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Original Article

Fitness training in functional preparedness of highly qualified football players

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Abstract
Problem Statement: In football, the task of improving the functional preparedness of highly qualified football players requires the use of special modes of training work, which has little connection with the system of special exercises for football players. Research hypothesis: innovative fitness techniques of functional training of football players will increase the level of their functional state, long-term maintain the necessary conditions during the two competitive periods of the annual training cycle, and thus contribute to a high final result of competitive activities. **The objective** of the research is to increase the functional conditions of highly skilled football players in the preparatory period of the annual macrocycle by means of fitness training. Participants: The study involved 25 players of FC "Zorya" (Luhansk city) aged 20 to 30 years. *Methods:* the submaximal bicycle ergometric test PWC_{170}. The absolute value of the total physical working capacity ($aPWC_{170}$) and the relative value of the total physical working capacity ($rPWC_{170}$), the absolute value of the aerobic capacity – maximum oxygen consumption (aMOC) and the relative value of the aerobic capacity (rMOC) were calculated. *Results:* An experimental program of physical training of highly qualified football players has been developed, the feature of which was the use of three innovative methods of modern fitness training: MAX®, Tabata, HIIT. Statistically significantly better indicators of physical work capacity of football players have been registered in the formative experiment at the end of both preparatory periods of the 2019/2020 season compared to the corresponding periods of the 2018/2019 season – by 21.7% and 24.1% ($p < 0.001$) and aerobic capacity – by 13.7% ($p < 0.001$) and 10.9% ($p < 0.01$); at the end of competitive periods – indicators of physical work capacity by 24.2% and 30.6% ($p < 0.001$) and aerobic capacity – by 15.8% and 15.9% ($p < 0.001$). *Conclusions:* The introduction of an experimental program with the use of fitness training innovative means in the training process of highly qualified football players of FC "Zorya" (Luhansk city) improved their physical performance and aerobic capacity. The effectiveness of the program was confirmed by the team of FC "Zorya" winning bronze medals in the championship of the Ukrainian Premier League of the 2019/2020 season.
Key words: fitness training, football players, physical working capacity, aerobic capacity, preparatory period, competitive period.

Introduction

The high level of physical, psychological, and functional conditions of football players is a significant factor in the successful competitive performance of professional football teams (Musalek & Kokstejn, 2019; Petrovska et al., 2020; Rites et al., 2022). At the same time, it is necessary to take into account the complexity of the process of developing functional capabilities at the threshold level of anaerobic metabolism, maximum oxygen consumption, anaerobic power and capacity (Bangsbo & Mohr, 2012; Longo et al., 2016; Iedynak et al., 2019). The problem of improving the functional readiness of highly qualified football players in the preparatory period of the annual macrocycle is related to the search for effective approaches that provide the educational and training process with modern training tools and methods of their practical implementation (Kachanathu et al., 2014; Jagielski, 2022), especially the innovative fitness technologies (Lisenchuk et al., 2021; Shchekotylina, 2022).

The analysis of scientific and methodological literature on the research problem shows the existence of various approaches to improving the content and structure of programs for physical training of highly qualified football players, due to the use of aerobics and step aerobics, crossfit, stretching, bodybuilding, etc. (Parmuzina, 2006; Cerrah et al., 2016; Charmi et al., 2020). In the training of football players of the most successful football clubs: "Liverpool", "Manchester City" (England); "Borussia Dortmund" (Germany); "Marseille" (France); "Real Madrid", "Barcelona" (Spain) – methods of high-intensity functional fitness training such as TRX-Rip and

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Muscle Activity Excellence M.A.X. are widely used. High Intensity Interval Training (HIIT), involves the alternation of short and intense anaerobic periods with short periods of aerobic recovery, and adapts well to a sport such as high intensity intermittent aerobic-anaerobic football, with breaks broadly variable and a mixed metabolic activity, where aerobic and anaerobic energetic processes are solicited alternately (Agostino, 2019).

