

MODIFIED FIELD TEST FOR DETERMINING THE SPECIFIC ENDURANCE IN RHYTHMIC GYMNASTICS

Maria Gateva

National Sports Academy „Vassil Levski”, Sofia, Bulgaria

ABSTRACT

Several attempts have been made in the past years to create adequate tests in order to determine the fitness level of the athletes in the gymnastics disciplines. Considering the high-intensity movements and the total routine time, we hypothesized that anaerobic metabolism is a determinant for rhythmic gymnastics performance. Based on the physiological indicators of a competitive routine the aim of this study was to create a reliable and valid specific field test to measure the fitness level (specific endurance) of the rhythmic gymnasts competing at national and international level.

12 high level gymnasts aged 15.7 ± 2.1 were involved in this study. The testing was done twice – once in the preparatory and second time in the competitive period. Two tests were performed in the field – the specific anaerobic test and a competitive routine. The heart rate and the blood lactate were recorded during and after the load. Specific endurance gymnastics field test is a simple routine including specific but very basic rhythmic gymnastics exercises from each body group – steps; waves; balances; pivots; leaps and acrobatic elements with very low level of difficulties.

The maximal blood lactate concentration levels recorded in both tests and periods did not show any significant difference and varied between 7.2 to 8.4 mmol/l. All of the heart rate values after the loads indicated high work intensity – above 185 bpm. There were significant differences in both exercises (specific test & routine) between the preparatory and the competitive routine. The heart rate clearly showed adaptation of the cardiovascular system towards the load when tapering into the peak performance period. The suggested test is a standard field test suitable for active, mid to high level rhythmic gymnasts aged above 12 years which can measure the current specific endurance of a gymnast and compare it with her previous testing or gymnasts.

Key words: *rhythmic gymnastics, specific endurance, field test, blood lactate, heart rate*

INTRODUCTION

Several attempts have been made in the past years to create adequate tests in order to determine the fitness level of the athletes in the gymnastics disciplines. There is a field test in aerobic gymnastics, for example, that measures the anaerobic metabolism performance known also as Borelli's test (Alves et al., 2015). It consists of specific gymnastics elements performed in maximal repeated sprint fashion, during a total timeframe of 80–90 sec which aims at simulating the total duration and

intensity of a typical AG competition.

Sleeper et al. (2012) applied a whole battery of tests in order to measure the fitness level in women's artistic gymnastics. There is no doubt that strength, flexibility, mechanical and anaerobic powers are the primary factors in artistic gymnastics performance (Jemni et al., 2011). Some authors (Marina, Rodríguez, 2014), though, suggested that modern female competitive gymnastics imposes higher cardio-respiratory and metabolic demands than previously supposed.

Several authors have tried to identify the volume of internal load during the competitive program (routine) of rhythmic gymnasts (Gateva, 2014 & 2015; Fernández-Villarino et al., 2018). A statistical approach highlights the significance of aerobic and anaerobic metabolism (high energy phosphate and glycolysis) for successful performance in rhythmic gymnastics (Douda et al., 2008). The same authors recorded significant (high) correlation between the maximal oxygen consumption and the sport result as continuous maximal exercise for 60 to 90 seconds required aerobic metabolism. In concordance, Guidetti et al. (2000) found that the most taxed energy source during the ball routine was aerobic, which enabled athletes to perform high-intensity rhythmic gymnastics routines and also pointed out the importance of anaerobic metabolism. Training sessions and programs require gymnasts to have endurance in force production in rhythmic gymnastics (Polat, Günay, 2016). The routines have a short duration and the exercise intensity is maximal at some moments (Batista et al., 2018). The load during the competitive routine in rhythmic gymnastics has very high demands on the anaerobic system (Manos, et al., 2012) – blood lactate concentration after a group routine is up to 12.2 mmol/l. Similar and even higher results were obtained with the Bulgarian national team (Nikolov, Katelieva, 2004).

