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# THE PECULIARITIES AND DYNAMICS OF FUNCTIONAL STATE OF QUALIFIED HANDBALL PLAYERS DURING THE ANNUAL MACROCYCLE

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Longitudinal studies have focused on the characteristics and features of the functional state of the cardiovascular system, autonomic regulation, physical capacity and energy supply muscular activity qualified handball players Super League of Ukraine. As part of our research to determine the level of the functional state of the highly qualified handball

players and its individual components new computer program express-diagnosis "Handball Functional" has been used, which is designed to identify and assess the functional state of the leading physiological systems (cardiovascular system, autonomic balance, physical capacity and energy supply muscular activity) of the body athletes, level of fitness, sports qualification and specialization. The proposed program of authors' "Handball functional" form of interpretation of the functional state of the test data can significantly facilitate its analysis of the immediate aftermath of the control testing, and the use of functions provided by the program "Archive", is possible to analyze the dynamics of the individual. Indicators of cardiovascular system and its dynamics during the entire test period indicate maintaining a high level of hemodynamics. At the end of the study there is a hyperkinetic syndrome, that is a sign of a lack of tools, which can not maintain optimal control of cardio - vascular system, but can improve its performance. Maintaining a high level of vegetative homeostasis indicates a certain level of productivity of the athletes, sufficient to maintain high potential sympathetic-adrenal, and to overcome the fatigue processes. The findings suggest the need to find means and methods, which will help to adjust and optimize the performance of athletes at the most efficient level at the right time of the competition.

*Key words: handball, functional fitness, cardiovascular system, autonomic balance.*

## ОСОБЛИВОСТІ І ДИНАМІКА ФУНКЦІОНАЛЬНОГО СТАНУ КВАЛІФІКОВАНИХ ГАНДБОЛІСТІВ ПРОТЯГОМ РІЧНОГО МАКРОЦИКЛ

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Лонгітудинальне дослідження присвячено вивченню характеристик і особливостей функціональної підготовленості кваліфікованих гандболістів суперліги України. У межах нашого дослідження для визначення рівня підготовленості спортсменів і її окремих компонентів була використана нова комп'ютерна програма експрес-діагностики «Handball functional», призначена для визначення та оцінки функціонального стану провідних фізіологічних систем (вегетативної рівноваги, серцево-судинної системи, фізичної працездатності та енергетичного забезпечення м'язової діяльності) організму, рівня тренованості, спортивної кваліфікації і спеціалізації. Показники серцево-судинної системи і її динаміка протягом усього періоду тестування вказують на підтримку високого рівня гемодинаміки. У кінці дослідження виникає гіперкінетичний синдром, що є ознакою відсутності інструментів, які не можуть підтримувати оптимальне регулювання серцево-судинної системи, але можуть підвищити працездатність. Підтримка високого рівня вегетативного гомеостазу вказує на певний рівень продуктивності спортсменів, який є достатнім для підтримки високого потенціалу системи симпато-наднирників і для подолання процесів втоми. Отримані дані свідчать про необхідність пошуку засобів і методів, які допоможуть коригувати і оптимізувати робочі характеристики спортсменів на найефективнішому рівні в потрібний період змагань. Одними з важливих умов для успішної роботи спортсмена є підготовка відповідної навчально-тренувальної програми, яка зможе допомогти покращити функціональну продуктивність гандболістів та є інтегрованою характеристикою в контексті дієвості проведених заходів, що бере участь у впровадженні систем відповідно до критеріїв надійності і внутрішньої ціни.

*Ключові слова: гандбол, функціональна підготовленість, серцево-судинна система, вегетативна рівновага.*

## ОСОБЕННОСТИ И ДИНАМИКА ФУНКЦИОНАЛЬНОГО СОСТОЯНИЯ КВАЛИФИЦИРОВАННЫХ ГАНДБОЛИСТОВ НА ПРОТЯЖЕНИИ ГОДОВОГО МАКРОЦИКЛА

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Лонгитудинальное исследование посвящено изучению характеристик и особенностей функциональной подготовленности квалифицированных гандболистов суперлиги Украины. В рамках нашего исследования для определения уровня функционального состояния гандболистов высокой квалификации и ее отдельных компонентов была использована новая компьютерная программа экспресс-диагностики «Handball functional», которая предназначена для определения и оценки функционального состояния ведущих физиологических систем (сердечно-сосудистой системы, вегетативного равновесия, физической работоспособности и энергетического обеспечения мышечной деятельности) организма спортсменов, уровня тренированности, спортивной квалификации и специализации. Показатели сердечно-сосудистой системы и ее динамика в течение всего периода тестирования указывают на поддержание высокого уровня гемодинамики. В конце исследования возникает гиперкинетический синдром, что является признаком отсутствия инструментов, которые не могут поддерживать оптимальное регулирование сердечно-сосудистой системы, но могут повысить его

