Preparation of athletes in cyclic sports taking into account the functional state of the external respiratory system and cardiovascular system

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Abstract

Purpose: The purpose of the study is to investigate the preparation of athletes in cyclic sports, taking into account the functional state of the external respiratory system and cardiovascular system (on the example of academic rowing).

Material: The study involved 13 athletes aged 19-22 years old. Athletes went for academic rowing in the Dnipropetrovsk region. A control and experimental group of 6 and 7 people were created, respectively. At the beginning of the experiment, there were no significant differences in fitness, physical development, and functional status between groups ($p > 0.05$). All study participants gave written consent to participate in the study. The studies were carried out at the specialized school of the Olympic reserve in rowing of the Dnepropetrovsk regional organization of the sports society "Ukraine", the regional school of higher sportsmanship. Medical and biological testing was conducted at the scientific laboratory of the Pridneprovsk State Academy of Physical Culture and Sports.

Results: The dynamics of the indicators of the functional status of light weight rowers in rowing academic after using the experimental method was shown. It has been determined that under the influence of the experimental methods the cardiovascular system parameters underwent positive changes. These are the indices of variation range, vegetative rhythm index, pressure index, PWC170 test, maximal oxygen consumption, cardiovascular system response to exercise, recovery period. The introduced technique had a positive effect on the performance of athletes. In the experimental method, it was proposed to change the load in the complexes of exercises for the development of strength, maximum force, strength and speed endurance. The proposed technique of improving physical fitness was reflected in the formation of the plan of the annual training cycle. In accordance with the tasks of the period and mesocycles, exercises aimed at developing the leading qualities of light weight rowers were included.

Conclusions: The analysis of the literature on the problem of research and generalization of the training of athletes in cyclic sports at the stage of preparation for higher achievements has revealed problematic issues. On the example of academic rowing these questions relate to the peculiarities of improving the process of physical preparation of rowers with light body weight, the peculiarities of functional state, the study of indicators of their physical and functional fitness. The dynamics of the functional state of the external respiratory system and cardiovascular system of athletes in cyclic sports (on the example of academic rowing) has been investigated. Some positive changes in the results of the vegetative index of the rhythm of the athletes were revealed. These indicators have approximated the value of the autonomic balance of athletes in the direction of parasympathetic regulation. There is a tendency to decrease the index of pressure. There was a decrease in heart rate, an increase in the maximum oxygen consumption and the level of physical performance.

Keywords: athletes, academic rowing, functional state, respiratory system, cardiovascular system.

Introduction

An important condition for getting high results in the sport of higher achievement is having complex theoretical and practical knowledge by the athletes. A number of specialists were engaged in the problems of studying the functional state of the system of external respiration and cardiovascular system of athletes [1], So, Savchenko et al. [2] proposed modern methods of research in physical culture and sports. The features of the training process in cyclic sports were considered by such authors as Mitchell et al. [3]. The information on the functional state of an athlete's body is necessary to identify the features of his or her body's activity [3, 4].

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In academic rowing these issues were studied by Barykinsky [4], Dyachenko [5], Omelchenko [6], Thompson et al. [7]. So, Dyachenko proposes a system for improving the special endurance of qualified athletes, taking into account the indicators of functional state. Barykinsky [4] proposes the use of functional status assessment as a criterion for predicting training performance. Omelchenko [6] considered organizational and methodological aspects of a training program for light weight athletes. Thompson et al. [7] dealt with the issues of increasing the efficiency of the training process. Danziger [8], Brown [9], Ivanova [10] associate athletic performance with athletes' fitness level.

The functional state of the external respiratory system and cardiovascular system plays an important role in sports

with a predominant role of endurance [11-14]. In these sports, athletic performance depends on endurance. These kinds of sports include academic rowing. In this sport, for the rational planning and control of physical fitness, it is necessary to determine the level of functional status of the above systems [15-19]. According to scientists, the practical solution of the problem outlined is the most possible due to the search for new ways to increase the physical preparedness of rowers in different periods of the annual cycle [20-23]. This leads to the development of new training programs. These programs should take into account the level of correlation between rowers' fitness and functional state [24-26].