At the same time, modern requirements for the physical and functional fitness of highly qualified football players require further improvement of the existing programs for their physical training, in particular due to the comprehensive use of innovative fitness training methods, which will contribute to increasing the functional fitness and efficiency of the educational and training process. So the hypothesis of our experiment was that the innovative fitness methods of physical and functional training and rehabilitation of football players after high muscle loads will allow to bring their indicators to a new, higher quality level, to maintain the necessary conditions for a long time during two competitive periods of the annual training cycle, and thereby contribute to a high result of the athlete's competitive activity.

The purpose of the study is to increase the functional capabilities of highly qualified football players in the preparatory period of the annual macrocycle by means of fitness training.

Material and methods

Participants and Procedures

The research was conducted on the basis of FC "Zorya" (Luhansk) – the Premier League team of the Ukrainian football championship. 25 highly qualified football players aged between 20 and 30 took part in the study. The researchers followed all protocols and procedures required by the Biomedical research Ethics Committee and conform to the directive of the Helsinki 2008 Declaration to ensure adherence to all standards for adequate protection and well-being of participants.

In the sports seasons of 2017/2018 and 2018/2019, the training process was carried out in accordance with the training process construction program valid at that time. The ascertaining experiment was conducted within the framework of the annual macro cycle of the 2018/19 season. The formative experiment was conducted in the 2019–2020 sports season as a result of the application of an experimental program using innovative means in the first and second preparatory periods of the annual training cycle of FC Zorya (Luhansk) players.

Data collection

To determine the level of physical working capacity and aerobic capacity of football players, the submaximal bicycle ergometric test PWC_{170} was used. Each athlete performed two 5-minute loads of different power on the bicycle ergometer with a 3-minute rest interval between them. In the last 30 seconds of each load, the heart rate (HR_1 and HR_2) was recorded, the value of which was converted into the number of beats per minute by multiplying the result obtained in 30 seconds by 2. The power of the first and second loads (P_1 and P_2) in watts were set depending on the subject's body weight.

The calculation of the absolute value of the total physical working capacity ($aPWC_{170}$) and the relative value of the total physical working capacity ($rPWC_{170}$), the absolute value of the aerobic capacity – maximum oxygen consumption (aMOC) and the relative value of the aerobic capacity (rMOC) were carried out according to formulas 1, 2:

$$aPWC_{170} = \{P_1+(P_2 - P_1) \times (170 – HR_1) / (HR_2 – HR_1)\} \times 6.12 \quad (1)$$

where aPWC170 is the absolute value of total physical work capacity, $kg \cdot m \cdot min^{-1}$; P_1 – power of the first load on the cycle ergometer, watts; P_2 – the power of the second load on the bicycle ergometer, watts; $P_2 = P_1 + 0.75 \times P_1$ (for athletes regardless of gender); HR_1 – heart rate after the first load, $beats \cdot min^{-1}$); HR_2 – heart rate after the second load, $beats \cdot min^{-1}$;

$$rPWC_{170} = aPWC_{170} / BW \quad (2)$$

$rPWC_{170}$ is the relative value of total physical working capacity, $kg \cdot m \cdot min^{-1} \cdot kg^{-1}$; $aPWC_{170}$ – absolute value of total physical working capacity, $kg \cdot m \cdot min^{-1}$; BW - body weight, kg.

The absolute value of the aerobic capacity (aMOC, $ml \cdot min^{-1}$) was calculated according to formula 3:

$$aMOC = 2.2 \cdot aPWC_{170} + 1070 \quad (3)$$

aMOC is the absolute value of the aerobic capacity, $ml \cdot min^{-1}$; $aPWC_{170}$ is the absolute value of total physical working capacity, $kg \cdot m \cdot min^{-1}$.

