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METHODS FOR EVALUATING ANAEROBIC EFFORT CAPACITY OF ATHLETES

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Abstract

The first purpose of this article was to identify the current methods to assess the anaerobic exercise capacity of athletes, both in the laboratory and in the field of sports competitions. The second purpose of the research was to highlight the factors that limit the ability of anaerobic effort, according to the literature in the field. We found that anaerobic capacity is still difficult to estimate and/or measure, mainly because of the laborious, invasive, and expensive research methodology.To ensure the quality and veracity of the data, strict adherence to test procedures, calibration of instruments, and increased attention to physiological measurements are recommended.

Keywords: effort capacity, anaerobic system, sport performance, effort evaluation.

Introduction

Effort capacity is a component of particular importance of sports performance and represents the possibility for the active muscle system to release by anaerobic glycolysis or oxidative phosphorylation the energy needed to produce work as much as possible and maintain it as long as possible (Ionescu, 2013).

Muscle contraction is the basis of any sporting effort and is achieved by converting chemical energy into mechanical energy, at the level of the active muscles. Contractility is a unique property of cells in the human body and represents the ability of muscles to contract (Enoiu et al., 2009).

During training and competitions, energy production is changed, thus the need for oxygen (O_2 consumption) increases with the intensity of the effort. There is also a strong correlation between the intensity of the effort and the stress of the heart. In the process of cardiovascular adaptation to physical exertion, an increase in heart rate and heartbeat rate is manifested. The increase in heart rate (HR) is directly proportional to the maximum O_2consumption and is also the fastest mechanism to adapt the heart rate to physical exertion.

The main objective of general physical training, regardless of the specifics of the sport, is to improve the effort capacity. The essential condition for achieving maximum performance in sports activity, regardless of the specific effort required, is the compliance in preparation of the energy release mode during the competition. Of course, the training plan the objectives of training and the methods used for assessing the results are of major importance. Adam (2022), used means of action that improved the individual's ability to coordinate with the music and the partner depending on the sequence of rhythm changes, the duration of the time intervals between steps, and the rythm of the movements. Another study states that the video recording method is successfully applied and used in the training process as an observational tool, but also as a correction tool for the technical errors in the middle-distance race runner's step, to obtain superior sports performance (Dobre, 2020).

The improvement of repeated efforts at the cellular level, organic tissue and apparatus subject to physical demands is an essential process in the development of the athlete's integral biological system, by morpho-functional adaptation of the requested organs and by developing basic biomotric qualities (Demeter, 1981).

Depending on the solutions for energy assurance of the body's needs with O_2, imposed by the specific demands of different sports competitions, the effort is classified by specialists in the anaerobic, aerobic and mixed effort.

In this paper, we want to highlight the peculiarities of the anaerobic type of effort capacity, as well as to capture the current evaluation methods and the limiting factors of this system.

Research Methodology

To conduct the review, we used searches using the Web of Science electronic databases, PubMed, Google Scholar, usingthekeywordseffortcapacity, anaerobic system, sport performance, effort evaluation, and anaerobic laboratory tests. Wealsousedbooksandcoursesfromthe Romanian fieldliterature.The includedstudies had no limited publication date and examined the effects of exerciseactivity on athleteseffortcapacity.

Results

Evaluation of anaerobic exercise capacity

Anaerobic capacity refers to the amount of energy (mechanical work) that muscle can produce only on the basis of internal energy resources (i.e. in the absence of blood oxygen). Because the muscle cannot function uniformly, the amount of energy released varies over time.

Anaerobic power is the energy that a muscle can provide in the time unit, in the absence of oxygen, and can be expressed in maximum or average values. The units of power in which the intensity of the effort is measured are the watt (W) and kilogram (kg), all in relation to the execution time (t).

The anaerobic exercise capacity testing methodology aims to provide information specific to this type of effort on(Ionescu, 2013):

- recording of muscle efficiency, through tests applied to the muscles directly engaged in the specific movements of the respective sport, in order to increase the degree of accuracy;
- quantitative determination of some indicators of energy metabolism (oxygen deficiency and debt, respiratory coefficient);
- the study of metabolic functional indicators such as urine (before and after exercise), serum urea, and lactic acid (at rest, intra-effort, post-exertion. and recovery), etc.

Anaerobic capacity is still difficult to estimate and/or measure, mainly due to the laborious, invasive, and expensive research methodology.

Among the classic methods for determining anaerobic exercise capacity, we mention the following:

- Wingate test (in the laboratory) – which determines both maximum anaerobic power and maximum anaerobic capacity. In addition, it provides the possibility to calculate the fatigue index (the difference between the maximum value and the minimum power value, divided by the maximum value and expressed in percentages). This test is listed as a research methodology in more than 400 publications in the PubMed database and has been introduced in research studies since 1974 (Ayalon et al., 1974).