работоспособность. Поддержание высокого уровня вегетативного гомеостаза указывает на определенный уровень продуктивности спортсменов, достаточный для поддержания высокого потенциала системы симпато-надпочечников и для преодоления процессов утомления. Полученные данные свидетельствуют о необходимости поиска средств и методов, которые помогут корректировать и оптимизировать рабочие характеристики спортсменов на самом эффективном уровне в нужный период соревнований. Одними из важных условий для успешной работы спортсмена являются подготовка соответствующей учебной программы, которая может помочь улучшить функциональную подготовленность гандболистов, являющейся интегрированной характеристикой в контексте действенности проводимых мероприятий и участвующей во внедрении систем в соответствии с критериями надежности и внутренней цены.
*Ключевые слова: гандбол, функциональная подготовленность, сердечно-сосудистая система, вегетативное равновесие.*

## INTRODUCTION

Modern handball − a sport with a high intensity motor actions in the interaction of explosive speed and power, with the quick change of game situations that require instant solutions, with a wide variety of methods used, the ability to sprint, acceleration, a sharp change in the direction of motion [10]. This requires a high level of development of physical qualities and skillful their implementation during competitive activity [2, 8]. Handball has specific requirements that must be the practical application of research results. Moreover, it requires control of the preparation and analysis of the training process. Thus, knowing the physiological needs of handball, you can improve specific skills that define anaerobic and aerobic systems [9, 10, 15].

In professional sports, including handball, the whole management organization is working to achieve high quality of sportsmen. That requires correctly planed rational distribution of training facilities as well as a right developed training of micro-, meso-, macrocycles preparation throughout one training process **[**6, 12]. Additionally, it depends on the transition from organization to realization of the training session, nutrition, recovery system and regular events aimed to assessing the readiness of the various party athletes (operative, current, stage control) **[**14].

Scientific and methodological support of high-class athletes is an important factor to increase the efficiency of the system of training in handball. Currently, one of the main directions of research in handball is to improve the assessment of the physical condition, including the assessment of physical fitness, functional state of the main systems of the body, and the psychological trained athletes. Nevertheless, we cannot be limited to the assessment of the physical state at the present stage of development of the theory and methods of preparation in handball. It is no longer enough to manage the training process of athletes of high level that encourages the search for new solutions to the problem of forecasting performance results. Experience has shown that it is necessary to assess the physical condition of the handball players that must include necessary testing, such as group of physical exercises, previously compiled, tested, informative, reliable, with which you can determine not only the level of development of various motor skills and abilities, monitoring the functional state of cardiovascular and autonomic nervous systems of the body but psychological state as well [3, 11].

These methods can be widen if we analyze the level of function of myocardial, vascular, respiratory, sensory-motor, autonomic nervous system and other important given the integral index of the cardio-vascular system, describing the central hemo-dynamics. Typically, sports practice parameters are calculated because the use of instrumental methods during ongoing researches significantly complicates them. Therefore, the development of new approaches to the assessment of central hemo-dynamics has unquestionable importance for the further improvement of medical control. This is due to operational decision-making that need to improve sports selection, planning training loads, determine the degree of fatigue and predicting possible failure of adaptation [1, 5]. Additionally, the study of regulatory mechanisms influence spontaneous and controlled breathing on cardio-vascular activity can play a key role in determining the adaptive capacity of an athlete.

Monitoring HR of handball players is very important component as well. Heart Rate − sensitive indicator of regulatory influences the central nervous reference system. Reflecting influences of the environment in the afferent signals are refracted at cortical, subcortical and spinal levels efferent

autonomic impulses and humoral-metabolic activity, respond subtle variability of HR, giving the latter a high prognostic informative. HR can be changed in afferent signals depending on environmental factor is refracted at cortical, subcortical and spinal levels efferent autonomic impulses and humoral-metabolic activity. The study of neurohumoral regulation as an independent component affecting the physical state of handball players and largely limiting performance [13]. That defines the fundamental purpose of the analysis. Further, HRV was analyzed in handball and claimed that HRV can provide valuable data regarding a modulatory influence of the autonomic nervous system (ANS) on the sinus node. Clinical medicine and sport are using HRV as the prognostic value. Therefore, to evaluate the activity of the same node, HRV can be used. Non-invasive information regarding ANS, evaluating the changes in the sympathetic and parasympathetic systems at the sinus node level are provided by HRV.

Biomedical support of sports activity is very important today. Track and field and other endurance sports, which include handball, differ from other kinds of sport due to quick movements and very heavy motor activity. There is no doubt that the main functional systems that provide activity during work-out sessions and competitions include central nervous system, peripheral nervous system and locomotive system. Demand for study of psychophysiological, vegetative, physical qualities of individual players and the team as a whole is rather strong, and different studies help to organize and optimize these qualities at different stages. At the same time, the fragmentation of such studies and researches, carried out using different methods, involving athletes of different types and using different functional parameters at random stages of sporting activities do not give an opportunity to make a proper evaluation of dynamics of changes of athletes fitness shape within a big timeframe, and respectively, prevents from making adjustments of work-out sessions at different stages.

