

Physical condition improvement in elite volleyball players

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Abstract.

Purpose: to substantiate scientifically the content of the program of planning training sessions and increase the level of functional and special physical condition of elite volleyballers. *Material:* The pedagogical study was attended by 14 elite female athletes specializing in volleyball. The study recorded indicators of functional and special physical condition. *Results:* The use of the proposed training program in the training process contributed to maintaining during the competitive period the optimal level of functional and special physical condition of female athletes: a significant ($p < 0,001$) decrease in their indicators by the end of the competitive period was only 3-15%, while using the traditional program was significantly higher (5-50%). After the competition period, all indicators of the athletes' special physical preparedness were in line with the average level. The level of functional preparedness of the surveyed female athletes at the end of the competition period was significantly ($p < 0,001$) reduced and considered as below average. *Conclusions:* While designing new programs for constructing a training process for elite athletes, it is necessary to take into account the dynamics of functional and special condition in individual microcycles, the nature of the correlation between the level of functional condition and its individual components, indicators of special physical preparedness and organization on the basis of this that enables purposeful management of the training process. It was determined that the use of volleyball players in the training process of our training program, which provided for the presence of competitive and corrective modules, dependence of their content on the results of pre-testing contributed to the maintenance of the optimal level of indicators of functional and special physical condition of female athletes throughout the competitive period.

Keywords: elite athletes, physical fitness, volleyball.

Introduction

The results of international competitions show that today there is a gradual decline in sports achievements of Ukrainian athletes specializing in game sports (Pomeschkova et al., 2013; Kozina et al., 2016). According to a number of specialists in the field of higher achievement sports, this problem is caused both by objective reasons (deterioration of material and technical base, decrease in funding, the number of high level teams in national championships, etc.) and a significant decrease in the efficiency of the training process of athletes.

This is primarily due to the lack of attention to the latest achievements in sports science. A considerable amount of research has been devoted to studying the problem of improving the training process in the system of training high-skilled athletes in various sports, including volleyball (Shlonska 2015; Kozina Korobeynikov et al., 2018; Korobeynikov et al., 2019). However, traditional tools, methods and technologies, used in the training process of high-level volleyball players can no longer provide a high degree of productivity of this process. In addition, the objective increase in the volume and intensity of training and competitive loads, which are necessary to achieve high sports results, is the basis for comprehensive and thorough scientific and methodological research in this direction (Tishchenko et al., 2016; Imas et al., 2018; Ivaskevych et al., 2020).

One of the most promising approaches to the practical solution of this problem is, according to scientists, the search for new ways of improving the special physical and functional preparedness of volleyball players at different stages of the annual training cycle, in particular, on the basis of the development of new training planning programs that take into account the peculiarities of the correlation dependence of the level functional preparedness of female athletes with its individual components and indicators of special physical preparedness (Leporace et al., 2013; Mischuk et al., 2014; Kostiukevych et al., 2018; Karaulova et al., 2018).

This approach can be one of the most effective means of optimizing the training process for high-qualification volleyball players, since there is a real possibility to create a comprehensive management system and to plan the optimal amount of training loads and to operationally control the adaptation process in female

athletes to training at different stages. (Sato et al., 2017; Trajković et al., 2017; Chernozub et al., 2018; Korobeynikov et al., 2019). All this becomes of great importance during the competitive period, when there is a significant impact of physical and psychological stress on the body of female athletes.

The analysis of scientific sources revealed only some aspects of this problem, for example, justification of the possibility of using for this purpose some components of volleyball players' functional preparedness (functional state of circulatory systems, external respiration, energy supply of muscular activity, etc. (Agostini et al., 2013; Boichuk et al., 2017; Gorelik et al., 2018).

Therefore, the development, testing and practical implementation of the experimental program of the training process planning in the competitive period in the work with the volleyball female players of high qualification, which was developed taking into account the peculiarities of the dynamics of the indicators of the special physical and functional preparedness of the athletes within this period, the nature of the interconnection of the level of interconnection of the level of function individual components and indicators of special preparedness and which contributes to the effectiveness of training process, determine the relevance and practical importance of the study.