Wingate test is used in artistic and aerobic gymnastics to measure the anaerobic power of the athletes. In rhythmic gymnastics, though, this test is not adequate because it is designed towards more power orientated specific sports. VO_2 max is not appropriate either, as it measures the aerobic capacity. Considering the high-intensity movements and the total routine time, we hypostatized that anaerobic metabolism is a determinant for rhythmic gymnastics performance. Based on the physiological indicators of a competitive routine *the aim* of this

study was to create a reliable and valid specific field test to measure the fitness level (specific endurance) of the rhythmic gymnasts competing at national and international level.

METHODS

Subjects

12 high level gymnasts (some in the Bulgarian National team) aged 15.7 ± 2.1 were involved in this study. The competitors were category “elite” from Levski Triaditsa sports club in Sofia, training 30 to 35 h per week. The testing was done twice – once in the preparatory period and second time in the competitive period. Two tests were performed in the field – the specific anaerobic test and a competitive routine. Parental permission and informed consent were obtained from all participants.

The collected data were used in two ways – to check the validity of the test compared to other test as well as to determinate the sensibility of the test (comparing the values between preparatory and competitive period to see if the positive changes from tapering in peak performance are determined by the test).

Instruments

Heart rate was recorded by POLAR RCX3. The recording started at rest and continued until 10 min post exercise (recovery period). A drop of blood sample was taken from the fingertip to measure blood lactate using an Accutrend Plus Roche. Lactate was taken before and at the 3rd, 5th and the 9th min during the recovery period.

Study design

Specific endurance gymnastics field test is a simple routine including specific but very basic rhythmic gymnastics exercises from each body group – steps; waves; balances; pivots; jumps & leaps and acrobatic elements with very low level of difficulties. We investigated if the load during the test would match the ef-

fect of performing a real gymnastics routine regarding the HR and blood lactate values from both executions in both periods (preparatory & competitive).

Warm up

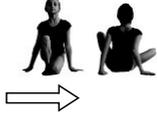
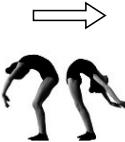
The test was carried out at the beginning of the training sessions after a 30 min warm up, followed by a 10 min specific warm up prior to each of the two routines. After the completion of the first test the gymnasts were given a passive recovery period for 10 min. The next field test was done after 20 min.

Description of the test (Author test) – specific endurance rhythmic gymnastics field test.

The total duration of the routine is 1.58 min

performed on the standard RG carpet 13 x 13 m. The presented 21 exercises in table 1 are 59 sec long and in order to perform them in tempo the song „We Will Rock You” by Queen was played (84 bpm). The route is repeated twice to reach the target time of 2 min. (1.58 min). It is composed of typical basic exercises for rhythmic gymnastics where the order of the performed elements is based on the choreographic decisions and alternation of the elements from the different body groups. All of the specific exercise groups are displayed in this routine with low level of difficulty and structure close to the competitive one. The aim of the test is to achieve the closest possible dynamics and kinematics of the rhythm in a gymnastics routine.

Table 1. Description of the specific endurance rhythmic gymnastics field test

1. 4 chassé with the right & left leg		8. Vertical & star jump 2 times (in one place)		15. Chaîné	
2. Vertical jump with 360° turn		9. Backwards walkover to squad		16. Cart-wheel	
3. Split leap dive with forward roll		10. Side split leap on hands		17. Pike jump	
4. Passé balance		11. 3 split leaps in a roll (with chassé)		18. Backwards body wave	
5. Two chaînés		12. Side roll		19. 360° en dehors passé pivot	
6. Body wave forwards		13. Forwards walkover		20. 3 turning cat leaps	
7. 2 illusions		14. Arabesque balance		21. 360° en dedans passé pivot	