Cardiorespiratory system is a system that is responsible for energy requirements, especially during short breaks not connected with game activity. This question requires deeper research, and that is why the determination of the features of fitness shape of cardiorespiratory system of top players is of particular relevance. Given the above, we have proposed to carry out the longitudinal study of the dynamics of physiological parameters of qualified handball players during the annual macrocycle [2].

Ultimate work and competition loads of modern sport lead to dyscrasia and significant adaptive changes. Taking into account this fact it is important to provide constant control of athlete’s fitness shape. Fitness shape evaluation is a rather complicated process that requires thorough medical examination of body organs and systems. Great attention was paid to cardiac rhythm investigation during the last decades, especially during adaptation periods to work and competition stresses. Increase of sympathetic regulation during physical and emotional overworks leads to the decrease of adaptive abilities and affects the cardiac rhythm characteristics in state of reference [4]. Rhythm and heart force are very sensitive to any stress. They contain data about the state of regulatory and adaptive abilities of organism, and force increase depend on the increase of parasympathetic regulation link during work-out session.

Investigating the indicators of HRV within the dynamics of annual cycle and the effectiveness of competitions activity of highly qualified handball players, it was determined that at final stage of competitions the objects of control showed the worsening of vegetative regulation of heart rate. It indicates that the players have accumulated a significant uncorrected fatigue that becomes stronger by the end of specific period and is accompanied by a decrease in efficiency during the games. It concerns both individual athletes and a team as a whole [7].

## PURPOSE, MATERIAL, METHODS

The purpose of the study was to examine the peculiarities and dynamics of functional state of highly qualified handball players during the annual macrocycle. In accordance with the purpose of the following tasks:

1. To study the characteristics and dynamics of physical capacity and energy of highly qualified handball players during the annual macrocycle.

2. To study the characteristics and dynamics of the indicators of the cardiovascular system and functional state of highly qualified handball players during the annual macrocycle.

3. To study the characteristics and dynamics of autonomic regulation of qualified handball players during the annual macrocycle.

The studies were carried out during an annual training and competition macrocycle at the start and at the end of pre-season, and at the start and at the end of contest season as well. Subjects: qualified handball players of Superliga Ukraine in the age of 18-32 were involved in study.

The study was approved by the local research ethics committee, performed in accordance with the ethical standards of the journal IJSM and conformed to the recommendations of the Declarations of Helsinki. Handball players gave voluntary written informed consent to participate in the experiment.

At all specified stages of experiment the following indicators characterizing the level of overall physical efficiency and body energy security (aPWC$_{170}$, kgm/min; rPWC$_{170}$, kgm/min/kg), absolute (aMOC, l/min) and relative maximal oxygen consumption (rMOC, l/min/kg), lactate (N lac, vt/kg) and alactate (N alac, vt/kg) power were registered by the athletes with help of cycle ergometer test PWC$_{170}$.

The study of central hemodynamics was performed using tetrapolar impedance plethysmography method. The researchers determined volumetric datum of central circulation: stroke and minute blood volume (SBV, ml; MBV, l/min). The tests were conducted in laboratory conditions in a state of relative rest and seated. Heart rate (HR, bpm) was calculated on the basis of ECG record; systolic (SAP) and diastolic arterial pressure (DAP) was determined using Korotkov auscultatory method; mean arterial pressure (APmean) was determined by formula: APmean= DAP + 0,42 x APpulse.

Method of evaluation of functional status of cardiovascular system, designed to asset the degree of stress of regulatory mechanisms of blood circulatory system, allows you to evaluate the stress of regulatory mechanisms of cardiovascular system, which is fairly considered by the scientists as the main indicator of the body's response to exposure to various stresses. Heart rate variability was assessed to determine the state of vegetative homeostasis. The following indicators were calculated: mode (Mo, s), mode amplitude (AMo, %), variation range (dRR, ms), standard deviation of full massive of RR intervals standard deviation of normal-to-normal intervals (SDNN, ms), index of tension of regulatory systems (IT, c.u.). The tests were conducted in laboratory conditions at rest in prone position during 5 minutes procedure.

As part of our research to determine the level of the functional state of the highly qualified handball players and its individual components new computer program express-diagnosis "Handball Functional" has been used, which is designed to identify and assess the functional state of the leading physiological systems (cardiovascular system, autonomic balance, physical capacity and energy supply muscular activity) of the body athletes, level of fitness, sports qualification and specialization. The proposed program of authors' "Handball functional" form of interpretation of the functional state of the test data can significantly facilitate its analysis of the immediate aftermath of the control testing, and the use of functions provided by the program "Archive", is possible to analyze the dynamics of the individual.

