Original Article

Endurance ratios of middle-distance race

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ABSTRACT

The paper deals with the ergometric endurance criteria in field-and-track middle-distance race and systematizes the applied training means according to the direction (nature) of the physiological effect. The ergometric analysis of 'velocity – time' and 'distance – time' dependences, according to the data of the world race records, allows defining the role of the aerobic and anaerobic energy production at particular distances of the field-and-track race. The level of development of the sportsmen's aerobic and anaerobic capacities affects the manifestation of special endurance in the middle-distance race. The experiment was conducted among field-and-track athletes of high qualification specializing in the middle (800 and 1500 m) distances. The main factor influencing the result in a race is the energy indicators. So, their measurement and estimate serve the main leverage of the training session. The use of predominantly anaerobic exercises during the specialized work-outs significantly improves the runners' special endurance indicators. **Keywords:** Time limit; Anaerobic; Aerobic; Ergometric criteria.

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INTRODUCTION

800 and 1500 m sports training in race aimed at achieving high results is a multifactorial process with the sportsmen's special endurance development indicator as the most important factor defining the level of achievements in the middle-distance race. A. Hill (1925; 1927; 1972) implemented the first attempt to connect the values of the external work with particular physiological mechanisms and based on the ergometric analysis divided the field-and-track race into three groups, each of which contained particular energetic processes. Short- distance race, according to A. Hill is connected with the activation of anaerobic energy sources, middle distances – joint functioning of anaerobic and aerobic sources, while long-distance race – mostly aerobic mechanisms. This direction was further actively developed by V.S. Farfel (1939; 1945; 1949; 1975), who had studied three sections of field-and-track race introduced by A. Hill, presented the record curve in the logarithmic scale and was able to create the concept of relative capacity zones. At the increase in the race distance, the general trend in the change of various energy production processes at the race distance increase became gradually visible. This regularity was quantitatively expressed by N.I. Volkov (1964; 1968; 1986; 1989), who presented the time-base scheme of the main energetic processes.

The purpose of the paper is the study of the endurance criteria of the field-and-track middle-distance race, as well as the systematization of the applied training means by the direction (nature) of physiological effect.

METHODS

The experiments were conducted among the field-and-track-athletes of high qualification, specializing in middle distances (800 and 1500 m). The main factor influencing the result in a race is the energy indicators. So, their measurement and analysis serve as the main tool for control over the training session. To define the individual capacity values and the taken load at the set time limit we used graphic analytic method of logarithmic dependence construction: 'capacity – time limit' – based on the results of the maximum anaerobic capacity tests (Margaria et al., 1966) and critical capacity withholding (Volkov et al., 1975). In order to define the values of the bioenergetic criteria of aerobic and anaerobic processes' capacity, we conducted the cycle-ergometric testing (Lazareva et al., 2015). This is the test of gradually increasing load for the definition of the maximum aerobic capacity, aerobic efficiency and total aerobic capacity (Hollman, 1963; Shephard, 1977). To define the maximum values of aerobic capacity we used the critical capacity withholding test (Volkov & Shirkovets, 1973); to define the capacity of glycolysis – the nonrecurrent limit work test (Volkov, 1975; Fox, 1973); recurrent limit work test, necessary for the estimate of the glycolytic capacity (Volkov, 1975; Janssen, 2001); and maximum anaerobic capacity test, necessary for definition of the maximum alactic anaerobic capacity (Margaria, 1976; Wilber, 2004; Rozhentsov & Polevshchikov, 2006).

RESULTS AND DISCUSSION

Endurance in a race, based on the conducted research explicitly shows that the middle-distance race is characterized by two main components: aerobic and anaerobic performance. One should improve the methods for development of the sportsmen's aerobic and anaerobic capacities and the ways of control over the level of their development to achieve further progress. The factors defining the level of achievements in the middle-distance race, to various extents, influence the increase in the sports qualification of the field-and-track athletes (Lazareva, 2015; Lazareva et al., 2013). So, the problem of their assignation, defining the achievement of high sports results in 800 and 1500 m race has actually not yet been solved. The solution to this problem may be found based on the precise measurements and quantitative processing of the obtained results. The quantitative analysis of the correlation between the race velocity and the time limit is of a specific

interest, which allows conducting an in-depth analysis of the aerobic and anaerobic components manifestation of the athlete's endurance (Knechtle, 2002). In this regard, the most valuable are the 'velocity – time' ('V – t') and 'distance – time' ('S – t') analysis results.

The analysis of the world race records showed that the logarithmic record curve is divided into 5 independent sections (Newsholme et al., 1994). Therewith the logarithmic curve salient point (in the area of submaximal capacity) is not the distance of 1500 m, as was first shown by V.S. Farfel (1945), but the distance of 1000 m. It allows stating that the distance of 800 and 1500 m are in different zones and differ by their energy production. The 'V – t' dependence, based on the field-and-track athletes results of different specializations, has different 'p' and 'A' ratios (A – a constant, equal to the section on the ordinate axis cut by the continuation of the line (at t = 0), p – indicator, characterizing the inclination of line to the abscissa axis – shows the speed of the decrease in the race velocity with the increase in its duration). These ratios, according to their values for field-and-track athletes of the same specialization, are close to the values set in different zones according to the data of the race world records.

