Original Article

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The changes in the adaptive processes of the male organism during training physical exercises

Authors' Contribution:

A – Study Design
B – Data Collection
C – Statistical Analysis
D – Manuscript Preparation
E – Funds Collection

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Abstract

The aim of the research was to find the changes of exercises in the organism of the men specialized in middle distance running. Physical working capacity and simultaneous registration of the functions of vegetative systems of organism were investigated. As well biochemical tests (determination of the content of lactate of red cells, haemoglobin, glucose in blood) were done. 10 men (two Masters of Sport, two First-Class Sportsmen and six Second-Class Sportsmen) aged 17-24 specialized in the middle distance running took part in the experiment. The sportsmen's level of health was within the physiological standard. The examination of the men's adaptive body responses to the offered burdens made by us indicates that their functional body capacity increases in the first, second, third and fifth microcycles and decreases in the fourth one. It can be connected with the decrease of haemoglobin content in the blood, especially in the Masters' of Sport blood and in the blood of First-Class Sportsmen, it leads to the decrease of their working capacity, respectively.

***Keywords**: training physical exercises, lactate, mesocycle*

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INTRODUCTION

The structure of training process is defined by the ultimate goal which is to perpare a well perorming athlete. It is caused by the factors which determine the efficiency of the competitive activity and the optimal structure of their fitness, the peculiarities of their adaptive reactions and individual features of the sportsmen [1,2,3].

Physical exercise adaptation is still one of the most current problems in sports physiology and medicine [4,5]. The informative and prognostic criterion which characterizes the efficiency of the physical exercise adaptation of the cardiovascular system is the heart rate which shows the changes in the controlling mechanisms of the vegetative nervous system and characterizes the activity of its regulator channels in some functional states [6,7].

The improvement of the training process of sportsmen is important at all stages of doing exercises. Therefore, optimization of the training process as a function of sportsmen's functional state becomes important. Numerous studies discuss the problem of improving the training process in the regime of long-term training in various disciplines, e.g., running, track and field disciplines [8,9]. The simplest and the most informative criterion of the state of cardiovascular system is the heart rate. Heart is the main organ of vascular system. It spends less energy if it contracts less often and with more strength. Cardiorespiratory endurance is closely related to development and functioning of the cardiovascular, respiratory systems and thus, the aerobic capacity [9,10]. Middle distance runners have a higher level of anaerobic glycolytic capacity. It is a result of adaptaion of the organism to a long-term training. Aerobic capacity also improves [11]. Training should be diverse in order to improve the functional state and to achieve a high level of performance [12].

Cardiovascular system in dormancy as well as during some trainings is an informative indicator of the regulatory mechanisms of human organism; notably it defines the level of training adaptation. Slowdown of heart rate indicates the improvement of heart work. A trained heart performs less work than an untrained one [1,11].

Urgent and long-term adaptations are distinguished in sports training. Platonov defines such processes as trans-adaptation, de-adaptation, and re-adaptation [2]. The rational course of adaptation of aerobic system of energy supply becomes apparent in economization of the reactions in dormancy and during trainings. As a rule, deregulation of vegetative control of cardiovascular system is the first indicator of the breakdown of the training adaptation of organism and it leads to the decrease of working capacity [4].

Optimally balanced regulation enables a sportsman to fully use his functional capacity, provides the necessary economization of functions during the endurance exercises, and defines the course of recovery periods [3,12].

The study of biochemical and functional parameters gives important information about the influence of training on the state of biological systems upon which a sportsman depends a level of his health, and also about the physiological mechanisms of training adaptation of human organism [9,10].

METHODS

10 men (two Masters of Sport, two First-Class Sportsmen and six Second-Class Sportsmen) aged 17-24, specialized in middle distance running took part in the study. The sportsmen's level of health was within the physiological standard.

The Human Subjects Research Committee of the University scrutinized and approved the test protocol as meeting the criteria of Ethical Conduct for Research Involving Humans. All subjects in the study were informed of the testing procedures and voluntarily participated in the data collection.