To reveal the factor structure of the functional state of the qualified handball players, we use factor analysis of indicators using the computer program SPSS 16. Initial data for carrying out of factor analysis were indicators of qualified handball players registered for the annual macrocycle.

## RESULTS

Diagnostic results at the start of pre-season show average and below average levels of indicators of overall physical efficiency, and stamina of athletes for this kind of sport. At the end of the preparatory period, there was a significant increase in the level PWC$_{170}$, (25%), both absolute (aPWC170) ($P<0,01$), and relative (rPWC170) ($P<0,001$) compared with the initial values (table 1).

Table 1 – Indicators of functional readiness from highly qualified handball players in the research stages ( $\overline{X} \pm m$ )

| Indicators | STAGES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | BPP | EPP | T BPP-EPP, P | BCP | ECP | T BCP-ECP, P | T BPP-BCP, P | T EPP-BCP, P | T EPP-ECP, P |
| aPWC170, kgm/min | 1324,12 ± 64,36 | 1658,72± 74,52** | 3,40 P<0,01 | 1799,28 ± 64,16*** | 1652,52± 74,28 | 1,50 P>0,05 | 5,23 P<0,001 | 1,43 P>0,05 | 0,06 P>0,05 |
| rPWC170, kgm/min/kg | 14,11±0,47 | 17,68± 0,38*** | 5,91 P<0,001 | 19,18 ± 1,22** | 17,61± 0,31 | 1,25 P>0,05 | 3,88 P<0,01 | 1,17 P>0,05 | 0,14 P>0,05 |
| aMOC, l/min | 4,24±0,21 | 4,66± 0,75 | 0,54 P>0,05 | 4,82 ± 0,28 | 4,78± 18,96 | 0,00 P>0,05 | 1,66 | 0,2 P>0,050 | 0,01 P>0,05 |
| rMOC, l/min/kg | 45,20 ±2,26 | 49,68± 1,86 | 1,53 P>0,05 | 51,39 ± 1,42* | 50,96± 1,26 | 0,2 P>0,053 | 2,32 P<0,05 | 0,73 P>0,05 | 0,57 P>0,05 |
| N алак, vt/kg | 2,38 ± 0,21 | 3,11± 0,46 | 1,44 P>0,05 | 3,80 ± 0,54* | 3,62± 1,18 | 0,14 P>0,05 | 2,45 P<0,05 | 0,97 P>0,05 | 0,40 P>0,05 |
| N лак, vt/kg | 2,84 ± 0,15 | 3,25± 0,52 | 0,76 P>0,05 | 3,67 ± 0,22** | 3,52± 0,76 | 0,19 P>0,05 | 3,12 P<0,01 | 0,74 P>0,05 | 0,29 P>0,05 |

Note: BPP - the beginning of the preparation period; EPP- the end of the preparation period; BCP- the beginning of the competition period; ECP - the end of the competition period; * - P<0,05; ** - P<0,01; *** - P<0,001

Thus, the absolute value of $PWC_{170}$ preparation period to the beginning and the end of the competition period is increased. Changes in overall physical health be correct not only from the beginning to the end of the preparation period, but from the beginning of the preparation period to the beginning of the competition period P<0,001 (t=5,23) values for $aPWC_{170}$ and P<0,01 (t=3,88) values for $rPWC_{170}$.MOC level tended to increase (на 10%) that was not statistically reliable statistically significant indicator of character for aMOC and for rMCS celebrated its significant increase (P<0,05) to the top of the competitive period. Anaerobic energy supply defined in tests as alactic (N alac) and lactic (N lac) power has been growing considerably during the whole pre-season and by the end of pre-season the growth of these indicators was 31% and 14% correspondingly. At the same time, a reliable character to improve these indicators was observed at the beginning of the competitive period compared to the beginning of the preparation period for creatine-phosphate power (P<0,05; t=2,45) and for N lac (P<0,01; t=3,12). A statistically significant improvement of absolute values of almost all functional parameters that characterize the level of physical efficiency, aerobic endurance and energy supply for muscle activity was observed by the start of contest season. At the same time the most significant changes have been noticed in respect to parameters characterizing anaerobic, specifically for handball, and endurance of team players. Significant increase has been seen as for indicators of anaerobic alactic (on 60%, (P<0,05)) and lactic (on 29%, (P<0,01)) power.

The analysis of central hemodynamic parameters at start of pre-season indicated the matching of system arterial level with standard indicators. Normocardia and volume indices of central hemodynamics (SBV, ml; MBV, l/min) are within the upper limits of age and physiological norms. Arterial pressure behavior throughout the study does not seem to be statistically reliable, but it shows a clear tendency to decrease of all indicators from the start of pre-season to the start of contest season as well as stabilization of these figures (SAP, DAP, APmean) until the end of the contest season, which corresponds to available reference datum. It was confirmed that there was a faster growth of anaerobic endurance combined with significant positive changes of their overall physical performance and aerobic endurance (tabl.2).

