Review Article

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Quality of sports training and the biological adaptation of athletes to race walking

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Abstract

The aim of the presented work is to describe the different trends in race walkers training and the biological adaptation of the body to the applied stresses, and to characterize the other phenomena accompanying this sport. The article is equally concerned with the scientific premises as well as the practical training indications. For a deeper characterization of the discussed problems, the biological considerations that underpin the selection of people to practice race walking are broadly described. It has been shown that diagnostic test that reveal the overall exercise potential of the body are useful tools in this area, and its specific development is related to the use of balanced training in which the most difficult part is to strive for optimal mastery of the sport walking technique. It was also suggested, that physiological, biomechanical and dietary determinants, which are assessed in scientific laboratories would be helpful for trainers and race walkers in achieving championship in race walking. The general nature of race walking was supplemented with a description of the social phenomena associated with this sport competition. The conclusions drawn in this article indicate the importance of mastering the technique of walking, the predisposition to practicing this sport, the importance of a coach in achieving high sports results, and the opportunity of health benefits mainly through the practice of recreational walking.

***Keywords**: race walking, predispositions, selection, training*

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INTRODUCTION

Race walking is another version of the normal fast walk. The technical improvements that have been made during the professional race walking training are connected to the changes that help one to go long distances during sports competitions. Race walking is an athletic competition that takes place at the Olympic Games, the World Cup, continental championships and national competitions. Its debut in the Olympics was inaugurated in 1908 (previously it was played as one of the combined events competition) and excluding 1928 at any subsequent Olympic Games at least one distance of the race walking competition was conducted.

Race walking during professional competitions is conducted at the following distances: women 20 km, men – 20 km and 50 km. There are records of the world, continents, national records as well as the records of individual sports events. Also race walking competitions organized at unusual distances, such as: 3 km, 5 km, 10 km and 35 km. There are also competitions in one- and two-hour, in which the length of the distance walked in a given time is measured. Unusual distances and race walking in predefined time are measured as the best times in history, not world records. In athletic indoor events, race walking takes place at shorter distances, 3 km for women and 5 km for men respectively, but they are not included from the 90s of the 20th century in the world or European indoor championships. In these untypical distances only national championships take place. Participation in competitions at such varied distances allows the athletes to both diversify the start-up season as well as the correct implementation of the training process in order to properly prepare for the main start.

The majority of Polish publications on race walking come from the seventies and eighties of the twentieth century, when race walking conferences were popular. Such conferences were held in Kalisz in 1977, Poznan 1985, and Gdansk 1986. The direct result of the conferences were text of delivered lectures published in post conference materials. Then, more and more scientific and practical publications began to appear, describing various aspects of this athletic competition. There are five book titles devoted to race walking history:*"From the history of athletics in Poland: traditions of sport walking from Tadeusz Kuchar to Robert Korzeniowski* (1904-2004)" [1], *„Development of women race walking in Poland* (1926-2004)" [2], discussing the basics of teaching methodology of this event: "*ABC of race walking*" [3], presenting the analysis of a competitive season: "*Race walking 2007*" [4] and a presentation of the former national race walking coach: "*Race walking*" [5]. In other scientific and coaching reports, the most frequently discussed issues were the subject matter of the training process and the methodology of teaching the technique of this event at different stages of the sport championship. The problems of training of race walkers in altitude conditions are important issue in this area [6].

The aim of the study is to present the current trends in the race walkers training and biological adaptation of the body to the applied stresses as well as the phenomena surrounding the sport accompanying this competition.

BIOMECHANICAL DETERMINANTS IN RACE WALKING IN SPORTS AND RECREATIONAL TRAINING

Walking is one of the basic forms of physical fitness that people master in early childhood, perfect it in subsequent phases of ontogenesis and undergoes degenerative changes in old age. Currently, race walking is also a popular form of recreational sport and sport for health. During 10km of intense walking, one can lose 1 kg of body mass [7]. Liptak [8] has characterized race walking as a cyclical endurance competition recommended for every person. The basic movement forming a walking cycle is a double stride (two steps), which consists of two resistant phases. According to athletic track and field regulations, a race walking athlete should keep unbroken contact with the ground. At high velocities, however, there is an invisible loss of contact with the ground in the two-resistant phase. Such a loss of contact with the ground does not have to be felt by the competitor, and the rules state that the violation of

this canon is considered only as such loss of contact with the ground, which is visible to the judge's eye [9].

