

Objective individualization of the endurance training programmes for the effort specific to the floor apparatus in men's artistic gymnastics

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Abstract

The ability of athletes to produce appropriate physiological responses to the specific requirements of the competition routine is one of the main factors for achieving the competitive performance in sports. In order to obtain objective information about the individual level of adaptation to effort, in the sports practice, the specialists use different measurement schemes of the main physiological parameters. **The purpose** of this study was to determine the individual particularities in terms of the metabolic and cardiovascular response following the application of a specific training stimulus for endurance training on the floor apparatus, in the men's artistic gymnastics. **Methods.** The study was carried out on a number of 10 elite gymnasts ($M = 24.4$ years, $S.D. = \pm 2.4$). The influence of a specific training stimulus (independent variable) on dependent variables (cardiac frequency and lactic acid concentration in capillary blood) was measured for the assessment of the level of adaptation to effort. **Results.** Based on the correlation of the two measured dependent variables, we was found that seven athletes were in the Stable Oxygen Zone, two in the Aerobic-Anaerobic Threshold Zone and one at the Oxygen Zone. For seven of the elite athletes, there was also a mismatch between heart rate values and lactic acid levels, suggesting an insufficient equilibrium between muscle and cardiorespiratory components. Considering the high variability of the measured variables ($C.V. = 6,7\%$ for heart rate and $CV = 43.6\%$ for

the lactic acid concentration values) and the ratios between them, we used for this research the case study method. **Conclusion.** Regardless of the specificity of each sports branch or routine, the planning of the training for specific endurance training requires a preliminary phase of knowledge of both the characteristics of specific effort and the individual degree of adaptation to effort.

Keywords: specific effort, biochemical management, effort zone, planning.

Introduction

It is not exaggerated to say that success in every sport is fundamentally based on the body's ability to generate energy. This is due to the fact that, in many respects, the performance of the athletes is expressed by the limits which the human body is able to overcome if an athlete wants to achieve the best results (Joel, 2014).

The effectiveness of the training programmes is determined by the understanding of the mechanisms which ensure the production of the energy needed to make various types of effort. The main factors determining the dosing of the intensity of effort in the specific endurance training programmes are: specific metabolic stress of the competition routine, training stage in the general training plan and the individual level of adaptation to specific effort. Depending on the intensity and duration of effort, the body mainly accesses a certain metabolic mechanism, which determines the metabolic specificity for each competition routine. It is considered that a training is metabolically specific if it stimulates accessing the same metabolic pathways used in the competition routine.

Whatever the characteristics of the effort made, the energy required to produce muscle contraction is provided by three basic metabolic mechanisms: the phosphocreatine system, the anaerobic glycolytic system or the glycogen system - lactic acid and the aerobic or oxidative system. (Guiton, 2006; Chandler and Brown, 2008). These three systems are based on distinct energy reactions and substrates, but they work in a coordinated manner, producing the recovery of ATP molecules required for muscle contraction. Shortly after the effort begins, regardless of its type, there will be a need for an amount of energy in addition to the energy stored in the muscle cell. Thus, the most obvious response following the stress determined by the effort, is the intensification of metabolism. All three energy systems are involved in this response, their relative contribution being proportional to the intensity and duration of each activity. (Plowman and Smith, 2014). In the efforts of high intensity and short duration, the mechanisms that have phosphocreatine and

anaerobic glycolytic systems as an energy source are prevalent, and in the long-term efforts, in which the oxygen intake is substantial, the oxidative mechanisms are prevalent.

The type of energy substrate used, its succession and efficiency in sustaining the effort made in training and competitions is determined by both external and internal factors. The external factors are represented by the characteristics of the training stimuli, the duration, intensity and complexity of the effort, and the internal factors are represented by two groups of factors:

Strength and capacity of energy systems. Mobility and effectiveness.