Purpose: to substantiate scientifically the content of the program of planning training sessions and increase the level of functional and special physical condition of elite volleyballers.

Materials and methods

Study participants

In the pedagogical experiment 14 elite female athletes specializing in volleyball (women's volleyball team of the Ukrainian league "Orbita-ZNU", Zaporizhzhia) participated. Evaluation of the effectiveness of traditional and experimental training programs was conducted in the competitive period of two different competitive seasons (2017/2018 and 2018/2019, respectively, ascertaining and formative pedagogical experiment). The study recorded indicators of functional and special physical preparedness.

Organization of research

The following methods are applied in the work: analysis and generalization of scientific and methodical literature; pedagogical observations; pedagogical experiment; testing of functional and special physical fitness; methods of mathematical statistics.

The assessment of the level of functional condition of volleyball players and its individual components (maximal oxygen consumption, alactic and lactic power, alactic and lactic capacity, anaerobic metabolism threshold, heart rate at the anaerobic metabolism threshold, level of physical performance) was carried out using the computer program "SHVSM", which includes the use of bicycle ergometric submaximal PWC₁₇₀ test (Korobeynikov et al., 2006; Malikov et al., 2019).

Indicators of fitness (levels of development of jumping, speed, general speed, special acrobatic endurance, mobility in the shoulder joints, muscle strength of the arms, legs, abdomen and back) were determined using traditional tests designed for high-level volleyball players.

Statistical analysis

The research materials were processed using the standard SPSS 20 digital data processing package.

The Shapiro-Wilk test was used to determine the normality of the distribution of test results. The following parameters were calculated: arithmetic mean, standard deviation. The estimation of the significance of the difference in the statistical indicators was performed with the help of Student's t-criteria.

A correlation analysis was performed with the Pearson correlation coefficient (r) calculator.

Results

In the first stage of the study we evaluated the traditional program of building the training process of volleyball players in the competitive period of the 2017/2018 season (ascertaining experiment). It was proved that at the beginning of the competition period the examined volleyball players were characterized by an average level of functional preparedness and its individual indicators (Table 1). It should be noted that at the beginning of the competition period, female athletes showed above average levels of development of general, jumping, speed endurance, jumping, speed, special agility, leg strength, abdominal and back muscles. Only the strength of the arms and the mobility of the shoulder joints corresponded to the average level.

At the end of the competition period, all female athletes showed a significant ($p < 0,05$; $p < 0,001$) decrease in their level of physical performance, aerobic performance, alactic and lactic power, heart rate at the level of anaerobic metabolism threshold (AMT) to below average, and AMT values – to average. In addition, there was a significant ($p < 0,05$; $p < 0,001$) impairment of their special fitness, above all, of general and jumping endurance. Negative changes in the levels of development of flexion, strength of the legs, arms, muscles of the abdominal press and back were also significant, there was a significant deterioration in the speed endurance of the volleyball players examined, the speed, special agility and mobility of the shoulder joints.

After the competition period, all indicators of the athletes' special physical preparedness were in line with the average level. The level of functional preparedness of the surveyed female athletes at the end of the competition period was significantly ($p < 0,001$) reduced and considered as below average.

Table 1. Indicators of functional and special physical preparedness of the volleyball players (n=14) at the beginning and end of the competitive season 2017/2018 ($\bar{x} \pm S$)