Race walking differs from the normal walking primarily by the straightening of the resistant support leg (in the front). The hip moves towards the back leg, the head and trunk maintain the vertical position, the arms work similar like in the long distance run. During the walk, the athletes achieve an average step length of 105-130 cm and a frequency of 180-200 steps per minute [10].

During the 42nd Congress of the International Association of Athletic Federations (IAAF) in Seville, 1999, the race walking technique was defined in regulation no. 230 as: "Race walking is the movement of steps that maintain constant contact with the ground. The retaining (resistant) leg must be unconditionally straight (i.e. not bent in the knee joint) since it is in a vertical position" [11]. Of course, the most important answer is to the question when the walking is changing into the running?

Walking speed is conditioned by critical steps' length (125 cm), steps' frequency (215-220 per minute), and single-resistant time (lasting 0.5 milliseconds). The above conditions allow theoretically maintaining proper walking technique at a pace of 3:34 min/km^{-1} [12].

During race walking, trunk movements are performed in all three planes. In the vertical plane, the body's gravity falls and rises on average 2.5-3.5 cm (the best race walkers). The better is the walking technique; the lower is the deviation of the center of gravity. In the front-back plane the trunk first leans forward and then backward, simultaneously with the feet placement on the ground and bounce-off [13]. Gravity point deflections in the horizontal plane depend on the distance between the feet to be set and the method of placing the feet on the ground. The size of the angles of the individual body parts relative to one individually and the substrate with the optimal technique according to Scholich [14] should be as follows:

- the front leg is straight in the knee - angle 178-180^0,
- the bounce leg (located at the back) is bent in the knee joint - angle 150-160^0,
- the foot of the front leg facing the ground is at an angle of 40-45^0,
- the foot of the rear leg facing the ground is at an angle of 50-60^0,
- the arms are bent at the elbow joints at right angles, hands slightly closed.

The muscle power is the primary force that affects the movement of a race walker. The size and direction of the force in the is varying between different phases of the step. Race walking speed is approximately two times greater than that of a normal walk and is around 12-15 km/h. The speed of the walk decreases in the landing phase and increases in the rebound phase. The bounce-off phase is longer than the landing phase [10].

BIOLOGICAL DETERMINANTS OF LEARNING RACE WALKING TECHNIQUE

Learning and improving athletic track and field competitions requires a lot of effort and work. The training volume and indirectly the number of training units conditioning formation of the movement habit – the factor determining the correct form of movement. Excluding disparities in individual aptitudes, the formation of a motor stereotype, the generalized phase of motion act in case of a race walker takes longer than in a runner's case. It is associated with the initial period of assimilation of a specific movement element. This is due to chronic stimulation in the motor centers of the cerebral cortex. In the initial phase of training, many muscles are stimulated, because in the cerebral cortex, the stimulus wave covers large areas. In the next stages of training, muscle activity is restricted only to necessary muscle groups, while the rest are stimulated minimally. Subsequently, through the phase of concentration, the automation of the movement occurs [13].

Automated motor activities are stimulated by cortical centers that are in a state of reduced excitement, that is, subconsciously. Athletes, who train in the group, are observing the

movements of their more experienced colleagues and record in memory a movement stereotype. The effect of modeling of movement patterns on other competitors is very great in race walking, because despite the apparent simplicity, this competition has to be trained from the ground up, which guarantees that the player does not perform relatively unfavorable movements shaped earlier in individual life.

Athletes who are talented and physically active, alongside with neuromuscular coordination and some constitutional traits that make it possible to correctly and effectively perform a specialized motor activity are most suitable for the sport. The most important features include: proper pelvic position, good mobility in knees, hips, and shoulders joints.
The premature development of speed with intensive training is contraindicated because it leads to technical errors and lack of stabilization of movements. Maximum speed is particularly undesirable at the beginning of race walkers training. In race walking, the walking speed should increase proportionally to the so-called "pinched level" that is to the length of the distance walked. Special speed training takes place for runners and race walkers during trial competitions at distances shorter than the main distance [15].

