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Original Article

Enhancing the sports training of elite female athletes in academic rowing

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Abstract:
Currently, the central concern in the training of athletes is the pursuit of effective management strategies for the training process. This involves leveraging insights into the structure of competitive activities, incorporating general principles of athletic development, and tailoring training approaches to individual athlete capabilities. **The objective of this research** is to assess the efficacy of different training programs in preparing female athletes from the Ukrainian National rowing team for the competitive season. **Material and methods**. The study involved Ukrainian National female rowing team members, selected based on specific criteria including age, athletic experience, and performance level. A longitudinal, comparative design was employed to assess the impact of different training programs on athletes' performance. The study period spanned several months, during which athletes underwent a baseline evaluation, followed by the implementation of the original training program. The original program emphasized speed-strength and strength training; alongside rowing pace stabilization based on model characteristics. Details on training frequency, intensity, and specific exercises were meticulously outlined. Athletes were monitored throughout the study, with regular assessments to evaluate changes in physical and functional readiness. Training sessions were adjusted based on ongoing evaluations.
Key words: rowing, female athletes, Ukrainian National team, physical fitness, functional fitness, training process, efficiency.

Introduction

The current level of development of elite sport puts forward the highest requirements for various components of the general preparedness of athletes in various sports, which raises the demands for all components of preparedness, as competition becomes more and more intense (Ivanenko et al., 2020; Tishchenko, 2016; Yuriy et al., 2016). Modern technologies and scientific researches in the field of sports allow us to understand better the physiological and psychological aspects of training (Korobeynikov et al., 2019a; Korobeynikov et al., 2019b; Lisenchuk et al., 2019b). In the current study, we aim to deepen the understanding and knowledge of the training process of elite female rowers, particularly in the context of rowing, which requires a high degree of physical fitness, technical performance and psychological stability. The importance of this study is due to the insufficient level of knowledge of the specific requirements for training women in this sport, which creates a need for the development and testing of new, optimized training methods that can increase their competitiveness on the international arena. Coaches and athletes use this knowledge to develop more effective training and preparation methods (Oliinyk et al., 2021; Malikov et al., 2019; Tyshchenko et al., 2018a). The specialists in the field of physiology, psychology and training are developing individual training programs for athletes, taking into account their unique physiological characteristics and the requirements of a particular sport (Adamchuk et al., 2023; Malikov et al., 2021; Valeria et al., 2015, 2017). Athletes are subjected to high levels of stress and pressure. Modern requirements emphasize psychological preparation, including stress management, concentration, motivation and confidence (Lisenchuk et al., 2019a; Steinacker, 1993; Tyshchenko et al., 2020). The relevance of the topic is also emphasized by changes in modern sporting paradigms, where there is an increasing emphasis on a scientifically based approach to the organizational process. This includes not only the use of sports science to measure the physical performance of athletes, but also the adaptation of sports programs to the individual characteristics and psychological characteristics of female athletes. Special attention to the details of the organizational process, including recovery, nutrition, stress management and psychological preparation, may significant impact on the final performance results. Traditional methods may not always fully meet the needs of modern high-intensity sports and the physical training requirements of athletes.

The complexity and versatility of preparation for competitions in rowing requires an integrated approach that would take into account all aspects of sports training. In this regard, the research aims to identify

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optimal training strategies and methods that maximize the development of key physical qualities necessary for success in rowing, such as endurance, strength, speed endurance, and technical skill. A number of scientists have shown that existing means and methods for optimizing the general, special physical and functional readiness of athletes specializing in rowing can no longer fully provide the most optimal form of preparing athletes for the most important international competitions and achieving high sports results at them (Domaszewska, 2021).