The relative value of the aerobic capacity (rMOC, $ml \cdot min^{-1} \cdot kg^{-1}$) was calculated according to formula 4:

$$rMOC = aMOC / BW \quad (4)$$

rMOC is the relative value of the aerobic capacity, $ml \cdot min^{-1} \cdot kg^{-1}$; aMOC – absolute value of aerobic capacity, $ml \cdot min^{-1}$; BW - body weight, kg.

Statistical analysis

Since the samples of the results of testing the physical performance and aerobic capacity of football players corresponded to the law of normal distribution (which was confirmed by Shapiro-Wilk test), parametric descriptive statistics were used in the study. The arithmetic mean $\bar{x}$, standard deviation SD were determined. The statistical significance of the difference between the test indicators was determined by t-test.

In order to be able to compare visually the dynamics of test results, the values of which differ by 2 orders of magnitude, the data were standardized so that they belong to a small specific interval [0,1]. In statistics, the term "standardization" has a very specific meaning and refers to the transformation of data by subtracting each value

from some reference value (usually the sample mean $\bar{x}$) and dividing it by the standard deviation (usually the sample SD). When applied to input data, standardization makes the results of various statistical methods completely independent of value ranges or measurement units. This important transformation brings all values (regardless of their distribution and original units) to compatible units from a distribution with a mean of 0 and a standard deviation of 1. This operation is often used when processing certain benchmarks and scores to remove certain data ranges and transform them into a dimensionless pure value, so that it is possible to compare and weigh indicators of different units or quantities.

Statistica Version 14.0.1.25 (TIBCO Software) was used for statistical processing.

Results

As revealed by previous studies, the coaching staff of FC "Zorya" makes very little use of the powerful fitness training tools adopted by most of the leading European football teams (Lisenchuk et al., 2021; Kokareva et al., 2018; 2021). Some of them were not used at all. Therefore, we considered it expedient to build the program of the first and second preparatory periods of the 2019/2020 season, based on the replacement of outdated training tools and methods with innovative ones, which are currently little studied and almost not used in Ukraine.

In the ascertaining experiment, it was determined that after the completion of the 1st competitive period, the indicators of working capacity and aerobic capacity of football players of FC "Zorya" were mainly kept in the zone of "average" level of values, except for the relative indicator of working capacity $rPWC_{170}$ ("below average" level), although they experienced a significant ($p<0.05–0.001$) decrease. After the completion of the 2nd round of the 2018/19 championship, almost all indicators of physical performance and aerobic capacity of football players were characterized by more pronounced negative changes compared to similar indicators determined after the 1st round of the championship (*Figure 1*).

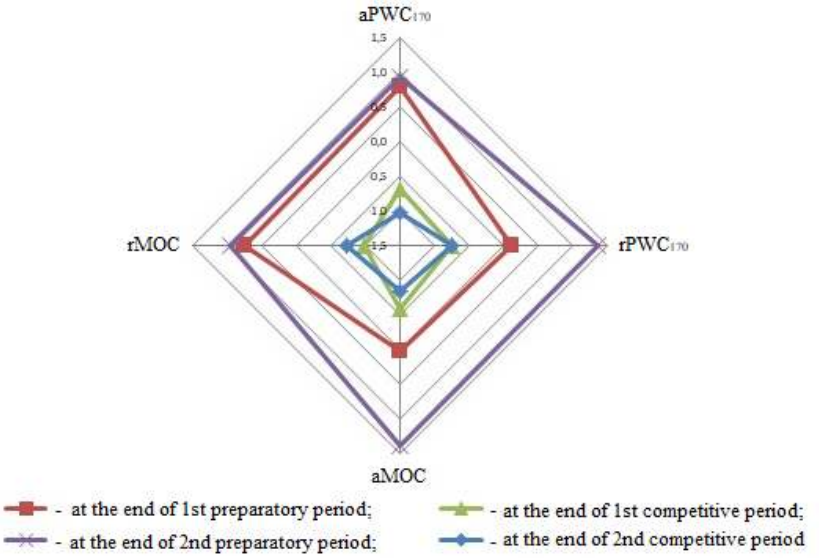

Figure 1. Dynamics of indicators of physical performance and aerobic capacity (standardized values) of FC "Zorya" players at the end of various training periods for the 2018/19 sports season (n=25)