According to Lukovskaya [27], Savchenko et al. [2] the most promising approach for improving the fitness of athletes in cyclic sports is to take into account their current functional state of the external respiratory system and cardiovascular system. The analysis of the literature indicates that there is no research regarding the influence of certain methods of training athletes in cyclic sports, taking into account the functional state of the external respiratory system and cardiovascular system.

Hypothesis. It was assumed that the use of experimental methods of improving the physical fitness of athletes will have a positive effect on their functional state of the system of external respiration and cardiovascular system.

The purpose of the study is to investigate the training of athletes in cyclic sports, taking into account the functional state of the external respiratory system and cardiovascular system (on the example of academic rowing).

Material and methods.

Participants. The study involved 13 athletes aged 19-22 years old. They were engaged in academic rowing in Dnepropetrovsk region. A control and experimental group of 6 and 7 people were created, respectively. At the beginning of the experiment, there were no significant differences in fitness, physical development, and functional state between groups ($p > 0.05$). All study participants gave written consent to participate in the experiment.

Organization of research. The research was carried out at the specialized rowing school of the Olympic reserve of the Dnepropetrovsk regional organization of the sports society "Ukraine", the regional school of higher sportsmanship. Medical and biological testing was conducted at the scientific laboratory of the Pridneprovsk State Academy of Physical Culture and Sports. The participants of the experiment were trained 11 times a week. The duration of one session was 180 minutes.

The training process of the control group was planned according to the "Curriculum for children's and youth sports schools, specialized children's and youth Olympic reserve schools, schools of higher sportsmanship and specialized educational institutions of sports profile".

The pedagogical experiment was to introduce and determine the effectiveness of the developed method of improving the fitness of athletes in cyclic sports at the stage of preparation for higher achievements (as an example of academic rowing).

The common features of the training and control process of the control and experimental groups were one-cycle planning during the year, construction of meso and microcycles. The number of mesocycles was 9, the number of microcycles was 52. The total number of hours planned for general and special physical training in accordance with the "Curriculum for children and youth sports schools, specialized children's and youth schools of the Olympic reserve, schools of higher sportsmanship and specialized educational institutions" academic rowing was 900 hours.

The experimental method of improving physical state, taking into account the functional state of athletes, was based on the basic points of the training system. The methodology took into account the general and specific principles of sports training, the task of the stage of preparation for higher achievements, scientific approaches to the planning of the training process [6].

In the experimental method, it was proposed to change the load in the complexes of exercises for the development of strength, maximum force, strength and speed endurance. In accordance with the tasks of the period and mesocycles, exercises for the development of leading qualities were included.

During the performance of the exercises for maximum strength development, 2 schemes were applied.

The first scheme: performing exercises with increasing weights from 85% to 97% with the number of repetitions 7-5-3-1 and performing the same exercises with decreasing weights from 97% to 85% with the number of repetitions 1-3-5-7. Maximum force development exercises were performed with a capacity of 85 to 97%. In the training session 2-4 approaches were conducted. The rest breaks were 3-4 minutes. In exercise mode after doing the exercise the projectile was put on the rack for a few seconds to relax the muscles. This mode of work maximally contributed to the improvement of the ability for "explosive" display of the effort. This is important for rowers while rowing during the start speeding of the boat.

The second scheme: 5 series (with 4-5 exercises) with 2-3 repetitions with a load of 95% of the maximum and a recovery period of 4-6 minutes are performed.

For development of power qualities were used squats with a barbell, lifting a barbell, exercises with dumbbells with a load of 40-50% of the maximum, and the number of series was increased from 3-4 to 5-7.

For the development of endurance in the performance of exercises with the barbell weight load was reduced from 45 to 40 kg. The number of series increased from 8-10 to 11-12. The development of power endurance during rowing on the water occurred by reducing the power of the rowing machine with increasing the speed of rowing from 12-16 to 14-18 rowing per minute. For the development of speed endurance at rowing on the ergometer «Concept-II» the speed of rowing was increased from 28-32 to 33-34 rowing per minute, while rowing on water - from 32-35 to 36-38 rowing per minute respectively. In the experimental group, boats with lower displacement and

lighter and shorter oars were used.

Means for improving the general and special fitness of athletes were formed in 5 blocks of 5-7 exercises. The volume, intensity and mode of exercise were determined taking into account differences in athletes' physical and functional fitness.