Table 2 – Indicators of the central circulatory highly qualified handball players in the research stages ( $\overline{X} \pm m$ )

| Indicators | STAGES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | BPP | EPP | T BPP - EPP, P | BCP | ECP | T BCP- ECP, P | T BPP - BCP, P | T EPP - BCP, P | T EPP - ECP, P |
| SAP, mm hg.art. | 124,5±8,56 | 120,7±12,06 | 0,26 P>0,05 | 118,4±9,62 | 118,2±10,28 | 0,01 P>0,05 | 0,47 P>0,05 | 0,15 P>0,05 | 0,16 P>0,05 |
| DAP, mm hg.art. | 85,12±6,48 | 78,08±7,82 | 0,69 P>0,05 | 76,52±6,56 | 75,94±7,64 | 0,06 P>0,05 | 0,93 P>0,05 | 0,15 P>0,05 | 0,20 P>0,05 |
| APmean, mm hg.art. | 101,66±8,32 | 95,98±6,12 | 0,55 P>0,05 | 94,11±7,24 | 93,69±6,4 | 0,04 P>0,05 | 0,68 P>0,05 | 0,20 P>0,05 | 0,26 P>0,05 |
| HR, bpm | 68,5±1,64 | 62,5±2,04* | 2,29 P<0,05 | 56,8±1,84*** | 58,4±1,62 | 0,65 P>0,05 | 4,75 P<0,001 | 2,07 P<0,05 | 1,57 P>0,05 |
| MBV, l/min | 5,88±1,17 | 5,39±1,23 | 0,29 P>0,05 | 4,68±1,12 | 5,13±1,08 | 0,29 P>0,05 | 0,74 P>0,05 | 0,43 P>0,05 | 0,16 P>0,05 |
| SBV, ml | 85,84±12,16 | 86,28±16,52 | 0,02 P>0,05 | 82,34±14,27 | 87,88±18,46 | 0,24 P>0,05 | 0,19 P>0,05 | 0,18 P>0,05 | 0,06 P>0,05 |

Note: BPP - the beginning of the preparation period; EPP- the end of the preparation period; BCP- the beginning of the competition period; ECP - the end of the competition period; * - P<0,05; *** - P<0,001

Chronotropic heart function was significantly reducing by the end of pre-season (on 9%, P<0,05), and by the start of contest season it shifted to the mode of functional sports bradycardia – decrease in heart rate compared to the start of pre-season by 17% (P<0,01), followed by stabilization till the end of the contest season. It was registered that 50% of handball players have high level of myocard capacity. As for the myocard metabolic reserve had no low indicators. The relative myocard metabolic reserve indicator was at normal lever by 97% of handball players.

Reduction of minute blood volume (MBV) can be treated as optimization of volume central hemodynamics, intense economization of myocard performance under the influence of correct training program. It is known that too high MBV gives so-called “volume load”, that loads the heart above the norm, reduces blood flow velocity and normal hemodynamic functioning of the body. The tendency to its increase by the end of contest season along with performance decrement is interrelated. By the start of contest season there was steady although no significant decrease of stroke volume. Increase of stroke volume by the end of contest season to the level of pre-season had no significant nature either. Minute blood volume behavior was of the same nature as stroke volume behavior, which indicated the economization in vascular blood circulation. Increased SBV by the end of the competition period to the level of the preparation period was not significant. Dynamics of changes in indicators MBV had similar changes in SBV, the character that pointed to economization link in the vascular circulation. Electrocardiographic parameters of cardiac output were rated as 4, based on five-grade scale at the moment of examination. This indicated the absence of maximum values. Single arrhythmias due to dysfunction of automatism were defined. These arrhythmias were often observed during the pre-season, and during the contest season they were connected with dysfunction of transition. The analysis of heart rate variability at start of pre-season indicates the balanced regulatory vegetative mechanisms and reflects a high degree of centralization of heart rate regulation.

Currently the heart rate variability test becomes very popular during cardiological tests. This test is based on determination of sequence of RR intervals on electrocardiogram. This method allows you to get information about the impact of vegetative nervous system and a number of humoral and reflex factors on heart performance. The heart rate variability test allows you to assess the fitness shape of an athlete and to follow the dynamics and detect the pathological conditions. Besides, this test provides the possibility to foresee the malfunctions of cardiovascular system and to get information about adaptation reserves of the body. Reduction of parameters indicates a violation of interaction of vegetative nervous and cardiovascular systems as well as results in pathologies associated with heart performance. The athletes have the highest parameters of heart rate variability

and high parasympathetic tonus. Analysis of heart rate variability in the early preparatory period indicates balanced autonomic regulatory mechanisms and reflects a high degree of centralization of control heart rhythm (tabl.3).