A deep understanding of the energy systems (aerobic and anaerobic) allows us to distribute more effectively the load and to optimize training processes for achieving the best results in rowing (Akça, 2014; Bourdin et al., 2017; Mäestu et al., 2005). In particular, the overwhelming number of experts believe that in order to optimize the overall level of preparedness of rowers, it is important to increase the total volume of training loads of various directions (Okun et al., 2020; Treff et al., 2021; Volianitis et al., 2020); some researchers focus on exclusively aerobic physical activity; others state the need for a significant redistribution of training loads, namely to increase the volume of special physical training of female athletes and respectively to decrease general physical and technical-tactical training (Holt et al., 2020; Possamai et al., 2022; Thiele et al., 2020).

Sport is constantly evolving and rowers must adapt to new standards and demands. Physiological analysis can help to determine optimal training strategies and tactics for current rowing trends. Thus, the integration of physiological principles into the training programs of rowers provides more scientific and effective approach to achieve optimal physical fitness of athletes (Hellebrand, 2023; Penichet-Tomas et al., 2023). In this regard, the researches aimed at the development, testing and practical introduction into the training process of highly qualified athletes of new training programs for various stages of the annual training cycle, are undoubtedly relevant taking into account the latest achievements of sports science, the dynamics of sports results in a particular sport, and also successful experience in preparing highly qualified male and female athletes for the most significant international competitions (Clausen & Astorino, 2023; Da Silva et al, 2020).

Analysis of scientific and methodological literature on the research problem has allowed us to state a limited number of works devoted to improving the training process of female rowers through the development of innovative training programs (Salnykova et al, 2017; Turner et al, 2021; van der Zwaard et al, 2021). It has been suggested that the achievement of the maximum result was implemented in an ineffective and uneconomical way of maximizing the functional reserves of the body, which may result in an increase in the degree of its functional tension, a significant expenditure of energy potential and a pronounced drop in adaptive capabilities.

In addition, it is important to recognize that success in elite sports largely depends on the level of scientific support and innovation in the training process. In this context, it is critical to synthesize and analyze existing researches and practical experience in the field of training in order to identify the most effective approaches and methods that could be adapted and applied to improve the training of female rowing teams (Kolumbet et al, 2018; Majumdar et al, 2017; Marinkovic et al, 2021). This conclusion has been the basis for the development of an experimental program for constructing the training process of highly qualified female athletes specializing in rowing, within the framework of the fourth (final) macrocycle of the Olympic training cycle. The relevance and undoubted practical significance of this problem has served as prerequisites for conducting this study.

The aim of the research is to evaluate the effectiveness of various training programs for preparing female quadruple scull rowers of the Ukrainian National rowing team for the competitive season.

Materials and methods.

Participants. The study has involved 10 highly qualified female rowers, members of the Ukrainian National rowing team.

Procedure / Test protocol / Skill test trial / Measure / Instruments. The female athletes were preparing for the competitive season according to the traditional training program (from October 2021 to May 2022) (the first stage of the experiment) and the original program – from October 2022 to May 2023 (the second stage of the experiment). Despite the achievement of high sports results, the female athletes of the Ukrainian National team were characterized by a fairly distinct “lag” from the model characteristics in terms of the indicators of functional, general and special physical fitness used in the study. Thus, Ukrainian female athletes won the Continental quadruple scull championships 11 years ago.

The development of the experimental program for constructing the training process has been based on the following principles (Figure 1):

• compliance of the sports training means, included in the program, with the level of qualifications and preparedness of female athletes specializing in rowing at the stage of maximum realization of individual capabilities;

• cyclical nature of the training process, which makes it possible to create training on the basis of various cycles (individual classes, micro-, meso-, macrocycles, stages and periods);

• gradual increase in load, which helps to increase the *working capacity* and mobilize the functional capabilities of the athletes;

• optimal sequence, which provides for a strictly defined sequence of solving key training tasks by year of the Olympic training cycle.

• optimization - a continuous desire to optimize the training process through the rational use of all types of training within the framework of the developed structure of the training process.

• optimal load ratios, according to which a change in the absolute values of the volume of training loads for the leading means of preparation is possible while maintaining the relative ratio between them.

• phasing, which provides for the identification of a four-year Olympic cycle in the structure of training high-class athletes as an independent structural unit in the system of long-term sports improvement.