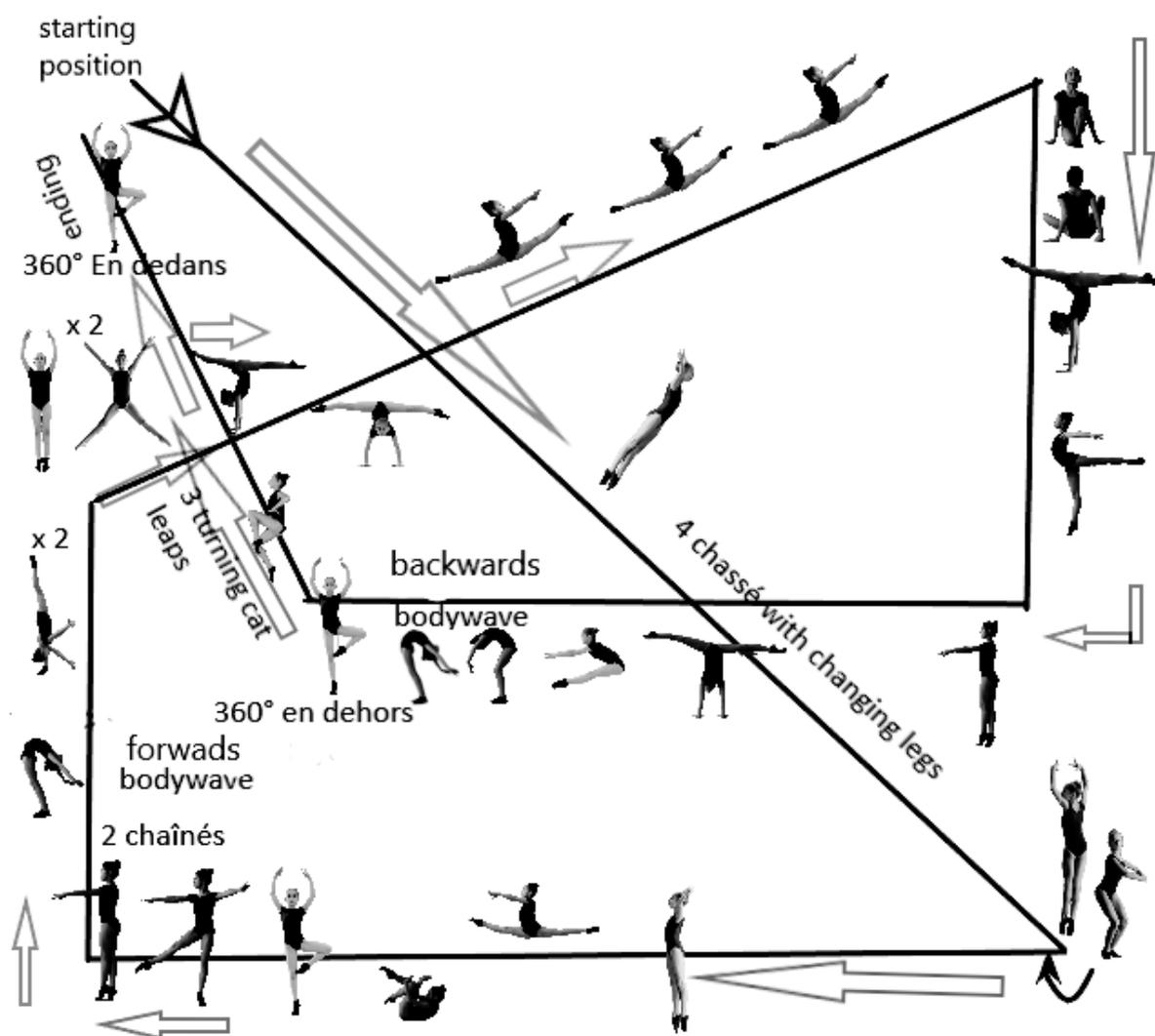


Figure 1. Directions and illustration of the specific endurance rhythmic gymnastics field test

Statistical analysis

Descriptive statistics was used to characterize the physiological reaction during and after applying the tests and routines in rhythmic gymnastics.

Pearson's correlation coefficient measures the relationship between the competitive routine and our specified field test (routine) based on the heart rate and blood lactate results. **Student's paired t-test** was applied to find differences in heart rate monitoring and blood lactate measurements between the two

periods – preparatory & competitive period. The level of significance of $p \leq 0.05$ was adopted in all cases.

RESULTS

The values of heart rate and blood lactate concentration measured during and after the specific endurance test on the field and the competitive gymnastic routines in both periods are summarized in the figures and tables below. The maximal blood lactate concentration levels recorded in both tests and periods did not show any significant difference.