Summarizing the obtained results and comparing them with the data of previously conducted studies (Bosco, 1990; Kokareva et al., 2021), a new strategic direction of work on the problem of improving special physical fitness, physical working capacity, functional condition and restoration of the musculoskeletal system of highly qualified football players in the preparatory periods of the Ukrainian Premier League (UPL) 2020/21 next championship was chosen.

To implement the training program for football players of FC "Zorya" in the first and second preparatory periods of the annual training cycle for the 2019/20 season, the following methods were chosen, which are best adapted to work indoors, and which are universal from the point of view of the conditions of sports grounds. Among the first: functional aerobic classes (step, fitball, medball, bodybar, etc.); 6D Sliding. Among the second: TRX/TRX-Rip; Tabata; HIIT; Strenflex; MAX®; 6D Sliding; types of circuit training.

The universal MFR technique was also used, one gives the expected effect under the conditions of a hard surface. Two complexes of circuit training were developed for the main part of the applied physical training session with highly qualified football players of the team of FC "Zorya" (*Table 1*).

Table 1. Methodical characteristics of circuit training complexes for general and special physical training with highly qualified football players

Structural component	*1st variant of circular training*	*2nd variant of circular training*
Means	Static & dynamic exercises	High-intensity aerobic and strength exercises
The main straightening of the training effect	Muscle system, support-motional apparatus	Cardiovascular, respiratory, muscular systems and support-motional apparatus
Intensity of physical load	30-60 % MR	60-80 % MR
Quantity of laps / mini laps	2 / -	1 / 6
Duration of each lap / mini lap	18-21 minutes	36 / 6 minutes
Number of "stations" in each lap	12-14	24
Duration of work at the "station"	1 minute	1 minute
Rest between laps (mini laps)	1 minute	1 minute – 1 min 30 sec

Note: % MR – training load in % of the maximum possible result

The analysis of the pulse mode (heart rate during the performance of basic exercises), which was monitored by the "PolarTeam 2 Pro" system in real time, showed that thanks to the methods of high-intensity training and the reduction of rest time, it was possible to prove the real indicators of football player's heart rate during training tasks to heart rate values during their playing activities.

The main amount of time in the first preparatory period was devoted to high-intensity exercises in a mixed mode (average heart rate=150–190 beats·min^{-1}). Working intervals during training exercises by the timekeeping method of direct playing practice of football players were brought to coincide with similar playing intervals.

Analyzing the impact of training loads on the physical working capacity and aerobic capabilities of the FC "Zorya" football players in the first preparatory period of the 2019/20 sports season, it can be stated that by the end of this period it was possible to raise the relative level of physical working capacity (rPWC$_{170}$=25.35±1.13 kg·m·min^{-1}·kg^{-1}) and aerobic productivity (rMOC=69.97±2.17 ml·min^{-1}·kg^{-1}) to the value "above average", which was statistically significant higher ($p<0.01$–0.001) than the same period of the 2018/19 season (*Table 2*).