In order to increase the overall fitness, we used general developmental exercises, jogging, skiing, swimming, barbell exercises, strength exercises with a partner, sports games. Special physical training was aimed at the development of special physical qualities. For this purpose such exercises as rowing with a hydraulic brake, rowing with weights, rowing on elements, rowing on the ergometer «Concept-II», rowing in a rowing pool, lifting of a bar were applied. Auxiliary training included exercises for shaping special motive actions: catching the ball (to form the correct grip of the paddle) and jumping on a 25 cm high platform (to form the correct kicking in the boat).

The proposed methodology was reflected in the preparation of the annual training cycle plan. In accordance with the tasks of the period and mesocycles, exercises for the development of leading qualities of rowers were included. An annual training cycle plan has been drawn up. The preparatory period lasted 20 weeks and consisted of three mesocycles - retractable, basic and control-preparatory.

The task of the preparatory period of the annual cycle was the individualization of physical training. It was aimed at improving endurance, strength endurance and maximum strength of light weight rowers.

The retractable mesocycle of the preparatory period was aimed at gradual bringing the body to the effective performance of specific training loads and increasing the functionality of the main systems of the body. Its tasks were to stimulate adaptation processes in the body of the athlete, to solve the basic tasks of all types of training, to improve the overall physical qualities (endurance and strength). The contents of the mesocycle consisted of barbell exercises. They were performed with a power of up to 50% of the maximum and at a heart rate of 150-160 beats per minute. Rowing on the Concept-II ergometer was performed with similar heart rate indicators. During the exercise with the barbell the number of series increased from 8-10 to 11-12 with a reduction in load capacity by 5 kg. During the rowing on the Concept-II ergometer the length of the sections was 250 m. The speed of rowing was increased to 36-38 rows per minute. In this mesocycle we used general training and special preparatory exercises with the use of continuous, interval, repeated training methods.

The basic mesocycle was aimed at enhancing the functionality of the body of athletes and the development of endurance, strength endurance and maximum strength. The main means of the mesocycle were jogging, rowing on the Concept-II ergometer, barbell exercises using continuous, repeated and interval methods. The power of exercises with the barbell and during rowing on the ergometer was 90% of the maximum at a heart rate of 170-180 beats per minute. The length of the rowing course on the ergometer was 250 m with a speed of 36-38 rows per minute.

The control and training mesocycle was aimed at integral training of the athlete. The tasks of this mesocycle were to stimulate adaptation processes, increase the level of physical training and the implementation of integrated training. Its contents included jogging and rowing exercises with the use of lightweight equipment. Continuous, repeated, and interval methods were used. Rowing exercises were performed with a power of 80-90% of the maximum at a heart rate of 170-180 beats per minute.

The focus of the annual cycle competition period was to maintain and further enhance the level of special preparedness and maximize sports performance.

The racing period lasted for 24 weeks. It consisted of pre-race, racing and test-preparation mesocycles. During the competition period, 50-60% of the time was devoted to the use of special preparatory exercises. The volume of special physical training increased to 30%. Total physical training was reduced from 15% to 10%, respectively. During this period, exercises to develop maximum strength and endurance were excluded.

In pre-race and control mesocycles, athletes worked to eliminate individual gaps in technical preparedness. Lightweight equipment was used during water trainings. The speed of rowing training stretches was increased to 36-38 rows per minute with a decrease in load capacity.

The racing mesocycle was aimed at achieving the highest possible result in competitive activities. The volume and load intensity were reduced by 30%. The number of special-purpose exercises was increased. Short distance rowing, race distance rowing, maximum speed distance rowing was used.

The transition period lasted for 6 weeks. It consisted of reducing microcycles. It was aimed at restoring the physical potential of athletes after training and competitive workouts.

The study of the functional state of the external respiratory system and cardiovascular system of rowers was carried out after the preparatory period and was evaluated by the indicators of cardiointervalography and bicycle ergometry. Special fitness testing was conducted during the competition period.

Statistical analysis. Statistical processing of the study materials was carried out using Microsoft Excel 2010. The arithmetic mean and the violation of arithmetic mean were calculated. The reliability of the differences between the sample rates was checked using the White test and the criterion of characters and has been considered statistically significant at $p < 0.05$.