Strength is the maximum amount of energy released per unit of time, and capacity refers to the size of the energy substrates. Mobility is manifested through the speed and variation of the energy-release processes depending on the stress, and effectiveness is characterized by the ability to effectively use the energy produced. (Platonov, 2015).

The athletes' training to get the highest energy-producing capacity to sustain specific effort is a complex process which cannot be achieved without periodically measuring and monitoring those parameters that can provide us with real and objective evidence about the effects of the effort on each athlete. Biochemical management in performance sports is one of the methods applied to make corrections in the training plans, depending on individual biochemical reactivity. The biochemical verification of the main stimuli used in the training sessions (intensity, volume and ratio of stimuli, their distribution within the training cycles, the significance of the stimuli, metabolic costs, determination of durations and effort tempos in different effort zones) leads to the achievement of an optimal training level, post-effort recovery programmes and maintaining the health of the athletes.

At present, in practice, specialists use different effort classification schemes in the so-called «effort zones». The number of effort zones differs from one group of specialists to another, ranging from 3 to 11 effort zones, and the distribution limits of these zones are determined by the ratio between different physiological parameters

(Gore, 2000; Esteve–Lano et al., 2005; Seiler and Tonnessen, 2009; Tocitu, 2000; Plowman and Smith, 2014).

The division into effort zones, according to Dr. Dorel Tocitu, the head of biochemistry laboratory of the National Institute for Sports Research, is made taking into consideration the pace, intensity and duration of effort, heart rate and lactate concentration (Tocitu, 2000). He divides the sports training into six energy effort zones, as follows:

1. Oxygen zone
2. Stable oxygen zone
3. Relative oxygen zone
4. Maximum oxygen consumption zone
5. Lactate tolerance zone
6. Lactate – oxygen zone

1. *Oxygen zone* is the zone in which the pace is slow, the duration of the effort is 30-60 minutes, the intensity of effort does not exceed 50%, and the heart rate is 140 ± 10 bpm. It is a zone of effort for recovery and has significance for high performance athletes only in the processes related to post-effort recovery.

2. *Stable oxygen zone* is the zone with a slower pace than the race pace, the duration of such effort is 45-120 minutes, the heart rate is 150 ± 10 bpm. The intensity of effort in this zone is 55-65%.

Working in this zone improves the aerobic capacity of the body, the energy resulting solely from aerobic mechanisms.

3. *Relative oxygen zone* or the aerobic-anaerobic threshold zone imposes a slower pace than the race pace, the duration of the effort is between 30-90 minutes, the intensity of the effort amounting to 70-80%. The heart rate is 160 ± 10 bpm.

In this zone, the mechanisms are mainly aerobic, the anaerobic ones being in a lower percentage, which makes the effort to produce concentrations of 3-5 mmol/l of lactic acid.

In the specialized literature, this zone is defined as the intensity zone at which the diffusion rate of the lactic acid into the blood stream exceeds its rate of elimination from the blood (Tocitu, 200, P. 112).

4. *Oxygen-lactate zone 2* or the maximum oxygen consumption zone is the zone in which the pace is slower or similar to the race pace, the intensity of the effort is 85-95%, and the heart rate reaches 170 ± 5 bpm.

It is the zone in which the aerobic mechanisms are prevalent, but the percentage of anaerobic mechanisms is fairly high. The concentrations of lactic acid can also amount to 12 mmol/l.

5. *The oxygen-lactate 1 zone* or the lactate tolerance zone is the zone whose pace is similar to the race pace, the duration of the effort is maximum 4.30 minutes, the intensity is 100%, and the heart rate is 180 ± 5 bpm. The aerobic and anaerobic energy-generating mechanisms have equal weights, the concentration of lactic acid having values ranging between 12-18 mmol/l.

Working in this area trains the athletes to cope with high lactate concentrations without losing much of the speed.

6. *The oxygen-lactate zone* is a zone in which the energy-generating mechanisms are mainly anaerobic, the intensity of the effort exceeds 100%, the heart rate is 190 ± 5 bpm, and the lactic acid concentration exceeds 18 mmol/l.