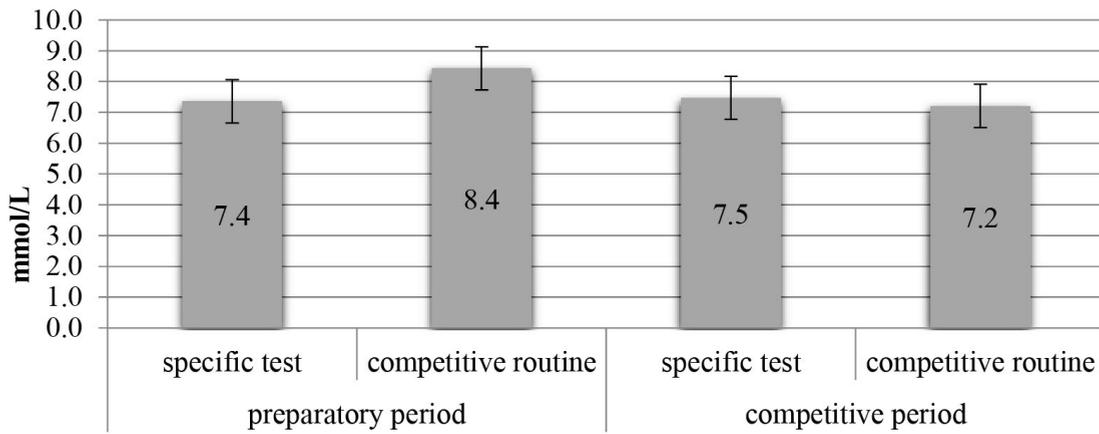


Figure 2. Blood lactate levels after specific test & routine

A very strong correlation in blood lactate indicator during the competitive period was found between the specific test and the competitive routine but not in the preparatory period.

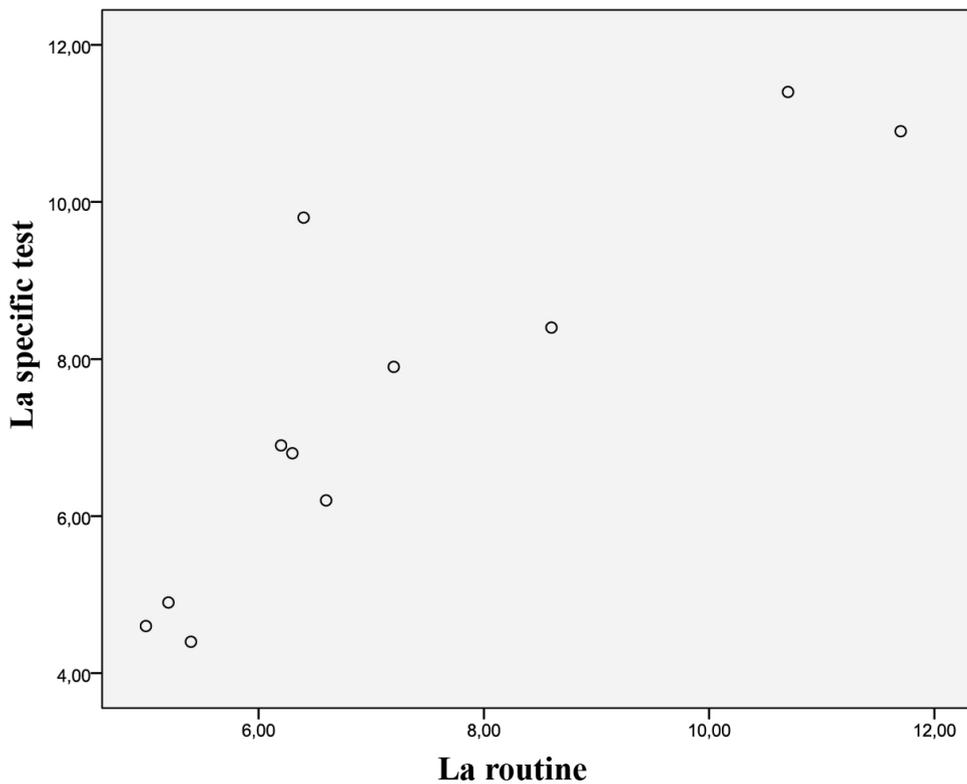


Figure 3. Pearson correlation coefficient – blood lactate concentration in competitive period