Results

The indicators of cardiointervalography of athletes make it possible to trace the dynamics and evaluate changes in the cardiovascular system after the implementation of the experimental method (Table 1). Heart rate (heart rate) in the experimental group remained unchanged (65.57 ±

8.93 bpm). In the control group, a decrease of 3 beats / min was observed, which was 4% by White's criterion, p> 0.05.

Positive changes in the indicators of the amplitude mode in both researched groups were not pronounced. This indicator changed by only 5% according to White's criterion (p> 0.05). The coefficient of variation decreased from 23.85% to 18.71%. This testifies to the activity of the sympathetic department of the autonomic nervous system and the interconnection of the nervous and humoral channels of stimulation of the heart rhythm and informs about the unchanged state of the department of this system.

The optimization of the cardiovascular system of the athletes of the experimental group of the experimental group was confirmed by the results of the analysis of the values of the variation range (X). They changed by White's criterion by 8% (p <0.05) and amounted to 341.71 ± 80.71 $. This indicates an improvement in the adaptive response of the body of the athletes of the experimental group to exercise.

In the vegetative index of the rhythm of the athletes of the experimental group observed some positive changes by 7%. The values of these indicators approximated the vegetative balance of athletes toward parasympathetic regulation (p <0.05 by White's criterion). Voltage index indices in both groups tended to decrease (by 12% in the control group and by 30% (p <0.05) in the experimental group). The value of this indicator in the experimental group was 59.37 ± 32.34 USD. There was a decrease in indices of the voltage index within the autonomic equilibrium (51-199 $). This indicates an improved resistance of the body of athletes to stress reactions and the preferential regulation of the sympathetic nervous system. The coefficient of variation (V = 44.16%) for this indicator indicates a large divergence of indicators due to the individual characteristics of the athlete's reaction.

The heart rate in rowers of the experimental group decreased by 5% and amounted to 70.50 ± 2.86 beats • min (p> 0.05 according to White's criterion). The coefficient of variation marked a greater homogeneity of results compared to the previous ones and amounted to 4.05%.

Also the results of a comparative analysis of the features of changes in cardiovascular system parameters were of great interest. In the PWC_{170} test data, the coefficient of variation in the athletes of the experimental group was halved to 12.25%. This indicates more uniform results of the athletes after the experiment (Table 2).

The performance of the PWC170 test of the athletes of the experimental group decreased by 9.3% and after the experiment amounted to 1472,14 ± 180,39 kgm • min-1 (Table 2). In control group athletes, the changes were 3% and amounted to 1541.17 ± 159.00 kgm • min-1.

A convincing proof of optimization of the training process of rowers of the experimental group was the results of the analysis of the values of maximum oxygen consumption. They improved by 7 ml · kg^{-1} · min^{-1} (13%) (p <0.05). The results of the control group changed significantly and remained at the same level - 54.17 ± 3.90 ml · kg^{-1} · min.

In both groups of patients, the response of the cardiovascular system after the introduction of our technique has become normotonic.

The recovery period of the cardiovascular system of rowers of the experimental group underwent positive changes and amounted to 9.17 ± 2.79 min. (p <0.05). This

Table 1. Indicators of cardiointervalography of athletes of the control and experimental groups before and after the experiment

Indicators	CG(n=6) $\bar{x}$ ± S		EG (n=7) $\bar{x}$ ± S	
	Before the experiment	After the experiment	Before the experiment	After the experiment
Heart rate beats per $minute^{-1}$	63.88±5.00	60.17±2.90	64.86±4.86	65.57±8.93
Arithmetic mean NN-intervals, c. u.	950.00±65.00	993.67±52.67	931.43±62.43	940.71±128.21
Standard deviation of NN-intervals, c. u.	62.00±10.00	60.43±2.,43	60.43±21.43	59.14±13.43
Standard deviation of difference of consecutive NN-intervals, c. u.	60.00±16.77	62.67±14.48	47.57±20.46	54.86±19.25
% of adjacent NN intervals, the difference between which exceeds 50 ms, c. u.	32.00±13.00	42.67±10.38	21.43±17.29	29.00±16.50
Mode, c. u.	990.00±55.00	979.56±44.29	926.29±68.96	920.71±134.46
The amplitude of mode, c. u.	10.66±3.55	10.10±2.74	9.97±2.38	8.57±1.60
Variation swing, c. u.	330.83±45.00	319.00±42.29	319.00±80.75	341.71±80.71
Total heart rate variability, c. u.	23.00±7.88	22.50±4.86	22.14±6.18	24.57±5.07
Vegetative Equilibrium Index, c. u.	135.00±36.00	113.15±24.29	147.47±68.05	125.29±52.36*
Vegetative rhythm indicator, c. u.	3.69±1.10	3.38±0.54	3.99±1.17	3.73±1.10*
Pressure Index, c. u.	83.00±16.65	73.23±14.06	85.57±40.45	59.37±32.34*