Table 3 – Indicators of autonomic regulation from highly qualified handball players in the research stages ( $\overline{X} \pm m$ )

| Indicators | STAGES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | BPP | EPP | T BPP - EPP, P | BCP | ECP | T BCP - ECP, P | T BPP - BCP, P | T EPP - BCP, P | T EPP - ECP, P |
| Mo, ms | 968,67± 165,84 | 1052,34± 177,76 | 0,34 P>0,05 | 1140,85± 182,45 | 1080,79± 166,92 | 0,24 P>0,05 | 0,70 P>0,05 | 0,35 P>0,05 | 0,12 P>0,05 |
| AMo,% | 34,45± 3,16 | 30,18± 2,45 | 1,07 P>0,05 | 28,42± 2,28 | 32,44± 3,26 | 1,01 P>0,05 | 1,55 P>0,05 | 0,53 P>0,05 | 0,55 P>0,05 |
| SDNN, ms | 82±5,55 | 80±4,63 | 0,28 P>0,05 | 78±5,12 | 80±5,67 | 0,26 P>0,05 | 0,53 P>0,05 | 0,29 P>0,05 | 0,00 P>0,05 |
| dRR, ms | 348,36±86,14 | 336,22±112,24 | 0,09 P>0,05 | 324,64±106,44 | 332,47±128,54 | 0,05 P>0,05 | 0,17 P>0,05 | 0,07 P>0,05 | 0,02 P>0,05 |
| IT, c.u. | 55,12±34,86 | 58,34±52,92 | 0,05 P>0,05 | 64,97±46,72 | 60,86±28,46 | 0,08 P>0,05 | 0,17 P>0,05 | 0,09 P>0,05 | 0,04 P>0,05 |

Note: BPP - the beginning of the preparation period; EPP- the end of the preparation period; BCP- the beginning of the competition period; ECP - the end of the competition period

The most probable lever of functioning of cardiovascular system Mo in terms of minute volume from physiologic point of view (RR interval value which is most common and indicates the dominant level of sinus node functioning) let us to evaluate the actual condition of regulatory systems. The mode performances of handball players varied within the macrocycle and the minimum value of the index is observed at the start of the preparatory period, and the maximum – in the end thereof. Mode amplitude (AMo), reflecting the stabilizing effect of centralization of heart rate control, which depends on activation degree of sympathetic section of vegetative nervous system, and reflecting the degree of rhythm rigidity, was changing in sinuous manner at the beginning of the preparatory period, reduced to the top of the competitive (28,42±2,28 %) and rises again at the end of the competition period (32,44±3,26 %). A single increase of mode amplitude was an indicator of predominance of sympathetic influences on sinus mode and significant rhythm rigidity.

SDNN (standard deviation normal to normal) is an integral indicator of heart rate variability and depends on the influence of sympathetic and parasympathetic sections of vegetative nervous systems on sinus node. The findings showed that there was a stress of systems responsible for compensation and adaptive abilities in relation to heavy physical activity during the sub-season. The researchers observed a few cases of higher performance limits that indicate an increased parasympathetic activity of vegetative nervous system. Differently directed changes of SDNN indicate a shift of vegetative balance towards the predominance of various sections of vegetative systems. 15% of handball players had a significant growth of SDNN that indicates the increased activity of vegetative regulation loop. Combined effect of SDNN vegetative blood circulation regulation (reflects all periodic components of variability of heart rate variability consolidated figures) decreased.

The degree of variability of dRR cardio intervals values in studied statistical series showed the decrease during the contest season. There was an increase of activity of sympathetic section of vegetative nervous system and of stress index central regulation loop condition. Stress index, provides the most comprehensive assessment of stress of central regulation mechanisms in the process of adaptation to changing effects and reflects the centralization degree of heart rage control, and was increased. Index of tension (IT), which gives the most comprehensive assessment of the voltage of the central mechanisms of regulation in the process of adaptation to changing influences

and reflects the degree of centralization of heart rhythm. Stable regulation of vegetative processes is maintained throughout the whole testing period from the start of pre-season and until the end of contest season.

In the first stage of our task was to identify the most important values of the three groups functional indicators: 1) functional preparedness; 2) central hemodynamics; 3) autonomic adjusting. For this we calculated the correlation coefficients between the indicators in each group.

First three by their rank functional preparedness indicators N lak, rMOC, $rPWC_{170}$, explain 56% general dispersion of the sample, were established by determination of correlation dependences between sportsmen's indicators of overall physical capacity for work and economy of work of the systems of providing energy ($aPWC_{170}$, kgm /min; rPWC170, kgm/min/kg), absolute (aMOC, l/min) and relative maximal oxygen consumption (rMOC, l/min /kg), lactate (N lac, vt/kg) and alactate (N alac, vt/kg) powers (tabl. 4).