Moderate correlation was recorded in the peak heart rate values in both testing – in preparatory and in competitive period. All of the heart rate values after the loads indicated high work intensity – above 185 bpm. There were significant differences in both exercises (specific test & routine) between the preparatory and the competitive routine. The heart rate clearly showed adaptation of the cardiovascular system towards the load when tapering into the peak performance period.

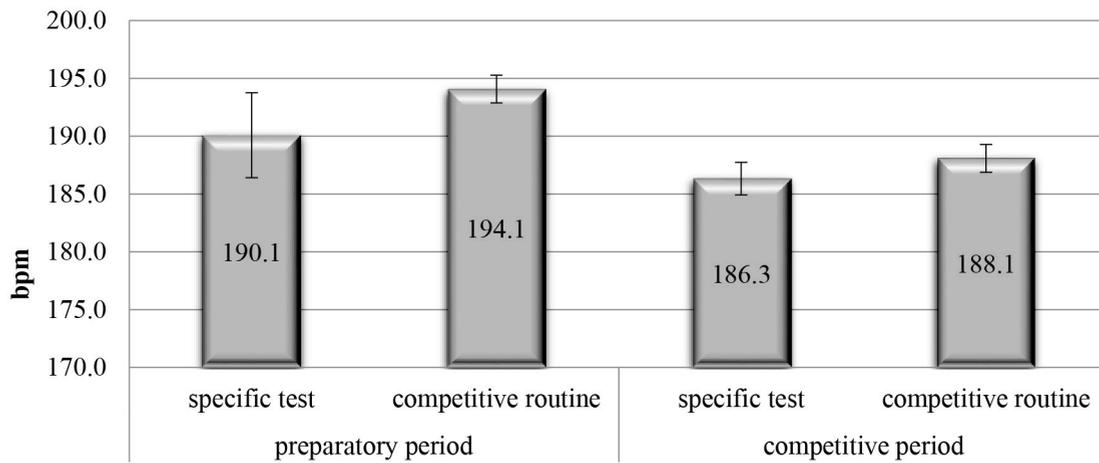


Figure 4. Heart rate values after specific test & routine

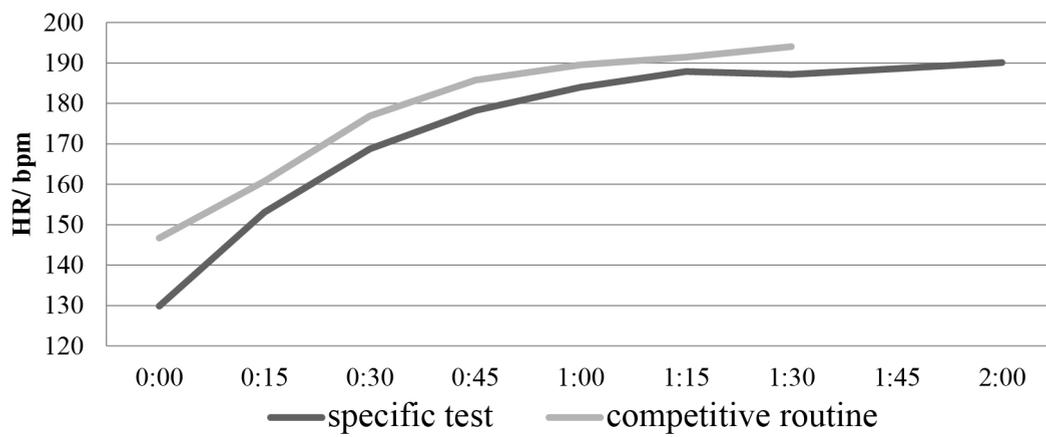


Figure 5. Heart rate values during specific test & routine - preparation period

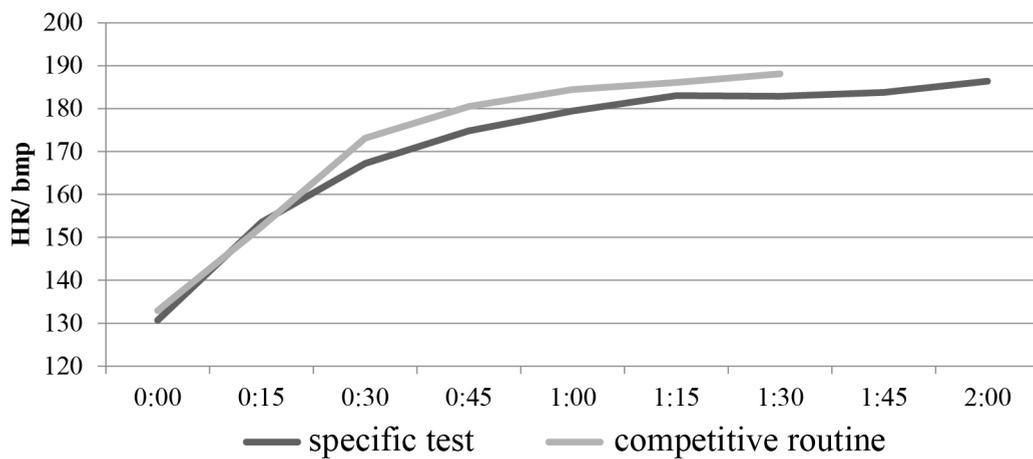


Figure 6. Heart rate values during specific test & routine - competition period

In figures 5&6 we can quite clearly see the cardio-dynamic and fast phases of the heart rate at the beginning of the tests. After the first 30 sec of the load, values continued to rise slowly with just 20 b/min up to the end of the tests. The specific endurance test provoked similar response in the cardio-vascular

system but with lower values than the gymnastics routine. We have to keep in mind that the competitive routine is performed with apparatus in hands while the modified routine is free of apparatus, so the intensity of load in the upper body during the RG competitive routine is higher.

Table 2. Descriptive statistics of the HR and concentration of the blood lactate after the load

Test	HR mean (SD) (b/min)	HR min. (b/min)	HR max. (b/min)	La mean (SD) (mmol/L)	La min. (mmol/L)	La max. (mmol/L)
Modified routine PP	190.1 (±5.4)	182	200	7.2 (±2.5)	4.6	11.5