Protocol

The level of energy supply of the athletes' organisms was measured in a standard veloergometric test PWC_{170}. The main criteria of training adaptation are heart rate (HR) and the maximal oxygen consumption (MOC) which show the maximum aerobic power of organism. The function of the cardiovascular system was characterized according to the HR (rate per minute) both in dormant state and after doing some physical exercises and during recovery period. HR was moinitoring by a Polar S610i sport tester, a product of Finland. The biochemical screening, i.e., calculating lactate and haemoglobin levels in blood, was conducted by a standard method of testing blood samples. The blood tests were carried out by a medical assistant with the highest qualification.

The test required the athletes to run 4x400 m at gradually enhanced speed at every split. The splits were separated by 5-minute rest intervals. The data collected during the tests allowed to define the level of anaerobic capacity of each sportsman. The level of fitness of each athlete was determined by the registered records and the recovery rate. After running every split lactate concentration was calculated with the use of of test stripes BM-Lactate № 25 with "Accutrend Plus" system (Switzerland).

Statistical Analysis

Microsoft Excel and R program package were used to process the quantitative indices of the morphological characteristics and functional features of the sportsmen. Descriptive statistics and correlation analysis were used–elaborate the obtained data. Student test was used to determine statistically significant distinctions between the samples the distribution of which was in compliance with the normal law. Mann-Whitney U-test was used to calculate the divergence between two samples. Spearman's rank correlation coefficient was calculated to establish the correlation between the indices characterizing special working capacity and functional state of organism of the sportsmen [13, 14].

RESULTS

The results obtained are summarized in Table 1 and shown in Figures 1-6.

Table 1. The evolution of male working capacity during the mesocycle specialized in middle distance running

Split (4x400 m)	Results					
	Microcycle	I	II	III	IV	V
1	Master of Sport. First-Class Sportsmen	66.28±5.53	67.62±5.83	67.54±5.46	67.84±6.30	67.52±7.36
2		64.20±4.23	64.10±4.51	64.54±3.88	64.96±4.44	65.82±4.57
3		63.20±1.69	63.92±3.75	65.40±5.94	64.18±3.11	63.81±3.21
4		60.56±2.71	60.42±2.77	59.82±3.41	60.68±2.96	60.46±2.89
1	Second-Class Sportsmen	73.68±8.21	74.74±8.10*	72.98±8.01	73.80±8.25	73.60±7.65
2		71.76±4.53	72.64±4.17*	71.16±4.59	71.54±4.49	71.32±4.39
3		69.88±2.23	70.50±2.11	69.70±1.30	70.02±2.02	69.38±1.66
4		68.00±2.32	67.82±2.35	67.82±3.09	68.26±3.17	67.16±3.06

Note * – ($p<0.05$) – authentic changes of results compared with the third microcycle.

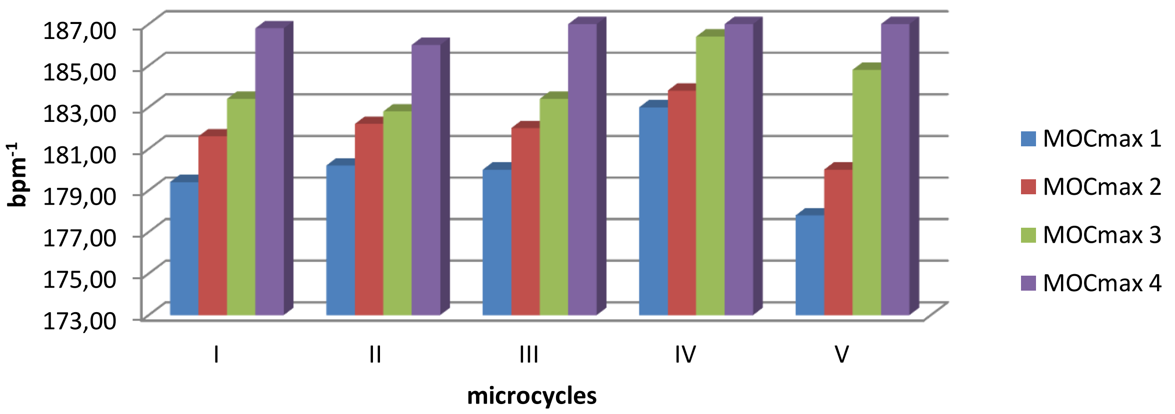

Figure 1. The evolution of the indices of MOC_{max} in different microcycles of the training process of the men specialized in middle distance running (Masters of Sport. First-Class Sportsmen)