Table 2. Indicators of general physical capacity and aerobic capabilities of FC "Zorya" players at the end of the first and second preparatory and competitive periods of the 2018/19 and 2019/20 seasons ($\bar{x}$; S), n=25

Parameter	*Season*	*At the end of 1st preparatory period*				*At the end of 2nd preparatory period*			
		$\bar{x}$	S	t	p	$\bar{x}$	S	t	p
aPWC$_{170}$, kg·m·min^{-1}	2018/19	1474.8	38.38	5.62	0.001	1491.7	38.38	2.44	0.019
	2019/20	1416.4	35.02			1517.48	36.42		
rPWC$_{170}$, kg·m·min^{-1}·kg^{-1}	2018/19	20.83	0.71	16.93	0.001	22.38	0.97	18.10	0.001
	2019/20	25.35	1.13			27.77	1.13		
aMOC, ml·min^{-1}	2018/19	3964.1	4.43	1.67	0.102	4164.1	84.45	8.60	0.001
	2019/20	3931.6	97.32			3955.3	87.11		
rMOC, ml·min^{-1}·kg^{-1}	2018/19	61.52	1.57	15.77	0.001	62.2	2.25	10.89	0.001
	2019/20	69.97	2.17			69.01	2.17		
		At the end of 1st competitive period				*At the end of 2nd competitive period*			
aPWC$_{170}$, kg·m·min^{-1}	2018/19	1295.80	59.1	4.68	0.001	1255.4	40.44	15.63	0.001
	2019/20	1363.98	42.56			1440.1	43.06		
rPWC$_{170}$, kg·m·min^{-1}·kg^{-1}	2018/19	19.76	1.11	13.70	0.001	19.74	0.65	20.53	0.001
	2019/20	24.55	1.35			25.78	1.32		
aMOC, ml·min^{-1}	2018/19	3871.3	121.6	2.64	0.011	3835.5	72.09	1.09	0.283
	2019/20	3787.4	102.1			3860.89	92.1		
rMOC, ml·min^{-1}·kg^{-1}	2018/19	55.73	2.76	14.36	0.001	56.53	1.45	22.87	0.001
	2019/20	64.53	1.33			65.53	1.33		

At the end of the second preparatory period of the 2019/20 sports season, the relative level of football player's physical working capacity also increased (rPWC$_{170}$=27.77±1.13 kg·m·min^{-1}·kg^{-1}) and their aerobic productivity (rMOC=69.01±2.17 ml·min^{-1}·kg^{-1}) to the value "above average" ($p<0.01$; $p<0.001$), which is a confirmation of the training effectiveness in the first and second preparatory periods of the experimental sports season.

It was established that at the end of the second competitive period of the 2019/20 season, characterized, as is known, by the maximum negative impact of physical and psychological stress on the athlete's body, the highest values were recorded for tests characterizing the level of physical working capacity and aerobic capacity. The values of the two investigated indicators ($rPWC_{170}$ and rMOC) maintained an "above average" level during this competitive period (25.78±1.32 $kg \cdot m \cdot min^{-1} \cdot kg^{-1}$ and 65.53±1.33 $ml \cdot min^{-1} \cdot kg^{-1}$ respectively). For the first parameter, the difference between the two seasons was 30.6% ($p<0.001$), and for the second one – 15.9% ($p<0.001$). It is important to note that the absolute value of $aPWC_{170}$ at the end of the 2nd competitive period also had a significant advantage (24.6%, $p<0.001$) compared to the test result in the 2018/19 season.

During the formative experiment, FC "Zorya" football players, who were preparing for competitions as part of the training process according to the experimental program using innovative fitness training tools, had a statistically significantly higher initial level of athlete's physical working capacity and aerobic capacity, characteristic of both preparatory periods (*Figure 2*).