It is worth remembering, that race walking is a competition judged by the judges, so in addition to the endurance training, one cannot forget about the technique of the athlete. Referees assess the skills of the competitors and are the verifiers of the training work of their coaches. By referring to the term "training process" it is understood not only as a set of activities aimed at achieving a higher level of training of the athlete's body, but also acquiring theoretical knowledge of the rules, tactics and the mental preparation of an athlete, the racing goals and set plan of competitions. In the teaching process, the emphasis should be on learning the proper technique, putting aside the ambition of obtaining a valuable result. It is only in the case of properly formed technique that the race walking conditioning should improve [16].

The technique of walking was described in details by coaches and in particularly by biomechanics researchers using laboratory measurement methods [17,18]. In this research they determine the greatest economics of motion with the restrictions of sports rules. Significant publications related to this topic are connected with the work done at Academy of Physical Education in Krakow [19-23]. As far as the foreign publications are concerned, it is worth mentioning the economics and change of race walking technique over the years [24-28].

THE IMPORTANCE OF ATHLETE SELECTION IN IMPROVING THE RACE WALKING TECHNIQUE

Hedge [16] maintains that race walking taught in childhood and adolescence should focus on teaching the principles and practical science of the correct technique, as it will determine whether or not the athlete completes a competition. It is especially important for beginners to learn to put their front feet on the heel on the ground. The body should be almost in a vertical position, only slightly inclined forward. Shoulder work, which is quite similar to fast-running long-distance runners, should reflect the leg movements (alternately). Shoulders should always remain in a position across the walking direction and be relaxed [29]. One of the basic techniques is the perfection in slow walking. Then cushioning is added in the hip joints. Any errors in the technique should be corrected properly before moving to higher speeds, and this should be limited to the correctness of the step in relation to the rules of the competition. These conditions are different for each competitor. Walking speed sessions by the lengths of only 100-200 m is a good training in this respect. Proper gait technique should not reflect muscle stiffness and use of excessive force. An athlete should move freely forward, supported by proper cushioning in the hips. In the next stages of training, the speed of movement of a race walker, is built on anaerobic basis (e.g. by repeated accelerations while walking up hill), and it should start at the beginning of the preparatory season [16].

DIAGNOSTIC TESTS

Mirek et al. [30] discussed the use of the stadium test for determining and classifying training loads, diagnosing training conditions and determining race speeds, mainly at a distance of 50 km. For the determination of the threshold heart rate and the threshold speed, the test is used to determine the training measures used by Żołądź [31,32], performed on an athletic track.

In this test, the tested athlete uses race walking technique to pass five sections, each of which takes 6 minutes, and the gap between them is 2 minutes. Each section should be made with a constant heart rate (HR). The rate of progression using the first one is determined by subtracting 50 from the HRmax (the maximum heart rate determined earlier). Each subsequent exercise is performed at a HR bigger by 10 bpm than achieved in the earlier section. The next section ends with a blood sample and a lactic at concentration test in the blood. Then the average HR value from the last 3 minutes of each section is calculated. If a blood lactate concentration increase of at least 0.5 $mmol \cdot l^{-1}$ is observed after the section has been completed, then the load is considered adequate to generate a lactate threshold. The walking speed is determined by the distance walked in each of the 6-minute sections.

Other selected aspects of race walking were dealt with by representatives of various sciences. Nowak [33] characterize athletes morphologically and show that the body build of race walkers is not different from long-distance runners, and the training routine used in both sports' groups is very similar. Prusik [34] assessed the anaerobic performance of athletes and demonstrated the importance of aerobic metabolic aspects of exercise in the race walking athletes.

DIET AND NUTRITIONAL SUPPORT

In Polish literature one can also find several articles about nutrition in race walking, as well as nutritional patterns during the competition itself [35]. These studies have shown that the diet of the race walkers does not differ much from other athletes practicing endurance sports. Nutrition was also the subject of several recent publications of the best Polish national race walkers [36,37]. It has been shown that athletes consume too much proteins and also overuse some minerals and vitamins. Interesting research was conducted in Australia, where a group of 29 race walkers representing the international level were subjected to special dietary interventions [38]. The results showed that low-carbohydrate and high-fat diets did not produce a beneficial ergonomic effect for top level athletes in race walking. Further research will be carried out in the coming years.

