pavement without participation of visual and auditory analyzer. Control of subjective sensations, inaccuracy of movements, photo and video shooting was made to clarify the angles of flexion in the joints of an athlete.

Exercise 3. Walking at a slow pace at the same distances. Visual and auditory control is present. The athlete increases the angle of flexion in the knee joints to 20° (half-squat), until the feeling of tension in the lower back, pelvic joints, ankle and metatarsal joints. To sustain a pause until appearance of *sensation 7* – the road pavement reactive response along the length of all lower extremity links.

Exercise 4. Walking in a natural position, visual and auditory control is present.

2-3 × 40-50 meters in a straight line. The athlete accentuates the movement of the pelvis from top to bottom and forward, pelvis - knee - foot - road pavement. Concentration of attention works on "proactive reflection", the take-off, forward movement through the foot of the whole body, acceleration of movement are predicted. It is important to sustain a short pause for "turning on" the depreciation and recoil of the road pavement to accelerate the movement of the leg links (stride length).

In this exercise, it is necessary to include a roll from the outer arch of the foot to the forefoot and the big toe, promoting the sensation of a ballistic wave throughout the whole leg to the pelvis and backward.

Exercise 5. Trunk twisting should be added to the lower extremity motions. Emphasize the left hand (elbow) movement towards - forward to the right knee. Depreciate the spine after a reaction of the support; perform the same with the right half of the body. The vertebral column is located at the top of the right and left kinematic chains of the lower extremities. Ascending loads are transmitted to it from bottom to top. Compensating counter-directed torsion loads of the shoulder girdle are directed from top to bottom along the spinal column, and usually meet at the XI thoracic vertebra. The axial position of the spinal column makes it the target for ascending effects of the

right and left kinematic chains of the lower extremities, pelvis and descending impacts of the shoulder girdle. In the traceable unified structural and functional kinematic chain "lower extremity - pelvis - spinal column", the structure and function of the underlying links determine those of the overlying ones. Within this framework, the shape of the vertebral bodies is formed under the influence of lifetime loads, their values and trajectories and depends on the plastic properties of the osseous tissue of the vertebral bodies. The causes of plastic deformations of the vertebral bodies should often be sought outside the spine, in the underlying links of the kinematic chains. The spinal column changes its shape during walking. The shape of a bent flat spiral with the right direction of the whorls alternates with that of a bent flat spiral with the left direction of the whorls, depending on the support on the left and right lower extremities. The vertebral column being at the top of the kinematic chains of the lower extremities concentrates relatively symmetrical or asymmetric loads on itself, partially compensating them [15].

HR should be recovered to 80-85 bt/min (in 3-4 min) after exercise completion. Motivational and cognitive components, objectives, their significance, personal beliefs, emotional resources were discussed during pauses. Psychological assessments of the state perceived by athletes were determined by athletes' interpretation of the efficiency of achievement drive; similar practice is known [16].

Statistical analysis. MS Excel licensed software was used for analysis of findings. Indices of descriptive statistics were determined: arithmetic mean ($\bar{x}$), standard deviation (S) and coefficient of variation (V). The significance of differences in the group in the result of experimental studies (dynamics of sports result and the technique kinematic characteristics) was evaluated by means of the Statistica-10 program (StatSoft, USA) using the nonparametric sign test for dependent samples (Z), at a significance level of p = 0.05.

Results

Comparison of the main biomechanical characteristics of athletes' technique in the course of experimental studies demonstrated their impact on walking speed increase.

Table 1 presents technical characteristics of movements before and after performance of the complex of special exercises, which were obtained in the course of covering 10 km distance.

As seen in Table 1, the average stride length of athletes increased to 1.14 m (S = 0.04) after applying the complex of exercises, which is higher than that at the beginning of the experiment - 1.09 m (S = 0.03) ($p < 0.01$). On the other hand, the stride frequency also increased to 3.17 stride·s^{-1} (S = 0.08), however no statistically significant difference was found ($p > 0.05$). The increase in stride length occurred at the expense of the length of the rear stride ($\bar{x}$ = 0.43 m; S = 0.02) and flight (= 0.20 m; S = 0.02) at statistically significant differences from the indices observed before using the complex of special exercises.

The increase of these indices largely depended on the efficiency of take-off. Index of its duration = 0.28 s (S = 0.009), which was on the average 0.011 s better than at the beginning of experimental studies, is indicative of more efficient take-off technique at the end of experimental studies.

An important point is that the reduction of the take-off time occurs, above of all, at the expense of the decrease of the depreciation duration at the single support phase by 0.12 s. All this indicates a higher efficiency of force interaction with the support, which is due to respective manifestation of speed-strength qualities. Therefore, the improvement in speed occurred at the expense of stride length increase to the fullest extent.

Table 1. Kinematic characteristics of the technique of athletes specialized in 10 km race walking before and after experimental training cycle (n = 10, body height: $\bar{x}$ = 1.74 m; S = 0.09; body mass: $\bar{x}$ = 63.20 м; S = 5.41).