• program-targeted planning and management, which implies a focus on achieving the final result.

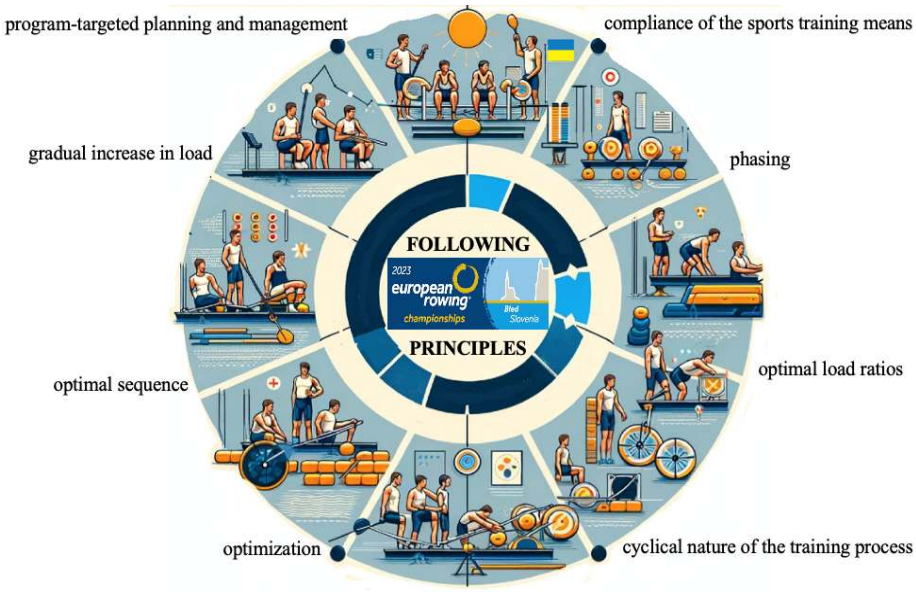

Figure. Principles of constructing the training process of the original program for female athletes specializing in rowing at the stage of maximum realization of individual capabilities

The main difference of the original program was the emphasis on increasing the number of training sessions and training hours for the development of strength and speed-strength training of female athletes in combination with stabilizing the rowing pace at the level of model characteristics (42 strokes per minute).

In connection with the above-mentioned within the framework of the involving mesocycle of the general preparatory stage, it has been proposed to increase the volume of rowing in the aerobic mode by 10% (up to 680 km), the volume of speed-strength and strength training (by 15% and 22%, respectively, or up to 8,000 and 16,000 repetitions), by reducing the volume of general physical training by 20% (up to 144 km of cross-country running and up to 10.8 hours of swimming in the pool). In addition, the volume of training sessions has been reduced by 27% on technical and tactical training and development of flexibility. Just as within the framework of the third macrocycle, the use of special exercises using a rowing ergometer, rowing on water in mixed (aerobic-anaerobic) and exclusively anaerobic modes has not been provided.

The training program within the basic mesocycle of the general preparatory stage has included 720 km of rowing training in aerobic mode (+11% compared to the volume of rowing training in this mode in the third macrocycle), 104 km of rowing training in a mixed mode (+12%), as well as increase by 17% in the volume of special training using the Concept-2 rowing ergometer (up to 180 km), by 15% and 22% in the volume of speed-strength and strength training (up to 8,000 and 16,000 repetitions, respectively). At the same time, the volume of general physical training has been reduced by 25% (up to 136 km of running and 21.6 hours of swimming in the pool). In general, within the framework of the general preparatory stage of the preparatory period of the final macrocycle, the volume of rowing training in the aerobic mode was 1,400 km, in the mixed mode – 104 km, and was not provided for in the anaerobic mode. The volume of speed-strength and strength training was 16,000 times and 32,000 times, respectively, special training using the rowing ergometer 180 km, general physical training 280 km of running and 32.4 hours of swimming in the pool.