DIFFERENCE BETWEEN TRAINING IN RACE WALKING AND RUNNING

Race walking training is generally similar to runners training [15], although, muscle mass involved is greater in the second one [39]. Race walking activates aerobic pathways of energy resynthesis to a larger degree rather than during running. Another factor is the time of the competition, which is also longer in race walking, because the best walkers cover 50 km distance in more than 3.5 hours, while the best marathoners take little more than 2 hours. The biomechanical aspects of motion, including oscillation of center of gravity and the frequency of steps that make up the best marathon runners, are about 180 per minute, and the best walkers exceed 200 steps during that time [21]. Differences between long-distance runners and race walkers also appear in training, while technical work, different surface used during training sessions, and the limitations of each competitor with their individual predispositions must take into account [10].

THE SPECIFICITY OF TRAINING IN RACE WALKING

The essential elements in the overall training work of race walkers are: (1) technique, mobility and flexibility, (2) strength, (3) speed and special endurance, and (4) strength and strength endurance. The overall program, structure and composition of each training unit must be carefully planned to properly map out the overall development of a race walker, and include all those elements. They must be objective and detailed in the course of the year as well as in the planning of one's entire career. The trainer must strive to develop a balanced program that will ensure that the peak of the sport performance is at a certain point in time [15].

According to Hillard [39] studies that include training loads and units in the training cycle, the essential element is whether the competitor properly utilizes his or her technical and endurance potential. It is important that the benefits of proper work interact with technical development, with full training load. The author proposes training in the development of special strength and endurance (up-hills), which should be included in the base training (2-3 times per week).

Scholich [14] believes that training in race walking should focus on the technical aspects and on the specificity of motor-technical requirements. Training and stretching exercises should be encouraged and applied from the beginning. Strength in training exercises for a race walker can usually be divided into three categories: (1) special strength with proper movement structure that is perfectly compatible with the walk; (2) a special strength with a motion structure similar to a gait or consistent with the different phases of the movement of the walker; (3) general strength with a motion structure that does not correspond to the movements of the walker but has similarities with the gait.

The purpose of special strength training is to develop the strength endurance by the groups of muscles that are most active during race walking. These exercises improve the functional systems of the body. Strength development should generally take place without the increase in muscles' cross-section.

Depending on how long the training program is, Vallance [40] notes that it is absolutely essential to clearly state that training to the 50 km distance is completely different from the 20 km distance training. Depending on the circumstances, race walkers (men) should try to cover the distance of 50 km, if they have a suitable length of training, they are at least 18-23 years of age, unless they have shown an international level performance potential for a distance of 20 km.

The distinctive feature of the competition in race walking is a vast variety of results obtained at individual events. This is mainly due to various weather conditions and the uneven scale of the difficulty of the courses on which the competition is being conducted [41].

The main aim of the race walkers' training is to prepare for the fastest possible walk of a given distance in the best technical style. In order to do this, a maximum of "aerobic endurance" and "lactic endurance" should be built using "tempo endurance". Both Olympic distances, and especially 20km are walked with high intensity. A well-rounded athlete is able to walking it in about 80 minutes (15km/h) while maintaining an average heart rate of 10-15 bpm below its maximum value and a blood lactate level of 4-7mmol/l.

In addition to well-developed motor skills, it is always a good idea to pay attention to the correct walking technique, as it is a means of reaching the finish line. Walking techniques are judged by referees who can disqualify a competitor for improper walk of one or both of their components (straightening of the attacking leg in the knee angle and break the "flight phase", i.e. not keeping contact with the ground at all times). It is not easy to work out and then maintain a good technique when the speed of the best race walkers is maintained within the range of 14-16 km/h. The first difficulty is to maintain the pace of the step and the second is the increasing fatigue and acidification of the body, which disturb the structure of the movement.

Being aware of these requirements, only those who have great patience, persistence, regularity and efficiency in the pursuit of the goal can be qualified to be very good and the best race walkers.

The psychological factors are important predispositions to walk such long distances. High intensity training and long stretches of training and start-ups require a tremendous amount of mental resistance to overcome physical barriers, pre-start stress, fatigue, failures and many other factors related to this sport activity.

In terms of somatic structure, the greatest chance of achieving the heights of athletic performance in race walking have slim persons (55kg-75kg), average height (between 165cm and 180cm), mesomorphic or ectomorphic types. A race walking athlete should have well developed not only the muscles of the lower limbs but also the trunk and arm muscles, and have a high mobility of the hip girdle and full extension in the knee joints [10].