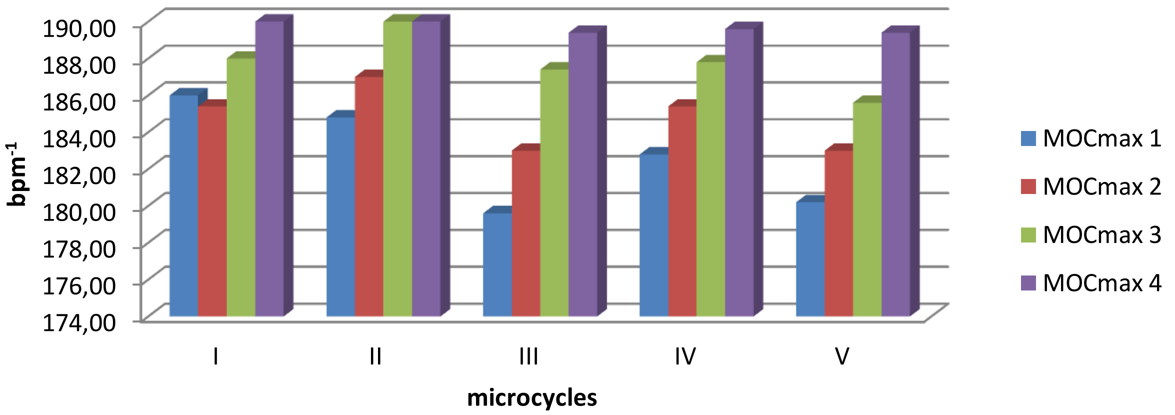

Figure 2. The evolution of the indices of MOC_{max} in different microcycles of the training process of the men specialized in middle distance running (Second-Class Sportsmen). Note* – ($p<0.05$) – significant changes of results compared with the third microcycle.

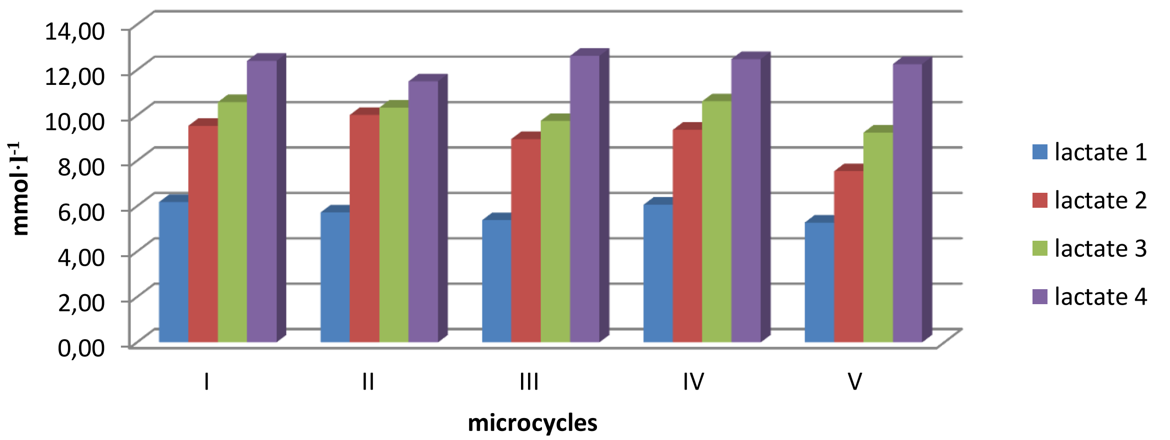

Figure 3. The evolution of the indices of lactate in the blood of the men specialized in middle distance running (Masters of Sport. First-Class Sportsmen)