Gymnastics routine PP	194.1 (±4.2)	187	200	8.7 (±2.3)	5.7	12.8
Modified routine CP	186.3 (±4.9)	179	197	7.5 (±2.5)	4.4	11.4
Gymnastics routine CP	188.1 (±4.0)	181	194	7.2 (±2.2)	5.0	11.7

PP – preparatory period; CP – competitive period

Table 3. Heart rate dynamics during the testing (means ± SD)

t (min)	Specific modified field test		Gymnastics routine	
	Preparation period	Competitive period	Preparation period	Competitive Period
00:00	129.8 (±17.1)	130.7 (±13.6)	146.7 (±10.9)	132.9 (±17.6)
00:15	153.1 (±15.6)	153.5 (±9.1)	160.8 (±11.6)	152.5 (±10.7) *
00:30	168.8 (±9.1)	167.2 (±5.2)	176.9 (±7.5)	173.1 (±6.4)
00:45	178.3 (±8.4)	174.8 (±4.5) *	185.8 (±5.3)	180.5 (±5.3) *
01:00	184.0 (±6.9)	179.4 (±5.2) **	189.5 (±4.9)	184.5 (±4.0) *
01:15	187.9 (±6.0)	183.0 (±5.1) **	191.5 (±4.2)	186.1 (±4.1) *
01:30	187.2 (±5.5)	182.8 (±4.6) **	194.1 (±4.2)	188.1 (±4.0) **
01:45	188.6 (±5.7)	183.8 (±4.8) **		
02:00	190.1 (±5.4)	186.3 (±4.9) **		

* $p < 0.05$ significant difference between the periods

** $p < 0.01$ significant difference between the periods

DISCUSSION

We hope that not only the laboratory examination but also the field gymnastic “specific anaerobic” test provide valuable information about the actual level of anaerobic abilities of the gymnasts and their changes during training. Heller, et al. (1998) considers that the field test of 30-s repetitive jumping performance may be used as a simplified measure of anaerobic capacity, because of its close relationship to the standard laboratory 30 s Wingate

test. Mackenzie, B. (2005) presents various field tests to determine the fitness level of the athletes (Harvard step test; Home step test; 3 min step test; ect.).