The characteristics of effort in the floor routine in men's artistic gymnastics

In the artistic gymnastics, the level of competitive performance is assessed by the degree of difficulty (Note D) and by the quality (Note E) of the execution of the specific technique, based on the criteria set out in the Code of Points. Although the measure of performance is given by the accuracy of the execution of some sequences of technical elements, the training of the typical energy systems to make the specific competitive effort is one of the essential aspects of the training of the gymnasts. This requirement involves the creation of training scheme that will produce metabolic effects similar to those in competitions and appropriate post-effort recovery programmes because, as many specialists argue, "all sports efforts ultimately depend on the rate and efficiency with

which chemical energy can be turned into mechanical energy for the contraction of skeletal muscles.” (Hawley, Nader, 2008).

In men’s artistic gymnastics, the competitive effort is characterized by a relatively short duration (6-7 seconds on the vault and 70 seconds on the floor) and high intensity. Biochemical measurements made in competitions on elite gymnasts led to lactic acid concentrations higher than 11 mmol/l and heart rate values higher than 180 bpm. (Monèm, 2011). Considering the results of these studies, we can consider that the intensity of the specific effort on the floor apparatus in men’s artistic gymnastics corresponds to the effort zones oxygen-lactate 2 and oxygen-lactate 1. The methodology of the sports training mentions that a high capacity to make high intensity effort is based on the proper development of the aerobic capacity. (Harre, 1973).

Methodology of research

Method

Through this research we aimed to determine the adaptive particularities of the elite gymnasts. The reduced number of subjects at this level and the inhomogeneous distribution of the measured parameters, determined us to use the *case study method*. In addition, this method allowed us to perform both the analysis of each athlete’s particularities and individual corrections in the training plan.

Subjects of research

The study was carried out on a number of 10 elite gymnasts, aged between 22 and 28 years old, Mean age (M) = 24.4 years and Standard Deviation (SD) = ± 2.4 . The research was carried out with the individual agreement of each athlete and with the agreement of the Romanian Gymnastics Federation, as stipulated in the scientific assistance contract between the Federation and the National Institute for Sport Research.

Purpose of research

The purpose of this study was to determine the individual particularities in terms of the metabolic and cardiovascular response following the application of a specific training stimulus for endurance training on the floor apparatus.

Objectives of research

Determining the individual level of metabolic and cardiovascular adaptation in relation to the training objectives corresponding to the phase in the specific annual plan.

Establishing an optimal individual dosing of effort in the training programme proposed as stimulus for the training of endurance in the general training phase of the annual training plan.

Description of the assessment procedure

Independent variable. All the athletes participating in this study made the same effort, designed to be adjusted and developed as a result of the individual assessment, so that this programme represents a training scheme for endurance training in the general training phase of the annual training plan. The training programme was made up of exercises specific to the floor apparatus, made successively in 18 series with a duration of 20 - 22 seconds, alternatively with an active break of 15 seconds. The total duration of the effort for each athlete was 11 minutes. The difficulty of the elements included in the programme progressively increased throughout the programme. The contents of the training programme as well as the dosing of effort were proposed by the athletes' trainer, specialized in the planning and management of the training on the floor apparatus, following the individual determinations as a training programme for specific endurance training on the floor apparatus for the general training phase of the annual training plan.

Dependent variable. In order to achieve the intended purpose, two parameters were measured in this study: concentration of lac-

tic acid in the capillary blood and the value of the heart rate. For the assessment of the lactate concentration in the blood, the lactate analyzer – *Lactate Pro 2* was used. This instrument quickly provides (in about 15 seconds) the values of the lactate concentration in a small quantity of blood (0.3µl) sampled from capillary blood. (<http://www.lactatepro.com.au>). The sampling was carried out in two moments: under basal conditions (T1) and immediately after the end of the specific effort (T2). In order to determine the adaptation of the heart to effort, the heart rate was determined under basal conditions, throughout the effort, and for 10 minutes in the post-effort recovery period. The instrument used to monitor the heart rate was Polar team system, specifically designed for measuring and storing the heart rate values during the effort, simultaneously for several athletes. In the practice of the sports training, the monitoring of the heart rate is one of the most common methods of assessing and guiding the intensity of effort.