Table 4 – Correlation dependences indicators of functional preparedness from highly qualified handball players

| № | INDICATORS | $aPWC_{170}$, kgm/min | $rPWC_{170}$, kgm/min/kg | aMOC, l/min | rMOC, l/min/kg | N alac, vt/kg | N lac, vt/kg | |
|---|---|---|---|---|---|---|---|---|
| 1 | $aPWC_{170}$, kgm/min | | 0,965 | 0,654 | 0,880 | 0,410 | 0,956 | |
| 2 | $rPWC_{170}$, kgm/min/kg | 0,965 | | 0,732 | 0,988 | 0,320 | 0,897 | |
| 3 | aMOC, l/min | 0,654 | 0,732 | | 0,889 | 0,328 | 0,899 | |
| 4 | rMOC, l/min/kg | 0,880 | 0,988 | 0,889 | | 0,299 | 0,911 | |
| 5 | N alac, vt/kg | 0,410 | 0,320 | 0,328 | 0,299 | | 0,888 | |
| 6 | N lac, vt/kg | 0,956 | 0,897 | 0,899 | 0,911 | 0,888 | | |
| | ∑ r | 3,865 | 3,902 | 3,502 | 3,967 | 2,245 | 4,551 | 22,032 |
| | % | 17,54 | 17,71 | 15,90 | 18,01 | 10,19 | 20,66 | 100 |
| | Grade | 4 | 3 | 5 | 2 | 6 | 1 | |

First three by their rank central hemodynamics indicators MBV, SBV, HR, explain 56% general dispersion of the sample, were established by determination of correlation dependences between sportsmens' indicators systolic arterial pressure (SAP, mm hg.art.), diastolic arterial pressure (DAP, mm hg.art.), mean arterial pressure (APmean, mm hg.art.), heart rate (HR, bpm), minute and stroke blood volume (MBV, l/min; SBV, ml) qualified handball players (tabl. 5).

Table 5 – Correlation dependences indicators of central hemodynamics from highly qualified handball players

| № | INDICATORS | SAP, mm hg.art. | DAP, mm hg.art. | APmean, mm hg.art. | HR, bpm | MBV, l/min | SBV, ml | |
|---|---|---|---|---|---|---|---|---|
| 1 | SAP, mm hg.art. | | 0,726 | 0,760 | 0,680 | 0,699 | 0,695 | |
| 2 | DAP, mm hg.art. | 0,726 | | 0,810 | 0,699 | 0,615 | 0,456 | |
| 3 | APmean, mm hg.art. | 0,760 | 0,810 | | 0,633 | 0,566 | 0,911 | |
| 4 | HR, bpm | 0,680 | 0,699 | 0,633 | | 0,988 | 0,711 | |
| 5 | MBV, l/min | 0,699 | 0,615 | 0,566 | 0,988 | | 0,977 | |
| 6 | SBV, ml | 0,695 | 0,456 | 0,911 | 0,711 | 0,977 | | |
| | ∑ r | 3,560 | 3,306 | 3,680 | 3,711 | 3,845 | 3,750 | 21,852 |
| | % | 16,29 | 15,13 | 16,84 | 16,98 | 17,60 | 17,16 | 100 |
| | Grade | 5 | 6 | 4 | 3 | 1 | 2 | |

First three by their rank autonomic regulation RS, AMo, dRR, explain 67% general dispersion of the sample, were established by determination of correlation dependences between sportsmen's indicators mode (Mo, ms), mode amplitude (AMo,%), standard deviation normal to normal (SDNN, ms), degree of variability of dRR cardio intervals values (dRR, ms), index of tension (IT, c.u.) qualified handball players (tabl. 6).

Table 6 – Correlation dependences indicators of autonomic regulation from highly qualified handball players

| INDICATORS | Mo, ms | AMo,% | SDNN, ms | dRR, ms | IT, c.u. | |
|---|---|---|---|---|---|---|
| Mo, ms | | 0,333 | 0,374 | 0,365 | 0,915 | |
| AMo,% | 0,333 | | 0,451 | 0,656 | 0,943 | |
| SDNN, ms | 0,374 | 0,451 | | 0,321 | 0,911 | |
| dRR, ms | 0,365 | 0,656 | 0,321 | | 0,963 | |
| IT, c.u. | 0,915 | 0,943 | 0,911 | 0,963 | | |
| ∑ r | 1,987 | 2,383 | 2,057 | 2,305 | 3,732 | 12,464 |
| % | 15,94 | 19,12 | 16,50 | 18,49 | 29,94 | 100 |
| Grade | 5 | 2 | 4 | 3 | 1 | |

In the second stage identify the factor structure of the functional state of the qualified handball players was performed rotation matrix of factor loadings through the varimax-criterion. Results of factor analysis are given in table 8. Analysis of the matrix of factors loadings testifies that the contents of the first, the most important factor, with the highest coefficients, include indicators N lak, MBV, IN. This factor causes 40,63% of general variance and interpreted as energy production, which represents an integral characteristic of functional state (tabl. 7). The second factor, with high values of factor loadings and the contribution to the overall general dispersion 30,22% underlined figures $rPWC_{170}$, HR, AMo. This factor was determined by as central circulation of blood (tabl. 7). The third factor with the contribution of shares in the general dispersion 29, 16% the highest values of factor loadings are indicators, such as rMOC, SBV, dRR. The factor due to these characteristics, we determined as variation pulse rate.