Note. * - p <0.05 compared to the values recorded in the control and experimental groups at the beginning and end of the experiment; KG - control group, EG - experimental group.

Table 2. Indicators of functional reserve and condition of the cardiovascular system of light weight rowers when performing dosed physical exercise after the forming experiment of control and experimental groups

Indicators	CG(n=6) $\bar{x}$ ±S		EG (n=7) $\bar{x}$ ±S	
	Before the experiment	After the experiment	Before the experiment	After the experiment
F rest beats per min ^{1} **	73.95±4.50	73.80±4.20	73.86±3.39	70.50±2.86*
f_1, beats per min^{-1}**	142.00±7.55	141.50±7.29	135.29±7.29	131.33±7.14
f_2, beats per min^{-1}**	168.00±9.77	172.17±7.86	164.43±11.07	166.14±7.36*
PWC170, kgm per mi^{n-1}	1590.00±175.00	1541.17±159.00	1622.14±348.18	1472.14±180.39
Assessment of the level of physical performance	low	low	low	Lower the average
Maximum oxygen consumption, ml.kg^{-1}·min^{-1}	55.00±4.00	54.17±3.90	55.33±3.71	61.86±5.36*
Reaction of the cardiovascular system	normotonic	normotonic	hypertensive	normotonic
Recovery period, min.	11.85±2.00	10.71±0.71	12.86±3.89	9.17±2.79*

Note. * - p <0.05 compared to the values recorded in the control and experimental groups at the beginning and end of the experiment; ** - F (f) - heart rate; KG - control group, EG - experimental group.

is 16% better than the previous data. The coefficient of variation decreased from 30 to 26%.

The results obtained indicate an increase in the fitness level of athletes. This was facilitated by the developed experimental method of improving the physical training of light weight rowers at the stage of preparation for higher achievements. This gives reason to recommend it for practical use.

Discussion

The analysis of the scientific and methodological literature has revealed problematic issues regarding the peculiarities of the process of training athletes in cyclic sports. In particular, there is no academic research on the impact of individual training methods on athletes, taking into account their functional state. We have investigated the functional state of athletes in cyclic sports (on the example of academic rowing) according to the indicators of cardiointervalography and cycling ergometry of light weight rowers.

Studies have shown the positive impact of physical training techniques for light weight athletes at the stage of preparation for higher achievement. This technique takes into account the requirements of program-normative documents, features of competitive activity, anthropometric indicators of athletes, their functional state and physical state. The distribution of training loads in meso and microcycles of the annual cycle of training for athletes with light body weight with the definition of the volume of general and special training is developed. This technique is intended exclusively for rowers with light weight. It takes into account their weight category and load capacity. Changes of loading in complexes of exercises on development of power qualities, maximum force, force and speed endurance were suggested. When performing exercises for the development of maximum strength, 2-4 approaches were performed with pauses of 3-4 minutes: loading up to 97% (7-5-3-1 repetitions), loading up to 85% (1-3-5-7 repetitions). There were performed 5 series (4-5 exercises, 2-3 repetitions) with the load 95% of the maximum, recovery period was 4-6 minutes. For the development of power qualities we used the load 40-50% of the maximum, the number of series was increased to 5-7. For the development of power endurance the load was reduced to 40 kg, the number of series was increased to 11-12. During rowing on the water the power of the paddle was reduced, the speed of rowing was increased to 14-18 paddles per minute. For the development of speed endurance at rowing on the ergometer "Concept-II" the speed of rowing was increased to 33-34 rows per minute; during rowing on the water - up to 36-38 paddles per minute. Boats with less displacement and lighter and shorter oars were used. The analogues of the existing methodology have not yet been identified.