Indicators	Start	Completion
Physical working capacity (PWC ₁₇₀), $\text{kg} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$	20,83±0,71 average	16,43±0,56*** below average
Maximal oxygen consumption, $\text{ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$	61,52±1,57 average	49,31±1,26*** below average
Alactic power, watt/kg	6,78±0,19 average	5,82±0,16*** average
Aalactic capacity, conditional units	38,55±1,03 average	31,76±0,85*** below average
Lactic power, watt/kg	5,05±0,15 average	4,27±0,13*** average
Lactic capacity, conditional units	28,62±0,83 average	21,84±0,63*** below average
Anaerobic metabolism threshold, % from aVO _{2max}	61,48±1,35 above average	51,52±1,13*** average
Heart rate, $\text{h} \cdot \text{min}^{-1}$	156,70±3,47 average	138,37±3,07*** low
Total endurance, sec	103,92±2,21 above average	133,58±2,74*** average
Jump endurance, the number of losses	5,92±0,40 above average	8,92±0,54*** average
High speed endurance, sec	24,76±0,21 above average	25,93±0,17*** average
Jumping, cm	60,83±0,84 above average	54,75±0,73*** average
Speed, sec	8,45±0,14 above average	8,95±0,08** average
Special agility, sec	3,38±0,02 above average	3,46±0,02* below average
Mobility of shoulder joints, conditional units	1,61±0,04 average	1,72±0,04 average
Leg strength, amount per 20 sec	17,50±0,45 above average	15,42±0,45** average
Arm strength, m	17,08±0,45 average	15,17±0,66* average
Muscles strength of abdominal and back, amount per 20 sec	6,67±0,50 above average	5,50±0,31 average
Level of functional preparedness, marks	75,66±3,73 average	62,34±3,54** below average

Note: * - $p < 0,05$; ** - $p < 0,01$; *** - $p < 0,001$ compared to the values recorded at the beginning of the experiment.

In order to determine the nature of the relationship between the level of functional preparedness of the examined female athletes with the values of its individual components and indicators of special physical preparedness in the framework of the ascertainment experiment, we also conducted a correlation analysis. The results showed that during the competitive period a strong correlation between the level of functional preparedness (LFP) of the examined volleyball players was recorded, with the indicators of special physical preparedness, aerobic performance and energy supply system of muscular activity, which reflect the state of aerobic and mixed aerobic and mixed aerobic and aerobic) of the body.

Table 2. Experimental program of planning training sessions in the competitive period of the annual cycle of training for women's volleyball team of higher qualification

Amount of loading, means of preparation and operation mode	The competition period					
	The first round of the Championship of Ukraine					
Amount of matches	Competition module -1	Adjustment module -1	Competition module -2	Adjustment module -2	Competition module -3	Adjustment module -3
Module duration, training days	4	-	4	-	4	-
Number of training sessions	4	-	4	-	4	-
Number of training hours	28	10	24	7	28	21
Developmental exercises, hours	35	14	35	11	38	48
Stretching, acrobatics, hours	61	30	66	22	70	99
Aerobics (special coordination (mixed mode, HR 140-170 $\text{h} \cdot \text{min}^{-1}$), hours	5,5	-1,3	5,85	-0,6	6,0	-0,5

Amount of background running training (uniform running, cross country; aerobic mode HR 130-150 h•min ⁻¹), hours	5,7	-1,6	6,75	-3,4	7,0	+1,6
Amount of special treadmill training in combined with elements of game technology (mixed mode, HR 145-185 h•min ⁻¹), hours	2,0	0	0	+4,5	0	+4
Athleticism: Special Strength and Speed-power (mixed mode, HR 145-185 h•min ⁻¹), hours	0	+6,7	0	+3,4	0	+10,1
Swimming, relay & water games (aerobic mode, HR 130-160 h•min ⁻¹), hours	2,8	+2,1	2,9	-0,3	2,0	+2,7
Scope of technical training: innings, assists, strikes, blocking (mixed mode, HR 135-170 h•min ⁻¹), hours	1,5	+0,8	1,5	0	2,0	0
Tactical training: individual, group, team (ЧСС 135-165 h•min ⁻¹), hours	1,0	+1,7	0	+4,5	2,0	0
Volume of integrated training (mixed mode, HR 150-190 h•min ⁻¹), hours	4,12	+6,5	9,0	0	6,0	+1,5
Amount of game training (mixed mode), HR 150-190 h•min ⁻¹), hours	10,38	-3,6	10,0	+3	10,0	-4,2
Testing preparation	17,0	+2,8	18,5	-2,8	24,0	-5,9
Amount of matches	10,0	-13,1	10,5	-6,8	10,0	-8,1
Module duration, training days	1,0	0	1,0	0	1,0	

The values of the correlation coefficients of the LFP with the values in rPWC₁₇₀ were 0,68-0,72; rVO_{2max} – 0,65-0,71, LACp – 0,61-0,62; LACc – 0,62-0,64; AMT - 0,61-0,62; HR – 0,60-0,64; with the level of general endurance - 0,63-0,69; jumping endurance – 0,62-0,67; speed endurance - 0,61-0,62; leverage – 0,61-0,64, arm strength – 0,60-0,62. As a whole, the results of the ascertainment experiment indicated that the traditional program of constructing the training process in the competitive period was not effective and that it needed to be corrected during this period of the annual training cycle.