The analysis of the 'S – t' dependence allowed revealing that the 1500 m runners have higher values of the critical race velocity compared with those running 800 m. But 800 m runners have more anaerobic resources ('the distance of anaerobic reserves'). Both the energetic factors develop in the training process of the middle-distance runners; however, as proved by the research results, their development among 800 and 1500 m runners is inconsistent. At all the stages of the training process, 1500 m runners have higher aerobic performance indicators.

To solve the tasks of the optimal training stricture at different states of the full-year cycle of high qualification sportsmen preparation for the most popular field-and-track race distances allows constructing the target functions that connect the improvement of the leading bioenergetic factors' indicators with the volumes of the training loads of different physiological effect (Hermansen & Osnes, 1969; Hermansen & Wachtlova, 1971).

The performed analysis of the ergometric 'velocity – time' and 'distance – time' dependences, according to the world record data in race during the 20th century, shows that the improvement of the training methods of the leading middle and long-distance runners of the world in the mid-50s was mostly implemented due to the improvement of the indicators of the sportsmen's aerobic indicators. With the introduction of different variants of the training interval method into the training session of the leading runners, the focus on the development of the special endurance has increasingly become implemented due to the increase in the parameters of anaerobic indicators of the sportsmen's bioenergetic qualities.

Due to the alactic, glycolytic and aerobic processes, the energy in the process of the muscle activity is transformed (Keul et al., 1969; Saltin, 1973; Saltin & Karlsson, 1971). As the human has three different metabolic energy sources, it is accepted to highlight three components of endurance (alactic, glycolytic and aerobic), each of which may be characterized according to the indicators of capacity, volume and efficiency (Volkov, 1986; Hottenrott & Neuman, 2002). With the use of nine bioenergetic criteria, all the diverse manifestations of endurance may be quantitatively estimated according to three capacity criteria (alactic, glycolytic, and aerobic), three volume criteria (alactic, glycolytic, and aerobic) and three efficiency criteria (alactic, glycolytic, and aerobic) (Henry, 1954).

Depending on the capacity and time limit of the training, the role of particular components in general manifestation of endurance undergoes regular changes (Henry, 1955), where the level of general energy expenditures does not exceed the values of maximum acceleration of the aerobic energy production speed,

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in moderate exercises the endurance is mostly presented as its aerobic component. With the exceeding by an exercise the capacity above the critical level corresponding to the maximum oxygen consumption, the role of the aerobic component of endurance gradually decreases and the value of the anaerobic components increases to the same extent (Volkov & Savelev, 2002; Volkov et al., 2003). In the short-term exercises of maximum capacity, the manifestations of endurance are predominantly of anaerobic nature with the almost equal representation of alactic and glycolytic components.

The differentiated estimate of endurance according to the parameters of capacity, volume and efficiency may be conducted based on the measurement of the indicators of the externally performed work (ergometric criteria) or through the direct physiological or biochemical measurements in the exercises, where it is possible to achieve maximum values for these bioenergetic parameters.

As the ergometric criteria of endurance with high prognostic significance, alongside with the indicators of time limit and limit of the performed work, definition of the critical velocity, the border of endurance (Hill, 1972), threshold of anaerobic exchange, the distance of 'anaerobic reserves', and maximum anaerobic capacity showed good results. The ergometric criteria used for the quantitative estimate of endurance may be divided into specific, reflecting the peculiarities of the endurance manifestation in some kind of exercises, and generalized, characterizing the peculiarities of the endurance manifestation in a specific group of exercises similar according to some parameters. The specific indicators of endurance may include the time limit of the work with the set intensity, and the record time for finishing the set distance in the cyclic exercises. The generalized endurance ratios are calculated through the mathematic analysis of the ergometric results in the wide range of exercises.

CONCLUSION

According to the data of the world records in race, the ergometric analysis of the 'velocity – time', 'distance–time' dependences allows defining the role of the aerobic and anaerobic energy transformation factors in particular field-and-track race distances only on the quantitative basis. The level of the anaerobic capacities development also influences the manifestation of the special endurance of the middle-distance race sportsmen. The estimate of the aerobic and anaerobic capacities' development level may be conducted both through the direct physiological measurements and through the ergometric methods. The conducted ergometric analysis of the 'velocity – time' development in the race allowed highlighting five ranges of distances characterized by various correlations between the aerobic and anaerobic endurance components. The distance of 800 and 1500 m belongs to different zones of relative capacity and there are different requirements imposed on the development of the aerobic and anaerobic sportsmen's capacities. The ergometric criteria of 'critical velocity' and 'distance of anaerobic reserves' deduced from the analysis of 'distance – time' dependence differ among the runners specializing in the distances of 800 and 1500 m: 800 m runners have higher values of 'distance of anaerobic reserves', while 1500 m runners have better indicators of 'critical velocity'. The main role, among the reasons having the greatest impact on the special working capacity of 800 m runners, is played by the anaerobic glycolytic capacity. An important role in 1500 m race in the manifestations of special endurance is played by the factors of aerobic capacity and efficiency of aerobic transformations in tissues. For significant improvement of the runners' special endurance ergometric indicators, we recommend using predominantly anaerobic exercises in the process of the specialized work-outs.

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