The introduction of this technique contributed to the realization of individual capabilities of athletes. The revealed data testify to optimization of work of cardiovascular system and improvement of adaptation reaction of an organism of athletes to physical activity (by indicators of cardiointervalography and bicycle ergometry). This demonstrates the superiority of this technique as opposition to the traditional training program.

The data of Dyachenko [5] on a system of improving the endurance of qualified athletes, taking into account the indicators of functional status were confirmed.

The data of Barykinsky [4] on the use of functional status assessment as a criterion for predicting training effectiveness were supplemented. These indicators may be a prerequisite for enhancing the specialized orientation of the training process of qualified academic rowers.

The data of Omelchenko [6, 28] on the features

of organizational and methodological aspects of the training program for light weight athletes and the data of Thompson et al. [7] on improving the efficiency of the training process, taking into account the functional state were supplemented.

Platonov's [1] ideas on the basic aspects of the modern system of training of qualified athletes in rowing academic and Ivanova [10] and Simpson's [29] views on the peculiarities of changes in the functional status of rowing athletes were further developed.

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Conclusions

1. The analysis of the literature on the problem of research and generalization of the training of athletes in cyclic sports at the stage of preparation for higher achievements has revealed problematic issues. On the example of academic rowing these questions relate to the peculiarities of improving the process of physical preparation of rowers with light body weight, the features of functional state, the study of indicators of their physical and functional fitness.

2. The dynamics of the functional state of the external respiratory system and cardiovascular system of athletes in cyclic sports (on the example of academic rowing) is investigated. Some positive changes in the results of the vegetative index of the rhythm of the athletes were revealed. These indicators have approximated the value of the autonomic balance of athletes in the direction of parasympathetic regulation. There is a tendency to decrease the index of pressure. There was a decrease in heart rate, an increase in the maximum oxygen consumption and the level of physical performance.

Prospects for further research are the scientific study of the dynamics of rowing spirography and electrocardiography in academic rowing.

Conflict of interests

The authors state that there is no conflict of interest.

References

1. Platonov VM. *The system of training athletes in Olympic sports.* Kiev: Olympic literature; 2016. (in Ukrainian)
2. Savchenko VH, Lukovska OL, Moskalenko NV, Miroshnychenko AO. *Modern methods for studying the functional state of the cardiovascular and respiratory systems in physical education and sports.*Dnipropetrovsk: Innovation; 2005. (in Ukrainian)
3. Mitchell W, McIver M. *Working in Sync: How Eleven Dartmouth Athletes Propelled Their College Sports Experience into Professional Excellence.* Aloha Publishing; 2018.
4. Barykinskiy ZA. Assessment of the functional state of the body as a criterion for predicting the effectiveness of training in rowing. Moscow; 2012. (in Russian)
5. Diachenko AY. *The system for improving the special endurance of qualified athletes in rowing:* [Doc. *Diss.].* Kiev; 2005.
6. Omelchenko OS. Features of control of the training process of light weight rowers in academic rowing. *Aktual'nyye problemy fizicheskoy zhizni, reabilitatsii, sporta i turizma*, 2013;164-165. (in Russian)
7. Thompson P, Wolf A. *Training for the Complete Rower: A Guide to Improving Performance.* Crowood Press; 2016.
8. Danziger M. *Small Puddles*: *The Triumphant Story of Yale's Worst Oarsman.* Ever; 2017.
9. Brown D. *Boathouse Row: Waves of Change in the Birthplace of American Rowing.* Temple University Press, Hardcover; 2016.
10. Ivanova N.I. *The functional state of the cardiorespiratory system of athletes with various specifics of muscle activity in the preparatory and competitive periods of preparation.* [Ph.D Thesis]. Moscow; 2010 (in Russian)
11. Omelchenko OS. The functional state of the cardiovascular system of athletes of various weight categories in rowing. Physical culture, sport as social phenomena of society: retrospective, reality and future. *Russian with international participation of the electronic student scientific conference, Irkutsk;* 2013. (in Ukrainian)
12. Karaliene R. *Rowing Through The Barbed Wire Fence*. Createspace Independent Publishing Platform; 2017.
13. Brown J. Daniel *The Boys in the Boat: Nine Americans and Their Epic Quest for Gold at the 1936.* Berlin: Olympics Paperback; 2014.
14. Neupokoev SN, Kapilevich LV, Kabachkova AV, Loson EV, Krupitskaya ON. Analysis of external respiration performance in improving shock movements in boxers of different sports qualification. *Tomsk State University Journal*. 2015(395):229-232. https://doi.org/10.17223/15617793/395/37
15. Omelchenko OS. Functional state respiratory and cardiovascular system of rowers of light weight. *Sportyvnyi visnyk Prydniprovia,* 2015; 3: 96-99. (in Ukrainian)
16. Nemirov AD. *Informativeness of heart rate variability parameters in athletes:* [Ph.D Thesis]. Yaroslavl; 2004. (in Russian)
17. Mikhalyuk YL, Didenko MV, Malakhova SN. Influence of yearlong training on the state of cardiovascular, autonomic nervous system and physical performance in female 400 meters runners. *Pathologia*. 2016(1):54-60. https://doi.org/10.14739/2310-1237.2016.1.71189
18. Gonzalez SL, Diaz AM, Plummer HA, Michener LA. Musculoskeletal Screening to Identify Female Collegiate Rowers at Risk for Low Back Pain. *Journal of Athletic Training*. 2018;53(12):1173-1180. https://doi.org/10.4085/1062-6050-50-17
19. Kowalik T, Klawe JJ, Tafil-Klawe M, Slomko W, Slomko J, Srokowska A, et al. Multiannual, Intensive Strength-Endurance Training Modulates the Activity of the Cardiovascular and Autonomic