The development of the experimental program was carried out on the basis of the program of training sessions generally accepted in the Orbita-ZNU team during this period of the training process, and its principles of the conformity of the volleyball players, the continuity and continuity of training for the age characteristics of volleyball players, the continuity and cyclicity of the training process, the gradual increase in loading, included in the program of sports training, were laid in its basis as well as the principle of modular construction of the training process in the competitive period, taking into account the specifics of the construction of the competitive period or competition calendar (Table 2). In accordance with the mentioned principles, the entire program of training sessions for high-qualification volleyball players during the competition period was presented in the form of 8 competitive (CmM) and 7 corrective (CrM) modules.

Continuation of **Table 2**

Amount of loading, means of preparation and operation mode	The competition period					
	The second round of the Championship of Ukraine					
Amount of matches	Competition module -1	Adjustment module -1	Competition module -2	Adjustment module -2	Competition module -3	Adjustment module -3
Module duration, training days	4	-	4	-	4	-
Number of training sessions	28	10	24	7	28	21
Number of training hours	35	14	35	11	38	48
Developmental exercises, hours	61	30	66	22	70	99
Stretching, acrobatics, hours						

Aerobics (special coordination (mixed mode, HR 140-170 h•min ⁻¹), hours	5,5	-1,3	5,85	-0,6	6,0	-0,5
Amount of background running training (uniform running, cross country; aerobic mode HR130-150h•min ⁻¹), hours	5,7	-1,6	6,75	-3,4	7,0	+1,6
Amount of special treadmill training in combined with elements of game technology (mixed mode,HR 145-185 h•min ⁻¹), hours	2,0	0	0	+4,5	0	+4
Athleticism: Special Strength and Speed-power (mixed mode,HR 145-185 h•min ⁻¹), hours	0	+6,7	0	+3,4	0	+10,1
Swimming, relay & water games (aerobic mode,HR 130-160 h•min ⁻¹), hours	2,8	+2,1	2,9	-0,3	2,0	+2,7
Scope of technical training: innings, assists, strikes, blocking (mixed mode, HR 135-170 h•min ⁻¹), hours	1,5	+0,8	1,5	0	2,0	0
Tactical training: individual, group, team (ЧСС 135-165 h•min ⁻¹), hours	1,0	+1,7	0	+4,5	2,0	0
Volume of integrated training (mixed mode, HR 150-190 h•min ⁻¹), hours	4,12	+6,5	9,0	0	6,0	+1,5
Amount of game training (mixed mode), HR 150-190 h•min ⁻¹), hours	10,38	-3,6	10,0	+3	10,0	-4,2
Testing preparation	17,0	+2,8	18,5	-2,8	24,0	-5,9
Amount of matches	10,0	-13,1	10,5	-6,8	10,0	-8,1
Module duration, training days	1,0	0	1,0	0	1,0	

Competition modules consisted of 4-6 official matches. The duration of the corrective modules ranged from 7 to 21 days. The total duration of the competition was 8 months, during which 34 official matches were played. Changes in the amount of physical activity within the framework of the correction modules are shown in Table 2 as a percentage of the absolute values of the data of the load in the previous competition module. In the first round of the Championship were allocated 3 competitive modules (Cm-1 – Cm-3), in the second – 4 (Cm-4 – Cm-7), and one module (Cm-8) corresponded to the playoff games.

The distribution of corrective modules was as follows: 3 corrective modules were allocated in the first round of the Championship (Cr-1 – Cr-3), four modules (Cr-4 – Cr-7) in the second round. A play-off corrective module was not anticipated.