The special preparatory stage of the preparatory period of the fourth macrocycle has been also divided into 4 mesocycles. As part of the first mesocycle of the special preparatory stage it has been planned to increase the volume of rowing training in aerobic mode by 12% (up to 820 km), by 14% in mixed mode (up to 104 km), and by 17% (up to 192 km) the volume of special training using the rowing ergometer, by 22% (up to 8,000 repetitions) – the volume of strength training due to a 15% reduction in the volume of running (up to 187 km)

and swimming (up to 20.4 hours) training. The use of speed-strength training and rowing training in an anaerobic mode has not been provided for within this mesocycle.

Similar to the third macrocycle, the training program within the second and third mesocycles of the special preparatory stages was almost identical. It has been proposed to increase the volume of rowing training in aerobic mode by 12% (up to 820 km), by 13% in the second and by 14% in the third mesocycle, the volume of rowing training in mixed mode (respectively up to 104 km in both cases), by 15% and 22% have been proposed to increase the volume of speed-strength and power training (up to 8,000 and 19,200 repetitions, respectively) and by 19% (up to 220 km) the volume of special training using the rowing ergometer. The corresponding decrease in running and swimming training (within the framework of general physical training) was 15% each (up to 136 km and 20.4 hours, respectively).

As part of the fourth mesocycle of the special preparatory stage, the female athletes of the Ukrainian National rowing team have been asked to increase the volume of rowing training in the aerobic mode by 14% (up to 660 km), in the mixed mode by 15% (up to 104 km), in the anaerobic mode by 12 % (up to 160 km). The increase in the volume of speed-strength, strength and special training, in comparison with the third macrocycle, was 15%, 22% and 17%, respectively, or 8,000, 19,200 repetitions and 180 km. The reduction in the volume of general physical training was to reduce the volume of running training by 15% (up to 136 km) and swimming by 15% (up to 15.3 hours).

In general within the framework of the special preparatory stage of the preparatory period of the annual training cycle in the training program for the female athletes of the Ukrainian National rowing team the following volumes of training loads have been provided: 3,120 km of rowing in aerobic mode, 416 km in mixed mode, 160 km in anaerobic mode, 24,000 repetitions for speed-strength exercises, 65,600 repetitions for strength training, 812 km using the rowing ergometer for special training. General physical training has included 595 km of running training and 76.5 hours of swimming.

The program of training sessions of the pre-competition mesocycle of the pre-competition stage of the competitive period the increase by 8% (up to 324 km) in the volume of rowing training in the aerobic mode, by 10% (up to 420 km) in the mixed mode and by 15% (up to 180 km) in the anaerobic mode has been provided. The increase in the volume of speed-strength, strength and special training was 16%, 20% and 17%, respectively (up to 6,000, 16,000 repetitions and 80 km). The volume of running and swimming training has been reduced by 20% (to 96 km and 9.6 hours, respectively).

As part of the program of training sessions for competitive mesocycles of the competitive stage of the competitive period of the annual training cycle, an increase by 6-7% in the volume of rowing training in the aerobic mode (up to 264 km, 220 km and 160 km, respectively), by 7-8% in the mixed mode (up to 420 km, 104 km and 104 km), 5-6% in anaerobic mode (up to 240 km, 420 km and 280 km), 16% speed-strength training (up to 2,000 repetitions), 20% strength training (up to 6,000 repetitions) has been provided. In general, within the framework of the competitive period, the female athletes of the Ukrainian National team rowing in aerobic, mixed and anaerobic modes (968 km, 1,048 km and 1,120 km, respectively) has been provided. Strength training has included 28,000 repetitions, speed-strength training - 10,000 repetitions. In addition, the volume of special training using the rowing ergometer was 80 km, running training – 96 km, and swimming in the pool – 9.6 hours.