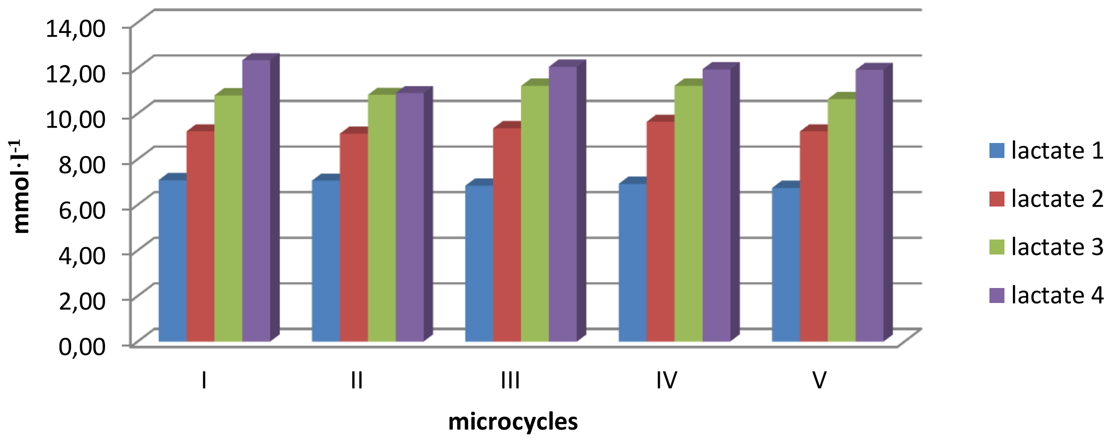

Figure 4. The evolution of the indices of lactate in the blood of the men specialized in middle distance running (Second-Class Sportsmen)

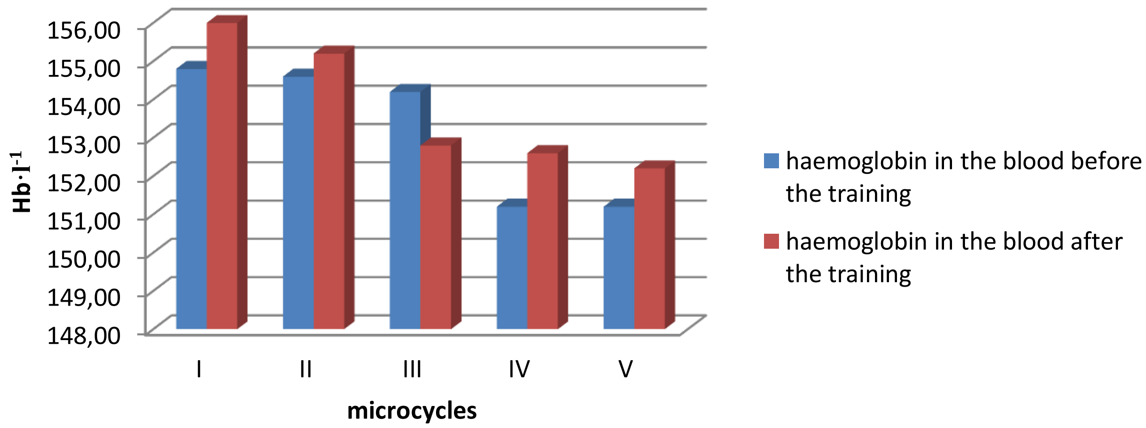

Figure 5. The evolution of the indices of haemoglobin in the blood of the men specialized in middle distance running (Masters of Sport, First-Class Sportsmen)