The main structural elements of the proposed program were special-preparatory, special exercises, means of general physical training.

The traditional and experimental programs of volleyball players' training sessions had the following similar characteristics: the training sessions were conducted in the same conditions (play hall and university stadium); the level of competitive activity of volleyball players was the same (Super League of Ukrainian Championship); training sessions with volleyball players were conducted by the same coaches; functional and special fitness testing was conducted by one group of researchers.

Table 3. Indicators of functional and special physical preparedness of the volleyball players of the experimental group (n=14) at the beginning and at the end of the competitive period of the 2018/2019 season ($\bar{x} \pm S$)

Indicators	Start	Completion
Physical working capacity (PWC ₁₇₀), kgm•min ⁻¹ •kg ⁻¹	20,46±0,69	19,08±0,65
Maximal oxygen consumption, ml•min ⁻¹ •kg ⁻¹	59,77±1,53	56,71±1,45
Alactic power, vatt/kg	6,97±0,19	6,54±0,18
Aalactic capacity, conditional units	39,75±1,07	42,97±1,15*

Lactic power, vatt/kg	4,84±0,15	4,57±0,14
Lactic capacity, conditional units	28,1±0,82	27,23±0,79
Anaerobic metabolism threshold, % from aVO _{2max}	63,28±1,39	59,03±1,3*
Heart rate, h•min ⁻¹	160,1±3,55	151,79±3,37
Total endurance, sec	108,17±3,17	120,17±1,80***
Jump endurance, the number of losses	6,17±0,53	7,08±0,36
High speed endurance, sec	24,93±0,15	25,46±0,14*
Jumping, cm	59,92±1,07	57,92±0,71
Speed, sec	8,64±0,12	8,58±0,05
Special agility, sec	3,41±0,02	3,47±0,02*
Mobility of shoulder joints, conditional units	1,67±0,03	1,70±0,02
Leg strength, amount per 20 sec	16,75±0,46	16,67±0,28
Arm strength, m	16,25±0,35	16,67±0,31
Muscles strength of abdominal and back, amount per 20 sec	6,75±0,41	6,75±0,25
Level of functional preparedness, marks	72,39±3,41	68,42±3,07

Note: * - $p < 0,05$; *** - $p < 0,001$ compared to the values recorded at the beginning of the experiment.

For the purpose of experimental evaluation of the effectiveness of our training program planning, we studied the peculiarities of the dynamics of the level of special physical and functional preparedness of high-qualification volleyball players in the competitive period of the annual cycle of the 2018/2019 competitive season (forming experiment). Testing of volleyball female players at the beginning of the forming experiment allowed to establish the absence of significant ($p > 0,05$) differences in all analyzed indicators at the beginning of the competitive period of two different seasons (2017/2018 and 2018/2019). The results obtained during the forming experiment showed that at the end of the competitive season athletes had a slight (by 3-7%; $p > 0,05$) natural decrease in their overall physical performance, aerobic performance, alactate and lactate capacity, lactate heart rate and heart rate at the AMT level (Table 3). Note that no qualitative changes in these indicators were observed. The changes in the parameters of the special physical preparedness of the volleyball players of the experimental group were similar. After the end of the competition period, female athletes showed a significant ($p < 0,05$) decrease in only general, high-speed endurance and special agility. Changes in other indicators of the special preparedness of the examined volleyball players were insignificant and unreliable (from 0.2% to 3%). Qualitative changes in practically all indicators of special preparedness, except for the level of jumping endurance, were not observed after the end of the competition period of the second stage of the experiment.

A convincing confirmation of the high degree of effectiveness of our training program planning program was the results of a comparative analysis of volleyball players' testing data conducted at the end of the first and second stages of the experiment (Table 4).