Results

It can be seen from the data presented in table no. 1 that the ten athletes involved in the study showed different degrees of adaptation to their effort, both in terms of the effort zone and the concordance between the two parameters measured, heart rate and lactic acid concentration.

The effort-induced metabolic stress could be assigned to three different effort zones:

- effort zone Aerobic-Anaerobic Threshold (P.A.) for two athletes, S8 and S10.
- effort zone Stable Oxygen (O_2S) for seven athletes, S1, S2, S3, S4, S5, S6 and S9.
- effort zone Oxygen Zone (O_2) for athlete S7.

Three athletes, S2, S8 and S10 showed a concordance of the heart rate values with the lactic acid concentrations, corresponding to their effort zones. All the other athletes under assessment showed a varying level of inconsistency between the values of the

heart rate and the values of the lactic acid concentrations. This suggesting an insufficient equilibrium between muscle and cardiorespiratory training.

Table no. 1. Results achieved by athletes in assessing effort adaptability

Subject	HR. basal	HRmax. in effort b/min	Lactate concentration lactat (T1) mmol/l	Lactate concentration (T2) mmol/l	Effort zone	Conclusions
S1	60	165	0	2	O ₂ S	Is not concordance HR-lactate
S2	60	140	1.2	2	O ₂ S	Concordance HR-lactate
S3	66	160	0,5	2,8	O ₂ S	Is not concordance HR-lactate
S4	60	165	0	2	O ₂ S	Is not concordance HR-lactate
S5	72	170	0	1,2	O ₂ S	Is not concordance HR-lactate
S6	54	150	1.2	2	O ₂ S	Is not concordance HR-lactate
S7	66	160	0	0,5	O ₂	Concordance HR-lactate
S8	66	160	2.8	3,6	P.A.	Is not concordance HR-lactate
S9	72	180	0.5	2,8	O ₂ S	Concordance HR-lactate
S10	72	167	1.2	3,6	P.A.	Is not concordance HR-lactate

For the seven athletes who were in the effort zone Stable Oxygen (O_2S), if the values of the lactic acid amounted to a low level, between 0.5 and 2.8, the values of the heart rate are too high for the effort zone within which the working intensity has fallen. We mention that the optimal intervals of the heart rate for this effort zone are 150 +/- 10bpm. Likewise, the athlete S7 shows a low lactic acid concentration corresponding to the effort zone Oxygen (O_2), but a very high heart rate of 160bpm, whereas the optimal values for this working intensity are 140 +/- 10bpm. This inconsistency between the values of the lactic acid concentration and the values of the heart rate indicates a poor cardiovascular adaptation. Regarding the distribution of the measured variables (Chart 1 and 2), we found an optimal level of homogeneity for the variable maximum heart rate (C.V.= 6.7%) and a very high degree of variability, for the lactic acid concentration values (C.V.= 43.6%).