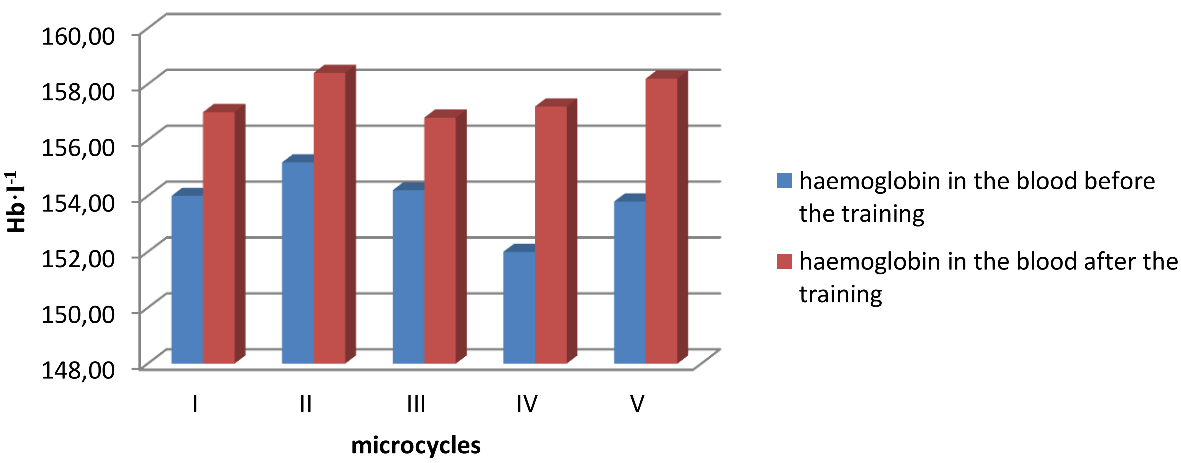

Figure 6. The evolution of the indices of haemoglobin in the blood of the men specialized in middle distance running (Second-Class Sportsmen)

DISCUSSION

The results of MOC of the men (Masters of Sport and First-Class Sportsmen) specialized in middle distance running indicate that oxygen delivery to the active muscles in the first and second microcycles increased (4.44±0.51 ml·min^{-1}; 4.37±0.76 ml·min^{-1}, respectively), achieving the maximum in the third microcycle (4.53±0.64 ml·min^{-1}). Considerable drop of the level of MOC was noticed in the fourth microcycle (4.04±1.01 ml·min^{-1}) and it was followed by a gradual increase in the fifth one (4.21±0.33 ml·min^{-1}). The level of MOC of the Second-Class Sportsmen was the lowest in the first microcycle (3.44±0.35 ml·min^{-1}) and it was gradually increasing in the second, third, and fourth microcycles to achive the highest value in the fifth one (3.66±0.81 ml·min^{-1}, 3.69±0.77 ml·min^{-1}, 3.76±0.83 ml·min^{-1}, and 3.86±0.49 ml·min^{-1}, respectively. The high level of correlation of PWC $_{170}$ and MOC was found during all the microcycles: the first – r_s=0.92, the second –r_s=0.95, the third – r_s=0.94, the fourth –r_s=0.85, the fifth –r_s=0.82, which indicates considerable dependence of physical working capacity on the aerobic capacity of the sportmen's organism. It was ascertained that at the first split the Masters of Sport had the best result in the first microcycle, a bit lower in the second, third, fourth and fifth microcycles. After running the distance twice, the indices were at the same levels.

The best result of the third split was 63.20±1.69 s in the first microcycle, 63.92±3.75 s – in the second one and 63.81±3.21 s in the fifth microcycle. The lower result was in the fourth one and the worst result was in the third microcycle. The best result of running the second split was in the third microcycle and it was almost the same in the first, second, fourth and the fifth. The results of running the given distance by the Second-Class Sportsmen were improving from the first to the fourth split in every microcycle. The best result of the first split was in the third microcycle (72.98±8.01 s); it was almost at the same level in the first, fourth and fifth microcycles and, the lower index is the result in the second microcycle compared with the third one.

The results of running the second split were almost the same: there were significant changes of the results as compared with the third microcycle. The results of the third split were almost at the same level as in all the microcycles.