In terms of physiological parameters, they should be as follows: maximal oxygen uptake in the range of 68-78 ml/min/kg, anaerobic threshold of about 75-90% VO_2max, oxygen pulse 20-26 ml/beat, maximal heart rate of 195-205 bpm, maximum lung ventilation of 130-161 l/min [10].

These are predispositions, but the characteristics acquired during the development of sports training should be versatility, efficiency and coordination. Due to the long-term nature of the work and the amount of workload (a distance of 150-220 km/week maintained for 9 months per year), the basic thing to withstand the training, and further improve the sports' achievements is nutrition, relaxation and proper rest. Therefore, a race walker should develop knowledge about proper diet and supplementation, as well as regeneration techniques during post-training and post-season periods.

In the above-mentioned predispositions and traits one can see the causes of the sport championship [41,42]. Failure to do so may cause injury or long-lasting overtraining. Linking them together and continuity is possible, and produces effects in the form of victories and life-time records.

The regulations of the International Association of Athletics Federations clearly specify the technique of race walking. Understanding this is not correlated with instant correct execution of this activity. The beginners often find it difficult or even impossible. The professionals are using this technique many kilometers at speeds higher than many amateur runners. However, this requires many years of hard work. Today's walkers are equipped with a full range of exercises to improve their technique of walking. By doing these exercises regularly, they have a good chance of completing a competition without bringing the attention of the referees.

Taking into consideration the length of the race, it is possible and necessary to formulate a tactic. When setting up an action plan, one should adjust one's physical and psychological predispositions for weather, distance, course profile, and keep an eye on one's rivals and the way of race going. An important element of tactics is also the proper preparation of nutrition, sport gels and drinks, which should be adapted to the weather conditions and use refreshment points prepared by the event organizers.

SOCIAL ASPECTS OF RACE WALKING

Both, cheering opportunity and organization of athletic competitions give it important social impact. Just as important are sports' competitions for runners, there are also equally important racing events attended by professional race walkers, who make it an interesting event for public in the center of many cities. Race walking takes an important place in athletics as it has been played at the Olympic Games since 1908, earlier than, for example, relay races, and at that time earned itself a valid, important and well-established position in the history of sport and athletics.

PATHOLOGIES ASSOCIATED WITH DOPING IN RACE WALKING

One of the biggest pathologies affecting race walking are the numerous cases of doping among athletes who win medals at the most important athletic events. In particular, the group of famous Russian coach, Viktor Chegin is well known, because more than 20 of his athletes were disqualified for doping. In recent years, more than thirty walkers have been disqualified in the world for the detection of prohibited doping agents in their bodies, most of them are Russians. The five present and former Olympic champions are "doppers" (three Russians, one Italian and one Greek). They were Atanasia Tsoulemeka from Greece - Athens 2004, Italy Alex Schwazer - 2008, three other Russians – Valeryi Borchin - Beijing 2008, Sergey Kirdiapkin - London 2012 and Yelena Lashmanova - London 2012.

CONCLUSIONS

The demands of modern sport impose constant pursuits to determine many factors that are helpful in managing sports training. Therefore, it is especially important to recognize the correctness in the interrelationships between the individual parameters of training load and the level of training achieved [42]. Much valuable information in this area is provided by analyzing the workloads and dynamics of the progress of the best race walkers. They become an indispensable element of the solutions aimed at optimizing the training process and the design of model training solutions [41,42]. Taking into account the above, the following conclusions were drawn from the present paper:

1. Race walking is characterized by a specific technique, which is an important factor in achieving the championship.
2. Achieving a high level of sport performance in race walking, besides the control of movement techniques, is conditioned by genetic predispositions (high aerobic capacity, somatic and biomechanical conditions, volitional characteristics) and environmental factors (diet, training load, and sport selection).
3. The athlete's sports career lasts over many years. In addition to the proper athlete with the requisite qualities to fulfill it, a suitable trainer familiar with the realities of youth and senior sport, constantly experimenting and educating himself is indispensable.
4. Contemporary race walking is a multi-faceted medium of health prophylaxis, which has a positive social impact, but is plagued by injuries and scourge of sports doping.

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