Gymnastics has been proven to be an anaerobic sport despite some discussions and different opinions. The duration of a rhythmic gymnast’ routine is 90 sec with high intensity of the execution. For that period approximately 90 to 100 different exercises are performed with body and apparatus with high

level of difficulty (Petrova, 2015). Anaerobic lactic system is the main provider of energy for exercises lasting from 10 to 60 sec and the aerobic system requires 60 to 80 sec to start producing energy (Bompa, Buzzicheli, 2015). There is an increasing contribution of the anaerobic metabolism in gymnastics (Jemni et al., 2011). The training sessions in rhythmic gymnastics are in aerobic regime of work (Gateva, 2008) but the competitive programs (routines) which are repeated many times per training session have submaximal demand based on the tested indicators. The aerobic fitness a gymnast may possess will show how quickly gymnasts recover between high intensity load such as routines or part of the routines. The blood lactate shows the anaerobic involvement of the body systems into the measured physical loads. Although there is no significant difference between the tests and periods, in the preparatory period the concentration of blood lactate is slightly lower in the specific test (7.4 mmol/l) than in the routine (8.4 mmol/l) but in the competitive period it is decreased in the value of the routine and we have recorded similar value for the specific test. By rehearsing the same skills and routines the gymnast becomes increasingly “economical” (Jemni et al., 2011) – in this case the competitive routine was practised many times per day in comparison with the specific endurance test which was not performed at all. Despite all the contradictory opinions about the reliability of the heart rate, some authors consider it as a useful first approach to assess exercise intensity in technical-combinatory sports such as gymnastics (Marina, Rodríguez, 2014). For others, heart rate is a significant variable used to explain performance in gymnastics (Douda et al., 2008). The results from the heart rate show that we have a certain type of a plateau – from the 45th sec of the loads onwards.

Analysing the curve of the heart rate we considered that from this moment the aerobic mechanism started to be the supplier of energy for the remaining part of the routine. Although the values of the heart rate were lower with 3 to 5 bpm for the specific endurance test (the routine still showed higher demands on the gymnasts’ body systems) we consider our attempt to measure the sport-specific physical abilities (specific endurance) a successful one. The two curves of the heart rate response towards the physical load are identical. The test is applicable as it is standardized and with the predetermined exercises all gymnasts will have the same physical load and we can compare the athletes to one another. As the test was set by a certain tempo we still can talk about specific endurance in rhythmic gymnastics. If we ask the gymnasts to perform it with maximal speed, then it can be an anaerobic endurance. The presented test is informative and gives the opportunity to compare the result from previous testing or to compare the specific endurance between different gymnasts. It is expected that with appropriate training between each test, the analysis would indicate an improvement.

Further research is needed to continue the process of establishing the various types of reliability and validity of the test.

CONCLUSIONS

The suggested test is a standard field test suitable for active, mid to high level rhythmic gymnasts aged above 12 years which can measure the current specific endurance of a gymnast and compare it with her previous testing. It can also be used to compare the specific endurance between different rhythmic gymnasts. Further investigation is needed to determine the correlation between the proposed test and the sports achievement. The blood lactate is the best indicator for the an-

aerobic regime of work of the physical activities in the study. The test can also be applied with several applications – to develop the anaerobic power (endurance) when requested to perform at maximal speed; to develop the aerobic endurance when performed with normal tempo (84 bpm) with several repetitions without resting period.

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Corresponding author:

Maria Gateva

Department of Gymnastics

National Sports Academy „Vassil Levski”

Studentski grad, 21, Acad. Stefan Mladenov str.

Sofia 1700, Bulgaria

E-mail: maria.gateva@abv.bg