In the fourth split, the best results in all the microcycles were recorded. In the first and in the fourth microcycles –68.00±2.32 s. 68.26±3.17 s, respectively. In the second, the third and the fifth microcycles the results were the best – 67.82±2.35 s, 67.82±3.09 s, 67.16±3.06 s, respectively.

The Masters of Sport and the First-Class Sportsmen had the highest index of MOC in the fourth microcycle (183.00±12.35 bpm^{-1}), it was lower in the first, the second, the third, and much lower in the fifth micro (177.80±5.50 bpm^{-1}) as compared with the fourth one (figure 1). The index of MOC at the second split was a little bit higher than in the fourth microcycle compared with the first, second, third and fifth ones. The First-Class Sportsmen had high content of haemoglobin in blood before the training, in the first, the second, the third microcycles, and lower in the fourth and the fifth ones.

Also, high index of MOC while running the third split was recorded in the fourth microcycle and a lower index of MOC was noticed in the first, second, third and fifth microcycles. At the fourth split the index of MOC was almost at the same level.

The Second-Class Sportsmen had higher indices of MOC_{max} than the Masters of Sport and the First-Class Sportsmen. At the first split the highest level of MOC_{max} was in the first microcycle; it was higher in the second one, compared with the third microcycle, and in the fourth and fifth they were 182.80±7.79 bpm^{-1}, 180.20±3.27 bpm^{-1}, respectively (figure 2). After running the second split, MOC_{max} reached the highest result in the first, second, and fourth microcycles. Lower index of MOC_{max} was in the third and fifth microcycles. During the third split the index of MOC_{max} was the lowest in the fifth microcycle and a little higher in the first, third, fourth ones, and it was the highest in the second one (190.00±7.28 bpm^{-1}). MOC_{max} of the fourth split was at the same level as in the first and the second, and slightly lower in the third, the fourth, and the fifth microcycles.

While running the first split, the highest lactate concentration in the blood of the Masters of Sport and the First-Class Sportsmen was 6.18±3.54 $mmol{\cdot}l^{-1}$ in the first microcycle and it was lower (6.06±2.72 mmol l^{-1}) in the fourth one (figure 3). After running the fourth split, the level of lactate concentration increased considerably because of the speed enhancing of running (figure 4).

Before the training in the first. second and third microcycles the content of haemoglobin in the blood of the Masters of Sport and the First-Class Sportsmen was unchanged it was lower in the fourth and fifth microcycles (figure 5). After exercising, there was a considerable increase of haemoglobin; that was observed in all the microcycles: in the first one – 157.00±17.03 $Hb{\cdot}l^{-1}$, in the second one – 158.40±16.32 $Hb{\cdot}l^{-1}$, in the third one – 156.80±13.41 $Hb{\cdot}l^{-1}$, in the fourth one – 157.20±13.03 $Hb{\cdot}l^{-1}$, in the fifth one – 158.20±10.94 $Hb{\cdot}l^{-1}$ (figure 6). There is a correlation between the mean value of MOC_{max} and the index of haemoglobin before the training (r_s = 0.51) in the second microcycle and there is high value in the fifth one (r_s = 0.72) at the first split.

At the second split there is a correlation between the mean value of MOC_{max} and haemoglobin before the training (r_s = 0.54) in the fifth microcycle. At the fourth split there is a negative correlation of the mean value of MOC_{max} and haemoglobin before the training in the first (r_s = - 0.54) and fourth (r_s = - 0.51) microcycles. We found of positive correlation between MOC_{max} after running the first split and content of haemoglobin before the training in the second (r_s = 0.55), third (r_s = 0.60), and fifth (r_s = 0.54) microcycles.

The index of maximal oxygen consumption is closely connected with the level of fitness of all the sportsmen. The level of MOC_{max} depends on the heart capacity to transport oxygen to the muscles and their capacity to utilize it. The index value depends on the level of fitness, age, sex, content of haemoglobin in the blood, and amount of adipose tissue.