The level of general physical fitness of female athletes has been assessed based on their overall endurance (running 3,000 m, s), strength endurance (number of times raising the barbell lying on a bench in 7 minutes) and maximum strength based on the results of pulling a barbell lying on a bench – the maximum force coefficient has been calculated FCmax, conventional units, CU). To assess the level of special physical fitness, a special Concept-2 rowing ergometer has been used: power load (N, W), heart rate (HR, beats•min^{-1}) and blood lactate level (LAC, mmol•L^{-1}) has been determined at passing a distance of 2,000 m using the ergometer. The emphasis on this distance has been made due to the fact that it is "working" for female athletes specializing in rowing, i.e. corresponds to the competition distance used in various domestic and international competitions (Pengcheng et al., 2020; Xianglin et al., 2020).

To assess the level of functional readiness, the following parameters have been determined:

• relative value ($rPWC_{170}$, kgm•min^{-1}•kg^{-1}) of general physical working capacity has been calculated using the formula:

$$rPWC_{170} = aPWC_{170} / BW$$

where $aPWC_{170}$ is the absolute value of general physical working capacity, kgm min^{-1}; BW – body weight, kg;

• relative (rMOC, ml•min^{-1}•kg^{-1}) maximal oxygen consumption value

$$rMOC = aAC/BW$$

where aAC is the absolute value of aerobic capacity, L min^{-1}; BW – body weight, kg.

Data collection and analysis / Statistical analysis. Mathematical processing of the study results has been carried out with assistance of the statistical software and the evaluation of the traditional parameters: the arithmetical mean (X) and the error in the mean (S). To assess the validity of differences between samples, we

have used the Fisher test with the calculation of the Fisher criterion (F) and the Bland-Altman method with the calculation of the total error (T, %).

Results. Analysis of testing data of female athletes of the Ukrainian National rowing team within the first stage of the experiment allowed us to establish the following (Table 1). By the end of the preparatory period, during which the female rowers of the Ukrainian National rowing team have followed a traditional training program, the female athletes have been characterized by a significant increase only in the level of their general endurance (based on the results of the 3,000 m race) (F=31.86>3.23; T=5.2%) and strength endurance (F=14.50>3.23; T=4.9%).

This was facilitated by the increase in the volume of aerobic training (3,000 m running), which led to an improvement in the cardiorespiratory system (the increase in the amount of oxygen that the body is able to consume), adaptation in the muscles and the increase in the number of mitochondria, which in turn increases the energy potential of the muscles and improves overall endurance.

Table 1. Indicators of general, special physical and functional readiness of the female athletes of the Ukrainian National rowing team at various stages of preparation according to the traditional training program

Indicators	Beginning of the preparatory period	End of the preparatory period	F (3,23)	T, %
3000 m run, s	815.57±1.18	806.23±1.16	31.86	5.2
Strength endurance, number of times	189.09±0.47	191.49±0.42	14.50	4.9
FCmax, CU	1.03±0.001	1.04±0.001	**0.50**	5.5
N_{2000}, W	336.04±7.20	343.25±7.36	**0.49**	5.9
HR_{2000}, bpm^{-1}	192.40±0.88	189.10±0.90	6.87	4.0
LAC_{2000}, mmol $\bullet L^{-1}$	15.94±0.24	15.37±0.08	5.08	6.1
$oPWC_{170}$, kgm$\bullet min^{-1}\bullet kg^{-1}$	22.30±0.34	25.44±0.38	37.92	4.7
rMOC, ml$\bullet min^{-1}\bullet kg^{-1}$	63.71±0.34	71.08±0.38	208.91	5.3

The results of female athletes testing on the Concept-2 rowing ergometer also indicated an improvement in the indicators of their special physical fitness by the end of the preparatory period. It should be noted, however, that significant changes in the power values of the work performed have not been observed. Thus, by the end of the first stage of the experiment, female rowers showed a significant decrease in HR (heart rate) when covering a distance of 2,000 m (up to 189.10±0.90 beats/min-1) (F=6.87>3.23; T=4.0%) and is interpreted as more efficient cardiovascular performance, indicating increased cardiorespiratory efficiency and energy savings during rowing.