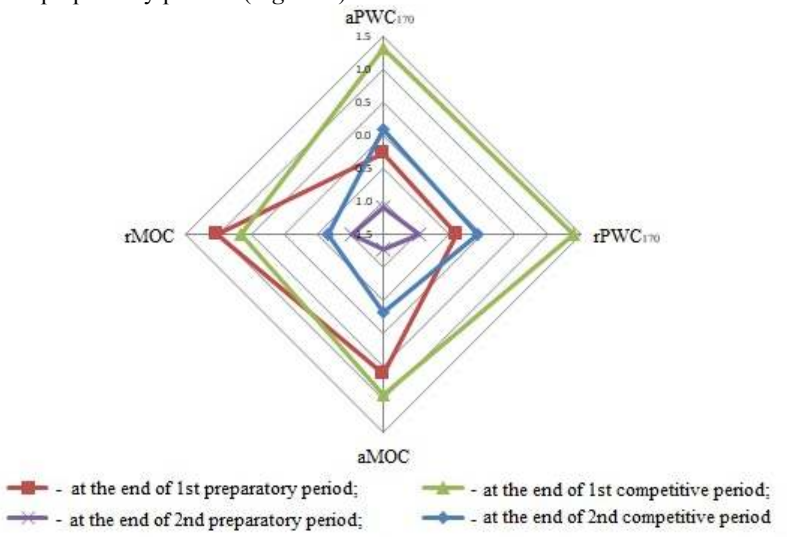

Figure 2. Dynamics of parameters of physical working capacity and aerobic capacity (standardized values) of FC "Zorya" football players at the end of various training periods for the 2019/20 sports season (n=25)

In our opinion, this led to a less significant decrease in their physical capacity and aerobic capacity and allowed them to maintain and more effectively use the acquired conditions during the first and second competitive periods of the 2019/20 sports season. At the end of both competitive periods of the second season, the athletes had statistically significant better parameters of physical performance compared to similar periods of the first season (see Table 2).

Confirmation of the effectiveness of the experimental program for the educational and training process of FC "Zorya" team in the first and second preparatory periods of the annual training cycle for the 2019/20 season was the result of the team's performances in the Ukrainian Premier League (UPL) championship, namely, winning the bronze medals of the Ukraine championship for the second time in its history.

Discussion

A systematic analysis of the references indicates the presence of various approaches to improving the content and structure of football players' physical training programs (Schmid & Alejo, 2002; Kostiukevych et al., 2019), in particular, due to the use of aerobics and step aerobics, crossfit, stretching, bodybuilding (Parmuzina, 2006; Charmi, 2020). Izzo et al. (2022) investigated the differences within and between microcycles throughout a season in a professional football club (Italian 3rd division) and it was confirmed the statement of another scientists in football to focus on the most effective recovery methods (Nassis, et al., 2020; Irtyshcheva, et al., 2022).

At the same time, the results of our research are consistent with the data of scientists regarding the insufficient efficiency of the approaches available today, which relate to the improvement of the physical and functional readiness of highly qualified football players, the provision of the educational and training process with modern means of training and methods of their practical implementation (Kokareva et al., 2018; Lisenchuk et al., 2021). The results of research by Parmuzina (2006), Bangsbo & Mohr (2012), Charmi et al. (2020) testify to the effectiveness of using specific training devices and their corresponding training tools in the training process of highly qualified athletes. At the same time, there are very few studies in the available scientific and methodical literature that contain methodological recommendations for variable use of various methods of high-intensity interval training for qualified football players during the annual cycle (Owen et al., 2012; Kunz et al., 2019), as well as means of express recovery of players after high muscular loads (Altavilla et al., 2018; Kokareva et al., 2018).

The development of an experimental program for planning training loads for the players of the FC "Zorya" – football team of the Premier League of the Ukrainian Championship – was based on taking into account the age characteristics of the athletes, the calendar of competitions, the initial level of integral readiness, the peculiarities of the dynamics of their physical condition, which were monitored and studied during the previous two sports seasons within the annual cycles of team training. It was based on the aim and task of the stage of maximum realization of individual capabilities, principles of sports training.

In the process of creating an experimental program, innovative fitness methods and corresponding training tools borrowed from health fitness were selected, refined, and adapted. In the training process in the first and second preparatory periods of the annual training cycle of FC “Zorya” in the UPL Championship 2019/20, mainly those physical exercises and their complexes that were characteristic of the specifics of the playing competitive activities of football players were used. Among such factors, first, the simultaneous active functioning of most or all large links of the support-motional apparatus and, mainly, aerobic support of muscle work are noted. In addition, the relatively significant total duration of work (from a few minutes to several tens of minutes) and moderate, high, and variable intensity of work (with the corresponding physiological power) made it possible to achieve a high cumulative effect of training.