The sportsmen's working capacity depends on the aerobic capacity and oxygen consumption by the active muscles. The results of MOC_{max} of the men (Masters of Sport and First-Class Sportsmen) specialized in middle distance running confirms the increase of oxygen delivered to the active muscles in the first and the second microcycles. The high level of correlation of PWC_{170} and MOC during all the microcycles indicates the high dependence of physical working capacity on the aerobic capacities of the organism of the sportsmen. The analysis of the results of MOC let us conclude that the special working capacity of the men depends on the state of their cardiovascular system and maybe, on the level of their training adaptation.

Doing the given exercises – running the distance of 4x400 m – the sportsmen ran every split at a higher speed during five microcycles. The increase of the results during the first three microcycles and during the fifth one is related to the increase of aerobic capacity according to the indices of MOC.

The decrease of the results in the fourth microcycle may be realted to the tiredness due to prolong exercises in the previous microcycles, which leads to the transadaptation of the functional systems of the organism. As a result, aerobic and anaerobic capacities decrease due to the decrease of MOC. A decrease and an absence of correlation between the results of the second split and the indices of VHR, PWC_{170} and MOC were found. It may be explained by the considerable decrease of aerobic capacity of the organisms of the sportsmen.

The men's HR_{max} decreased gradually during the mesocycle. In our opinion, it indicates the increase of the functional capacity of CVS caused by the training. The sportsmen who specialize in middle distance running should have aerobic efficiency at the expense of the power inputs caused by oxygen consumption and anaerobic processes without oxygen. That is, the athlete. running the given distance at his rapid pace, uses both aerobic and anaerobic capacity of his organism as much as possible. We calculated the lactate concentration in blood after running the distance of the test in 3 minutes to indicate the strenuous exercise and contribution of anaerobic processes of power supply to the performed work.

The functional value of the performed work of the men did not change considerably during the mesocycle. The level of lactate in blood indicates that power supply of the training exercises was almost at the same level during all the microcycles. Aerobic potential of the skeletal muscles increases while the sportsmen's fitness increases and less lactate is produced. Higher indices of lactate were observed in the first, second and third microcycles at a lower pace of running the distances compared with the fifth microcycle when the speed of running was higher and the concentration of lactate decreased.

The content of haemoglobin in the blood of the Masters of Sport and the First-Class Sportsmen was at the same level before the training from the first and up to the third microcycles. Lower level of haemoglobin was found in the fourth and fifth microcycles. It should be noted that the content of haemoglobin of the men did not increase significantly after the training. The content of haemoglobin in the blood of the Second-Class Sportsmen was high in the first, second, third microcycles and it was lower in the fourth and fifth ones. After doing some exercises the increase of haemoglobin was considerable in all the microcycles.

The results of our research are in agreement with the results presented in reports addressing the correlation between training exercises and functional capacity [1,2,3]. The important role of the training process of the sportsmen depending on the adaptive capacity of a cardiovascular system was also proved by other authors [8,12].

CONCLUSION

The results of PWC_{170} and MOC and their analysis indicate that special working capacity of the men depends on the state of their cardivascular system and it may also depend on the level of the sportsmen's training adaptation.

It was determined that the results of the Masters of Sport and the First-Class Sportsmen running the distance of 4x400 m were better in the third microcycle compared with the first and second ones, they were lower in the fourth one and they increased in the fifth microcycle. The results of the Second-Class Sportsmen increased in the first, second and third microcyclesand they decreased in the fourth one and they were the highest in the fifth microcycle.

The level of lactate in their blood indicates that power supply of the training exercise was at the relatively identical level. The content of haemoglobin was higher in the first, second and third microcycles and it decreased in the fourth and fifth ones.

Thus, it was determined that the functional capacity of CVS of the men specialized in middle distance running and as a result their special working capacity increases because of the adaptation to the increasing training exercise during the first three intensified microcycles. Therefore, the evolution of the adaptive reactions should be taken into account while working out mesocycles of the training processes for the men specialized in middle distance running.

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