- Sargent Test (field test) – evaluates maximum anaerobic power by measuring explosive force and vertical detent (Sargeant, 1987).
- Bosco Test (in the laboratory or on the field) - determines the mechanical strength of the leg extensor muscles (Bosco et al., 1983).
- The Szogy-Cherebetiu test or total labor performed (TTR) test – determines the maximum power and total labor performed (mechanical work) over different time intervals(Szögÿ&Cherebeţiu, 1974).
- Margaria test - determination of the maximum power at the lower limbs.
- Miron Georgescu test - a sample of 30 jumps executed on the spot, with maximum repetition speed, which determines the anaerobic effort capacity.

Jumping and throwing are means used successfully and consistently over the years in estimating the maximum anaerobic capacity and power. The only variable is the test tools used. Recently, modern functional exploration techniques can successfully investigate physiological, biochemical, and biomechanical parameters through portable, minimally invasive electronic instruments. This technological advance has allowed specialists to complete the baggage of measurement and investigation techniques and to collect much faster and more accurate information provided by athletes during laboratory tests, but especially during field tests.There is much interest among researchers in estimating maximum anaerobic power with the help of new devices(Beattie & Flanagan, 2015; Bobbert et al., 1987; Charlton et al., 2016; Chavda et al., 2017; McMahon et al., 2017; Sole et al., 2018; Van Hooren&Zolotarjova, 2017). Of course, the degree of precision and confidence in these innovative methods is also of great importance, and therefore numerous validation studies are available(Banyard et al., 2017; Carrier et al., 2020; Coqueiro et al., 2014; Lake et al., 2018; Orange et al., 2019).

Haugen et al. (2017),identified a higher anaerobic maximum capacity in men, higher than ~85 W·kg-1 (maximum anaerobic power) in vertical jump, countermovement jump(CMJ), and ~36 W·kg-1 on speed running. In women, the maximum values are ~70 W·kg-1 for CMJ and ~30 W·kg-1 for speed running (athletics, cycling and rowing).

Medical-biological factors that limit effort capacity in competitions

During maximum anaerobic efforts (>80-85% of VO_{2max}), which last no more than 20-30 seconds, there is a disagreement between the need for O2 and existing resources, with the muscle forced to use anaerobic energy to contract. This process is based on the breakdown of ATP and PC and is carried out in oxygen debt (which is paid at the end of the effort). Georgescu, M. (1971), states that at this level, efforts are not accompanied by the production of lactic acid, are called anaerobic alactacide efforts, and are specific to weightlifting competitions, some athletics, cycling, or gymnastics.

Submaximal efforts (30-60 seconds) involve the intervention of glycogen resources (anaerobic glycolysis) and trigger the production of lactic acid, known as lactacid anaerobic efforts, and are found in some athletics, skating, or swimming samples. These two types of anaerobic effort (maximal, and submaximal) are carried out only in very short intervals of time, maximum of 30 seconds.

Although oxygen does not play a decisive role in the release of energy required by muscle contractions, its action allows the muscle to regain its energy potential and thus, muscle activity can be continued without the accumulation of toxic products.

Limiting factors of the anaerobic alactacid system

In situations where the body is subjected to maximum intensity efforts, through the rapid transition from low stress, the energy needs cannot be immediately ensured by the oxidative processes, due to insufficient adaptation to the demands of the cardiovascular system, and thus an oxygen deficiency is created(Ionescu, 2002).However, Georgescu (1971) considered that not only does the cardiovascular device limit the maximum and submaximal efforts, but also the proper functioning of the neuromuscular system, which must be based on optimal energy support. The same goes for Alexe, N. (1993), who believes that indices such as muscle mass and structure strongly correlate with achieving performance in power efforts. By assessing the maximum anaerobic power (by jumping samples and throwing), the level of preparation of the neuromuscular system can be determined. Only in this way do decomposition and resynthesis processes run faster, and the ability to perform higher-intensity efforts over a longer time increases.

Limiting factors of the anaerobic lactate system

Research by specialists such as Ionescu, A., (2002) and Alexe, N. (1993) shows that achieving performance in competitions involving anaerobic lactacid efforts is primarily influenced by the body's ability to pay the O_2 debt and the level of lactic acid (AL) accumulated. Alexe, N. claims that, unlike alactacide efforts, where effort is stopped with depletion of ATP and PC resources, in sports where glycogen breakdown occurs to obtain energy, the accumulation of lactic acid (AL) begin. If high-intensity efforts are carried out over a long period of time, a large amount of AL accumulates in the muscles, causing fatigue, decreased intensity of effort, and, finally, stopping activity. Therefore, Ionescu, A, believes that good training helps athletes better support lactate synthesis, which is weaker and can return to normal values after an hour after the exercise has ended. The same author recommends an active recovery of 30-50% of VO_{2max}, after exercise, because the blood intervention is meant to "wash" the muscles and thus speed up the elimination of AL from the body.

Conclusions

Depending on the sport performed, objective evaluation of some physiological indicators, directly or indirectly involved in the type and/or specificity of the competitive effort, can provide important data that help the coach schedule and plan training efforts to increase the biomotric potential of the athlete's body.

However, methodological aspects of the test should be taken into account in the interpretation of the results. To ensure the quality and veracity of the data, strict adherence to test procedures, calibration of instruments, and increased attention to physiological measurements are recommended. All of this poses the risk of misinterpretation of the data.

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