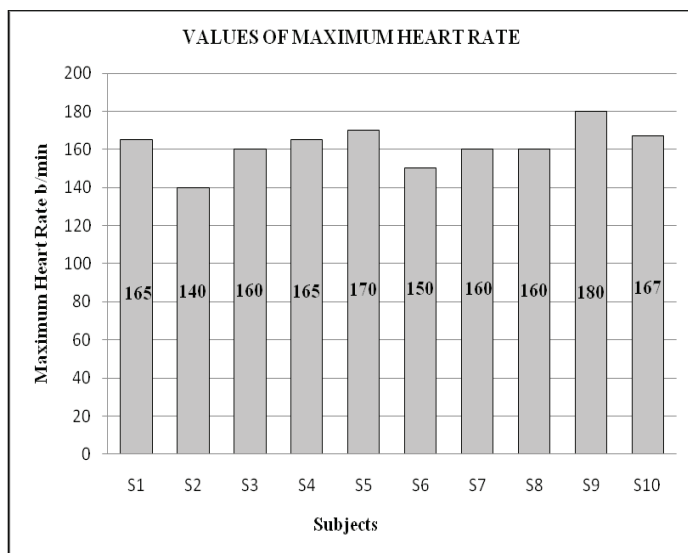


Chart 1. Values of maximum heart rate

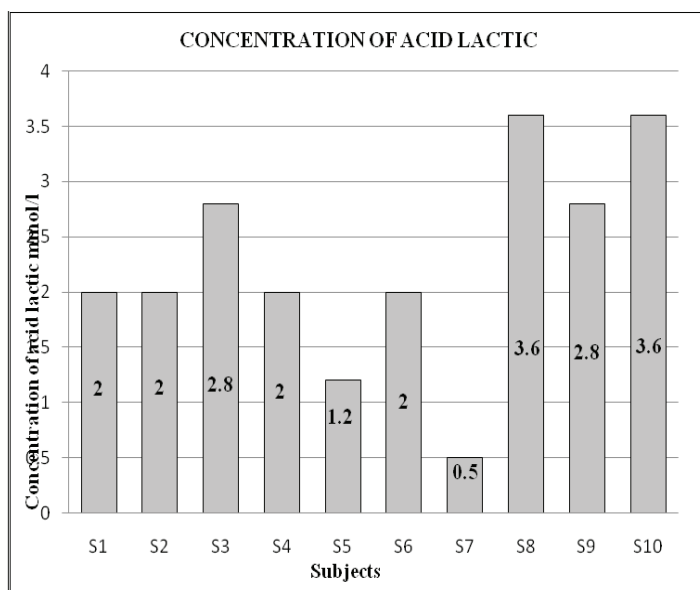


Chart 2. Values of lactic acid

Conclusions

Considering the results achieved by the athletes and the fact that they were in the general training period, it was recommended that while continuing this phase, the training in the effort zone Stable Oxygen (O_2S) should be emphasized for all the athletes, with special attention paid to athletes S1, S2, S3, S4, S5, S9 and S9. The introduction of training tasks characterized by medium intensity and long duration in the training plans in the preparatory phase ensures, on one hand, an improvement in the level of individual cardiovascular adaptation and, on the other hand, improves overall effort capacity, thus reinforcing the basis for specific endurance training in the subsequent stages. For sports branches where competition involves very high intensity effort, extensive, medium-intensity effort is important to ensure both the efficiency of the mechanisms required during the specific effort and a high post-effort recovery capacity of the body.

From the data presented in Table 1, it can be noted that two athletes, S8 and S10, had a higher lactic acid concentration as compared to the rest of the group of athletes, which indicates a low level of muscle adaptation to the effort. There are five important factors

that determine the production of lactic acid: muscle contraction, type of muscle fibres, enzyme activity, activation of the sympathetic nervous system and oxygen deficiency. (Plowman, Smith, 2014). For these athletes, it is recommended to improve their muscular capacity to sustain high intensity effort in parallel with the development of the aerobic effort capacity, for quick metabolising of the lactic acid during recovery.

In conclusion, regardless of the specificity of each sports branch or routine, the planning of the training for specific endurance training requires a preliminary phase of knowledge of both the characteristics of specific effort and the individual degree of adaptation to effort, in relation to the characteristic objectives of each training phase in the annual training plan. The main issues which the trainers should know, both for the planning of the effort for each phase of the training plan, and for the current adjustment of the established programmes are:

Metabolic stress specific to the competition routine.

Basic energy mechanisms which provide specific energy.

Metabolic products resulting from the specific effort.

Appropriate methods and means for post-effort recovery.

The individual level of specific endurance training in relation to the requirements of the routine and the current training phase.

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