A decrease in the level of lactate in the blood (to 15.37±0.08 mmol•l-1) (F=5.08>3.23; T=6.1%) indicates a better adaptation of muscle cells to metabolic changes, which can be the result of improved lactic acid metabolism or increased muscle energy distribution capacity. The lack of reliable changes in the power of the work performed may be due to the level of training load being insufficient to change it. Also, these changes may be associated with the characteristics of the distance itself and its nature. Reducing of heart rate and lactate level indicates better functioning of the aerobic systems and reduced dependence on anaerobic processes, as the important factors in the context of long-term endurance on longer distances.

Changes of indicators of their functional readiness also turned out to be positive among the examined female athletes. It has been shown that by the end of the preparatory period, the female rowers of the Ukrainian National team were characterized by a significant increase in the level of their general physical performance (up to 25.44±0.38 kgm•min-1•kg-1) (F=37.92>3.23; T=4.7%) and aerobic capacity (up to 71.08±0.38 ml•min-1•kg-1) (F=208.91>3.23; T=5.3%), which have been considered as above average.

As a whole, the results obtained during the first stage of the experiment have indicated a fairly high effectiveness of the traditional training program for highly qualified female rowers during the preparatory period of the annual training cycle.

In this connection, we have developed measures to improve the training program for female rowers of the Ukrainian National team during the preparatory period of the macrocycle of preparation for the European Championship 2023 and conducted an experimental assessment of its effectiveness (the second stage of the experiment).

The results of the final testing at the end of the preparatory period have shown, that there was a significant growth of all indicators of general and special physical and functional readiness of examined female rowers (Table 2).

Table 2. Indicators of general, special physical and functional readiness of the female athletes of the Ukrainian National rowing team at various stages of preparation according to the original training program

Indicators	Beginning of the preparatory period	End of the preparatory period	F (3,23)	T, %
3000 m run, s	818.30±1.25	757.75±1.15	1270.82	4.9
Strength endurance, number of times	188.08±1.14	204.44±1.24	94.34	5.2
FCmax, CU	1.04±0.01	1.12±0.03	6.40	6.5
N_{2000}, W	328.90±6.85	361.40±7.92	9.63	5.1
HR_{2000}, bpm^{-1}	194.30±0.67	185.10±0.78	80.05	4.8
LAC_{2000}, mmol $\bullet L^{-1}$	16.00±0.25	14.10±0.22	32.55	4.2
$oPWC_{170}$, $kgm\bullet min^{-1}\bullet kg^{-1}$	22.80±0.21	27.86±0.38	135.83	5.0
rMOC, $ml\bullet min^{-1}\bullet kg^{-1}$	64.19±0.28	74.97±0.66	226.09	4.7

It is important to note that all indicators used in the study have corresponded to a high level, which indicated a higher effectiveness of the original training program in comparison with the traditional one. Convincing confirmation of this was the results of a comparative analysis of the values of indicators of general, special physical and functional readiness of the female rowers of the Ukrainian National team, registered at the end of the first and second stages of the experiment (Table 3).

Table 3. Comparative analysis of indicators of general, special physical and functional readiness of female athletes of the Ukrainian National rowing team at the end of the preparatory period, who have trained under various training programs

Indicators	Beginning of the preparatory period	End of the preparatory period	F (3,23)	T, %
3000 m run, s	806.23±1.16	757.75±1.15	880.89	4.4
Strength endurance, number of times	191.49±0.42	204.44±1.24	97.84	4.9
FCmax, CU	1.04±0.001	1.12±0.03	6.40	4.1
N_{2000}, W	343.25±7.36	361.40±7.92	**2.82**	5.3
HR_{2000}, bpm^{-1}	189.10±0.90	185.10±0.78	11.28	6.2
LAC_{2000}, mmol $\bullet L^{-1}$	15.37±0.08	14.10±0.22	29.43	5.7
$oPWC_{170}$, $kgm\bullet min^{-1}\bullet kg^{-1}$	25.44±0.38	27.86±0.38	20.28	4.1
rMOC, $ml\bullet min^{-1}\bullet kg^{-1}$	71.08±0.38	74.97±0.66	26.09	5.2

Discussion.