Nervous System among Rowers of the International Level. *Biomed Research International*. 2019;2019. https://doi.org/10.1155/2019/3989304
20. Omelchenko OS. Features of indicators of cardiointervalography and bicycle ergometry of light weight athletes in academic rowing. *Visnyk Chernihivskoho natsionalnoho pedahohichnoho universytetu*, 2013; 112: 181-183. (in Ukrainian)
21. Durkalec-Michalski K, Nowaczyk PM, Podgorski T, Kusy K, Osinski W, Jeszka J. Relationship between body composition and the level of aerobic and anaerobic capacity in highly trained male rowers. *Journal of Sports Medicine and Physical Fitness*. 2019;59(9):1526-1535. https://doi.org/10.23736/s0022-4707.19.08951-5
22. Klusiewicz A, Borkowski L, Sitkowski D, Burkhard-Jagodzinska K, Szczepanska B, Ladyga M. Indirect Methods of Assessing Maximal Oxygen Uptake in Rowers: Practical Implications for Evaluating Physical Fitness in a Training Cycle. *Journal of Human Kinetics*. 2016;50(1):187-194. https://doi.org/10.1515/hukin-2015-0155
23. Rahmani A, Giroux C, Ben Abdessamie A, Chorin F, Lardy J, Maciejewski H. Anaerobic physical evaluation of young national rowers. *Computer Methods in Biomechanics and Biomedical Engineering*. 2015;18:2034-2035. https://doi.org/10.1080/10255842.2015.1069609
24. Saville K. *Rowing for My Life: Two Oceans, Two Lives, One Journey*. Hardcover; 2017.
25. Giannini BG. *Rowing: Complete Manual with Illustrations and Valuable.* Advice; 2018.
26. Silva-Alonso T, Iglesias-Perez MD, Garcia-Soidan JL. Percentile curves and reference values for 2000-m rowing ergometer performance time in international rowers aged 14-70 years. *Journal of Human Sport and Exercise*. 2018;13(4):731-742. https://doi.org/10.14198/jhse.2018.134.02
27. Lukovska OL. Modern methods of research of cardiac activity in physical culture and sports. *Sportyvnyi visnyk Prydniprovia*, 2010; 1: 87-91. (in Ukrainian)
28. Omelchenko OS. *Improvement of lightweight rowers physical training in rowing at the stage of preparation for higher achievements.* [Ph.D Thesis]. Dnieper; 2016. (in Ukrainian)
29. Simpson C, Flood J. *Advanced Rowing: International perspectives on high performance rowing.* Bloomsbury Sport; 2017.

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