Table 4. Indicators of functional and special physical preparedness of volleyball players after the first and second stages of the experiment ($\bar{x} \pm S$)

Indicators	After the first stage of the experiment	After the second stage of the experiment
Physical working capacity (PWC ₁₇₀), kg•min ⁻¹ •kg ⁻¹	16,72±0,57	19,08±0,65**
Maximal oxygen consumption, ml•min ⁻¹ •kg ⁻¹	50,21±1,28	56,71±1,45**
Alactic power, vatt/kg	5,90±0,16	6,54±0,18*
Aalactic capacity, conditional units	32,24±0,86	42,97±1,15***
Lactic power, vatt/kg	4,34±0,13	4,57±0,14
Lactic capacity, conditional units	21,52±0,63	27,23±0,79***
Anaerobic metabolism threshold, % from aVO _{2max}	50,95±1,12	59,03±1,3***
Heart rate, h•min ⁻¹	136,14±3,02	151,79±3,37***
Total endurance, sec	135±2,24	120,17±1,8***
Jump endurance, the number of losses	9,08±0,66	7,08±0,36**

High speed endurance, sec	25,65±0,29	25,46±0,14
Jumping, cm	55,08±0,93	57,92±0,71*
Speed, sec	8,89±0,11	8,58±0,05**
Special agility, sec	3,49±0,02	3,47±0,02
Mobility of shoulder joints, conditional units	1,73±0,03	1,70±0,02
Leg strength, amount per 20 sec	15,5±0,48	16,67±0,28*
Arm strength, m	15,42±0,48	16,67±0,31*
Muscles strength of abdominal and back, amount per 20 sec	5,83±0,3	6,75±0,25*
Level of functional preparedness, marks	57,88±3,21	68,42±3,07*

Note: * - $p < 0,05$; ** - $p < 0,01$; *** - $p < 0,001$ compared to the values at the end of the first stage of the experiment.

It is proved that at the end of the second stage of the experiment volleyball players were significantly ($p < 0,05$; $0,01$; $0,001$) higher than at the end of the first stage, the values of practically all indicators of their functional and special physical preparedness.

In general, the obtained data indicate that the use of high qualification volleyball players in the training process during the training period helps to maintain the optimal level of their special physical and functional readiness during the competition period, which significantly improves the effectiveness of the training process. A significant confirmation of this conclusion was the improvement of sports results of the examined volleyball players: from the 4th place of the 2017/2018 season to the silver medals of the 2018/2019 season.

This gives reason to recommend the developed program for practical use in the system of sports training of volleyball players at the stage of maximum realization of individual opportunities.

Discussion

In the work a comparative analysis of the effectiveness of different programs of training process of volleyball players of high qualification in the competitive period of the annual macrocycle is made.

The obtained results supplement the data of scientists on the peculiarities of the dynamics of indicators of functional and special preparedness of athletes specializing in volleyball within the competitive period of the annual training cycle (Kozina et al., 2018; Imas et al., 2018, Boichuk et al., 2019).

The analysis of experimental data allowed us to determine the peculiarities of the correlation dependence of the level of functional fitness of female athletes with its individual components and parameters of special physical fitness, which were taken into account in the development of the experimental program of training sessions, which confirms the data of other authors (Leporace et al., 2013; Mahedero et al., 2015; Kozina et al., 2017; Valeria et al., 2017) on the important role of the use of high-qualification volleyball players in the training process adequate facilities, methods and workloads aimed at improving their fitness and athletic skills.

Comparative analysis of the results of the study confirmed that the use of physical activity in the training process, which corresponds to the current functional state of athletes, significantly increases the efficiency of training sessions and maintain the optimal level of their functional and special physical fitness throughout the competitive season.

Conclusions

The analysis of the scientific and methodological literature on the problem of research has revealed that one of the most promising ways of improving the efficiency of the training process of athletes at the stage of maximum realization of individual opportunities is the use of purposeful actions that contribute to the formation of the optimal structure of the physical state of the organism necessary to ensure a high level of special physical and functional fitness and high athletic performance.

It is substantiated that the issue of development and experimental testing of new training programs planning programs for athletes specializing in sports games, in particular in women's volleyball, at different stages of the annual cycle of sports training is urgent.

It was determined that the use of high-qualification volleyball players in the competitive cycle of the training program of the experimental training planning program during the competitive period helped to substantially optimize the level of their special physical and functional fitness.

Conflict of interests

The authors declare no conflict of interest.

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