The development and implementation of the original training program is a symbiosis of advanced scientific and training approaches, which is reflected in a significant increase in almost all parameters of the physical and functional readiness of the female rowers of the Ukrainian National rowing team, which not only raises the bar of the training process, but also focuses on optimizing of individual parameters of adaptation, and is a key element in achieving outstanding results (Schünemann et al., 2023; Wang & Zhao, 2023).

Thus, the decrease in race time (increase in efficiency) in the original program is associated with a more accurate balancing of training intensity, which contributes to an optimal energy system and improved aerobic endurance, which helps to adapt heart and blood vessels for intense physical activity. More precise balancing of training intensity has contributed to more efficient metabolism and optimization of the glycolytic pathway, which is important for high-intensity exercise (Nolte, 2023). This is due to improved utilization of energy from various sources, such as aerobic and anaerobic metabolism, which ultimately helps to optimize the energy system of body.

Increasing the number of repetitions is the result of a more effective training system, aimed at improving metabolic processes and optimizing muscular strength endurance, and indicates an increased lactate threshold (Wolf, 2021). This means that the muscles become more efficient at utilizing and eliminating of lactate, improving the efficiency of energy delivery to the muscles, which helps to extend the time during which the muscles can work at high intensity. In addition, the original program has contributed to better muscle

adaptation to high loads. This includes the improving muscle fiber structure, the increasing of mitochondrial density, and the increasing of protein synthesis. All these factors help to improve muscle strength endurance (van der Zwaard et al, 2021).

The increase of FCmax marks a high level of muscle adaptation to intense loads, which is a sign of increased efficiency of the training process. Creatine Kinase is an enzyme released into the blood when muscles are damaged. The increase in which reveals a higher level of stress caused by training, which leads to some degrees of muscle damage (Dudašova et al., 2022). In response to muscle damage, adaptation and regeneration occurs, which contributes to muscle strengthening, and if the increase of FCmax is accompanied by rapid recovery and adaptation, this indicates an effective training program. The FCmax level can serve as an indicator of how well the training load and recovery processes are balanced. The effective training program should allow adequate recovery time while minimizing muscle damage.

The increase of power at 2,000 m is due to more targeted training, improve the aerobic and anaerobic energy systems, which is especially important for the aerobic energy system, which depends on efficient oxygen metabolism for energy production (Ingham et al, 2002; Majumdar et al, 2017; Quidel-Catrilelbún et al, 2024). The original program has promoted the adaptation of mitochondria, organelles which are responsible for energy production in cells (the increase in the number and functionality of which supports aerobic processes); improvement of oxidative metabolism, which in turn has increased the efficiency of fat utilization and improved endurance over long distances; increasing the capacity of the glycolytic pathway, which has allowed muscles to use more efficiently glycogen for rapid energy production; aimed at increasing the lactate threshold, which allows muscles to work at a higher intensity, minimizing the accumulation of lactate and preventing fatigue; increased anaerobic capacity, which has contributed to use more efficient energy under high-intensity conditions (Martin &Tomescu, 2017; Steinacker et al., 1986).

The decrease in heart rate indicates better control of the cardiovascular system at high intensities, making it more efficient at pumping blood, causing the heart to handle a larger volume of blood per cycle, which lowers the heart rate. Training loads that increased the angular output of the heart have decreased the heart rate at a given load, which has allowed the heart to supply more efficiently blood to the body during physical activity (DeBlauw et al, 2023).

The reduction of lactate level at 2,000 m indicates better adaptation to metabolic demands resulting from improved aerobic efficiency and lactate metabolism, and is associated with more efficient tissue oxygen uptake, improved muscle oxygenation, better cardiorespiratory function and increased cardiovascular endurance (Marcora, 2008; Messonnier et al, 1997). Improved aerobic efficiency has led to increased use of aerobic metabolic pathways for energy production, which has reduced the need for anaerobic glycolysis and, as a result, lactate level in muscles and blood could become less high, meaning that less of this metabolite entered the blood, and this is reflected in its levels at 2,000 m. The improved adaptation of the body to metabolic demands also has indicated greater metabolic flexibility, which means the ability to switch efficiently between aerobic and anaerobic metabolic pathways depending on conditions (Zoltán, 2023).