The general features of training programs of previous years and the experimental program for planning the training loads of FC "Zorya" football players include the following: the total amount of training loads; a complex of traditional training tools, which was used in the training process of athletes (general developmental and acrobatic exercises, technical-tactical and integral training exercises); the number of games within the competitive periods of the annual training cycle; variable conditions for conducting training sessions on the football lawn and constant (same) conditions indoors; the same group of coaches who conducted the educational and training process with the athletes of FC "Zorya". To achieve the set tasks, 3 types of classes were used: individual, group, and team.

The differences between the training programs of previous years and the experimental program for planning the training loads of FC "Zorya" football players include: the duration of the preparatory and competitive periods of the annual training cycle (preparatory – from 4 to 6 weeks, competitive – 11-12 weeks); stretching and relaxation exercises, general and special physical exercises, special motor training; exercises involving innovative equipment and inventory, such as TRX/TRX-Rip, Strenflex, 6D Sliding, BOSU, MFR; innovative methods (Tabata, HIIT, MAX®, types of circuit training) based on which classes were built not only with the specified exercises and their corresponding equipment, but also with traditional, widely used exercises for all types of training of football players.

The results of our study are consistent with the data of Wagner (2000) and Diachenko, et al. (2021), regarding the features of changes in the level of physical working capacity and aerobic capabilities, physical and functional fitness of highly qualified football players within the framework of individual stages and periods of the annual macrocycle. Our studies have confirmed the effectiveness of training programs by increasing the volume and redistribution of physical loads within individual micro- and mesocycles (Gissis, 2012; Kostiukevych et al., 2019; Leibo et al., 2021), optimizing training and recovery modes (Cerrah et al., 2016), as well as using additional training tools (Modric, 2021).

Conclusions:

1. Studies have shown that the use of a traditional physical training program for highly qualified football players in the preparatory period of an annual macrocycle did not fully contribute to the improvement of their general level of fitness and its preservation during the competitive period. It was determined that at the end of both preparatory periods of the 2018/19 competitive season, physical capacity, aerobic capabilities, and functional fitness were at the "average" level. After the first and second competitive periods of the 2018/19 season, football players had a statistically significant decrease in their physical performance by 5.1% ($p<0.05$) and 11.8% ($p<0.001$), respectively.
2. An experimental program of physical training using innovative methods of fitness training was developed to increase the effectiveness of the training process of highly qualified football players basing on the results of the ascertaining experiment. The educational and training process of FC "Zorya" team in the first and second preparatory periods of the annual cycle of preparation for the 2019/20 season was built according to an experimental program.
3. According to the results of the formative experiment, at the end of both preparatory periods of the 2019/2020 season, there were statistically significantly better physical performance parameters of football players, compared to the corresponding periods of the 2018/2019 season, by 21.7% and 24.1% ($p<0.001$) and aerobic capabilities – by 13.7% ($p<0.001$) and 10.9% ($p<0.01$). At the end of the competitive periods of the 2019/2020 season, athletes had statistically significantly better values of physical working capacity by 24.2% and 30.6% ($p<0.001$) respectively, and aerobic capacity – by 15.8% and 15.9% ($p<0.001$).
4. The implementation of an experimental program using innovative means of fitness training innovative means in the training process of highly qualified football players of FC "Zorya" (Luhansk city) contributed to improving the level of their physical working capacity, functional readiness and achieving high sports results (bronze medals of the championship of the Ukrainian Premier League and entry to the UEFA Europe League),

which gives reason to recommend the developed program for practical use in the system of sports training of highly qualified football players.

Conflict of interests

The authors declare that there is no conflict of interest.

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