Indices	Period of measurements						Z	p*
	Beginning of cycle			End of cycle				
	$\bar{x}$	S	V	$\bar{x}$	S	V		
Result, min:sec	46:12	01:07	2.4	48:50	01:38	3.3	2.846	p<0.01
Average speed, m·s^{-1}	3.61	0.09	2.4	3.42	0.11	3.3	2.846	p<0.01
Stride length, m	1.14	0.04	3.5	1.09	0.03	2.7	2.846	p<0.01
Rear stride length, m	0.43	0.02	5.0	0.40	0.01	3.0	2.214	p<0.05
Flight length, m	0.20	0.02	9.7	0.17	0.02	12.5	2.214	p<0.05
Front stride length, m	0.22	0.03	13.2	0.25	0.02	6.2	1.581	p>0.05
Length of support transition, m	0.28	0.01	4.8	0.28	0.01	3.9	0.500	p>0.05
Stride frequency, stride·s^{-1}	3.17	0.08	2.7	3.12	0.05	1.4	1.581	p>0.05
One stride duration, s	0.316	0.009	2.7	0.320	0.005	1.4	1.581	p>0.05
Single support duration, s	0.280	0.009	3.2	0.298	0.011	3.8	2.214	p<0.05
Depreciation duration at single support phase, s	0.120	0.006	4.6	0.130	0.010	7.6	2.214	p<0.05
Knee joint angle at the moment of foot placement on the support, degr.	179.04	0.40	0.2	178.54	0.94	0.5	0.949	p>0.05

* - sign test was used

Discussion.

The findings confirm previously obtained results that during walking with presented affirmations, athletes were trained to feel the support of the surface, the ability to adjust to it with account for the speed-strength, power capacities of athlete and his working body mass [1, 3, 17]. This is confirmed by the fact that the take-off along the direction of movement was mastered and improved as a basic skill with apparent variable properties [9].

There are known facts of differentiating information from articular receptors (reaches the higher parts of the brain) and that from tendon receptors. This is of independent importance, since the magnitude of the angular displacement (changing angles from 5° to 20°) causes a switch from the magnitude of muscular tension to controlling joint movement. For instance, it is thought that in order to keep the balance in case of minimal oscillation a person uses an "ankle" strategy at the expense of changes of the ankle joint angle, whereas in case of large and frequent oscillations – that of "hip" one [18].

Presented methodology contributed to individual improvement of a new movement image; the motive and purpose led to perfection of technical skill in race walking. Obtained data confirm that before performing suggested exercises, the athlete should visualize the position of the head, arms, trunk and vertical moment.

Studies have shown that usage of specially designed exercises, performed in a standard sequence, helps to form a muscle sensation, which can be described as a "reactive response of the road pavement". Athletes were trained to form seven consecutive sensations: 1 - liberation of the body links; 2 - inertia of free motion; 3 - fullness, profuseness of the supporting leg; 4 - emptiness in the support free leg; 5 - pelvis - thigh, body forward orientation; 6 - thigh - knee - foot, forefoot; 7 - reactive response of the road pavement.

In such a sequence, "building sensations" can be recommended in order to use the impulse of force of reactive-mechanical origin, the inertia of free motion at competitive speed, when the role of elastic deformation and the use of swing movements through the strength muscular component become more and more important.

The findings confirm the results of the key factor significance in the structure of special fitness of skilled race walkers, when technical fitness is put first, followed by physical work capacity and athlete's psychomotor system state [3]. Formation of new movement images in the athlete necessitates the activation of his cognitive processes for better mastering technical parameters of movement [19]. The effectiveness of training work while improving race walking techniques is closely associated with the athlete's special endurance with account for the stability of special sensations of the motion key characteristics during fatigue development.

Therefore, to improve the quality, reduce time and increase the reliability of training, the traditional approaches to improving the coordination complex movements may be supplemented with the presented exercises to form specialized sensations of the motion characteristics.

New technologies and research methods exist today. For instance, some NBA teams use wearable sensors to monitor training and recovery. The possibility of non-invasive and continuous monitoring of saliva or sweat biomarkers, electrodermal activity (EDA) refers to changes in the activity of sweat glands, which reflect the emotional state intensity. Their utilization can be useful for measuring the level of stress, a way to assist in the "athlete quantitative assessment" of physical load, physical condition, fatigue. For instance, Kitman Labs use motion technology training to diagnose the athlete's responces to various movements [20].

Suggested approach creates prerequisites for further research on the formation of the motor composition of skill of body position accuracy. The development of sensations of inertia of free motion, liberation from excessive degrees of freedom in the body links with account for the athlete functional state envisages the use of new technologies. It is planned to develop and apply special means under conditions of preparation process intensification for improving the race walking technique and effective maintaining technical capabilities of athletes during fatigue development.

The data obtained show the possibility of forming a stable technique during fatigue development on the basis of targeted improvement of athletes' special sensations.

Conclusions

1. The use of special exercises to focus on motion key parameters contributes to enhancement of technical fitness of athletes in race walking.

2. The use of a complex of suggested exercises for three weeks to develop special sensations in an athlete focused on the key components of sports technique resulted in significant increase of walking speed.

3. The increase of speed occurred at the expense of stride length increase after applying the complex of exercises. At the same time, the increase of stride frequency was not observed; stride length increase occurred at the expense of the "rear" stride length, as a result of applying a complex of special exercises.

4. Reduction of take-off time occurred at the expense of decrease in depreciation duration at single support phase, which may be indicative of higher efficiency of strength interaction with the support.

5. The findings allow to assume that the usage of special exercises for enhancing special sensations of motion key parameters may be the important factor for technical fitness improvement in race walking.

This work was carried out as part of the scientific theme of Sports and Fitness Department of Borys Grinchenko Kyiv University "Theoretical and practical bases of fitness technology usage in physical education and sport" (state number 0118 U 001229) UDC 796.015:615.83

Conflict of interest

The authors declare that there is no conflict of interest.

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Cite this article as:
Vinogradova OA, Sovenko SP. Improving technical fitness of race walkers on the basis of special exercises to focus on key parameters of movements. *Pedagogy of physical culture and sports* (*Pedagogics, psychology, medical-biological problems of physical training and sports)*, 2020;24(2):100-105.
https://doi.org/10.15561/26649837.2020.0208

Received: 30.10.2019
Accepted: 25.11.2019; Published: 30.12.2019