The increase of power has confirmed a higher level of adaptation of the cardiovascular system to training loads, which has improved overall endurance. The original program has stimulated the increase in the number of capillaries, which has improved the supply of oxygen to the muscles, has contributed to the increase in the angular output of the heart, that is, the heart could pump a larger volume of blood in one contraction, which has improved its effectiveness. In this regard, the adapted cardiovascular system has provided more effectively the muscles with oxygen and nutrients, which has increased the productivity of energy generation processes and improved overall endurance (Mazza et al, 2023).

The increasing maximal oxygen consumption has reported about more efficient use of oxygen in the body, which is a key indicator of aerobic fitness, has indicated the improved respiratory function, including more efficient ventilation of the lungs and increased inhalation and exhalation volume, has stimulated adaptations in the gas exchange surface of the lungs, which contributed to more efficient exchange of gases between air and blood, confirmed developed cardiac function, including a higher level of cardiac output and better adaptation to physical activity (Omelchenko et al, 2020, 2023).

The improvement of all these parameters in the original program can be the result of integration of scientific methods, a personalized approach and more effective management of the training process. This conclusion has been fully confirmed by the results of the performance of our female athletes at the 2023 European Championships, which took place in Slovenia, the city of Bled, where our female rowers won gold medals with a score of 6.19.2 in the final. At the “blue-yellow” distance, the female crew has beaten the female representatives of the Netherlands and Great Britain, who won “silver” and “bronze”, respectively. For Ukraine, this “gold” was the first at the European Rowing Championships since 2014.

Conclusions.

The findings elucidate the superior efficacy of a specialized training regimen for the Ukrainian National female rowing team, underscored by significant enhancements in general, special physical, and functional readiness parameters. This regimen, distinct from conventional methods, leverages cutting-edge scientific

principles and a tailored approach, facilitating marked improvements in performance metrics such as endurance, strength, cardiovascular efficiency, and metabolic adaptation. The improvements have been observed in a number of key metrics, including general endurance, strength endurance, maximal strength, 2000-meter rowing ergometer power, as well as indicators of heart rate and blood lactate levels. These results indicate an increase in the efficiency of the cardiorespiratory and metabolic systems, as well as optimization of energy metabolism, which, in turn, contributed to an increase in the athletic performance of female athletes. The empirical evidence supports the conclusion that this innovative program not only elevates athletic performance but also played a pivotal role in securing a gold medal at the European Rowing Championships, thereby underscoring the critical importance of evidence-based, personalized training strategies in the realm of elite sports achievement.

The study enriches theoretical knowledge in the field of sports science about the specifics of the training process in rowing for women, demonstrates the importance of integrating evidence-based approaches and an individualized training program to optimize the physical and functional readiness of female athletes. The study complements existing theoretical frameworks by providing new insight into the impact of a comprehensive and evidence-based training program on the development of key components of physical and functional readiness of female rowers. It also contributes to a deep understanding of the body's adaptation mechanisms to specialized training loads under conditions of high training intensity.

The results of the study provide coaches and sports specialists with an evidence base for the implementation and adaptation of the developed training program into the practice of training elite female athletes specializing in rowing, which can contribute to the achievement of better sports results at the international level. Our program can serve as the basis for creating the individualized preparatory plans for female rowing athletes, taking into account their personal physiological and psychological characteristics. This provides the opportunity for more targeted and efficient use of training time, which not only improves athletic performance, but also reduces the risk of injury and overtraining. Overall, the study makes an important contribution to sports science by offering valuable recommendations for optimizing the training of female rowers, and highlights the importance of the evidence-based approach in modern high-performance sport.

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