Table 7 – Factor structure of the functional state from highly qualified handball players

| № | INDICATORS | f | | |
|---|---|---|---|---|
| | | f1 | f2 | f3 |
| | | energy production | central circulation of blood | variational pulse rate |
| 1. | N lac, vt/kg | **0,952** | 0,512 | 0,545 |
| 2. | rMOC, l/min/kg | 0,745 | 0,531 | **0,752** |
| 3. | $rPWC_{170}$, kgm/min/kg | 0,851 | **0,842** | 0,595 |
| 4. | MBV, l/min | **0,931** | 0,513 | 0,510 |
| 5. | SBV, ml | 0,847 | 0,526 | **0,872** |
| 6. | HR, bpm | 0,855 | **0,831** | 0,574 |
| 7. | IT, c.u. | **0,957** | 0,613 | 0,418 |
| 8. | AMo,% | 0,837 | **0,828** | 0,533 |
| 9. | dRR, ms | 0,843 | 0,619 | **0,812** |
| | TOTAL ∑ | 7,818 | 5,815 | 5,611 |
| | % | 40,63 | 30,22 | 29,16 |
| | Grade | 1 | 2 | 3 |

When making a comprehensive assessment of functional status of athletes' bodies, taking into account the behavior of physical performance, cardiovascular system condition and nature of vegetative reactions, it is important to pay attention to nature of interference of above mentioned regulatory loops, where the direction of changes, although expressed with varying reliability degrees, indicates these or those features of training programs. Thus, definitely achieved increase of overall physical efficiency by the start of contest season is provided mostly by means of higher capacities of anaerobic energy supply systems with less significant gains of aerobic mechanisms.

Decrease of overall physical efficiency in the end of pre-season shows a certain fatigue processes development, and is a result of statistically not significant but undirected decrease of intensity of all three tested energy systems. Along with this, at early stages of pre-season there was an optimization of cardiovascular system performance, that is reflected in hypotonic orientation of arterial blood pressure dynamics, switching to less energy-consuming functional sports bradycardia and in hypokinetic orientation of central circulation dynamics, and that is as assumed reduces the so-called "volume load" on heart.

At the later stage, during the contest season, and apparently under the influence of permanent physical and psycho-emotional stress, there are the changes in dynamics of cardiovascular system performance. Along with some weakening of the energy mechanisms and synergistically with them, they contribute to the development of fatigue processes of an athlete's body. At the end of contest season, there is a shift to hyperkinetic type of regulation, that with some increase of activity of heart chronotropic function, apparently, due to compensatory, overcoming the fatigue processes, stimulates the sympathetic-adrenal system. It seems that in this sense the maintaining a stable balance of vegetative regulation mechanisms is a response to parasympathetic influence increasing along with fatigue. These effects confirm rather high fitness level of tested athletes. The other important conditions for the successful performance of an athlete are to make an appropriate training program, which can help to improve functional efficiency of an athlete. Functional efficiency is an integrated characteristic in the context of effectiveness of carried out activities and involved in the implementation of systems according to criteria of reliability and inner price.

## CONCLUSIONS

This study made it possible to conduct a longitudinal study of fitness shape and functional status of highly qualified athletes such as, handball players.

1. Dynamics of physical performances and energy systems condition shows positive influence on the work-out processes during and before the contest seasons as well as shows relative lack of tools for maintaining the high level of physical efficiency and as well as preventing the signs of fatigue in energy supply systems during the contest season.

2. Cardiovascular system performance and its dynamics during the whole testing period indicate the maintaining a high level of hemodynamic servicing the athletes' bodies. However, at the end of contest period there is a hyperkinetic syndrome, which is a sign of lack of tools that can't maintain the optimal regulation of cardiovascular system but it can increase its performance capabilities.

3. Maintaining a high level of vegetative homeostasis indicates the certain fitness level of athletes, sufficient to maintain the high potential of sympathetic-adrenal system and to overcome fatigue processes during activity.

4. The findings suggest the necessity to search for the methods and tools that can adjust and optimize the athletes' performance capabilities at the most effective level just at the right period of competitions.

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# ОСОБЕННОСТИ АНТРОПОМЕТРИЧЕСКИХ ПОКАЗАТЕЛЕЙ ЛЕГКОАТЛЕТОВ

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В работе рассмотрены особенности соматотипа и пропорций тела спринтеров различной квалификации мужского пола в возрасте 18-20 лет. Проанализирована научно-методическая литература и практический опыт работы тренеров по вопросам спортивного отбора и оценке морфологических особенностей легкоатлетов специализирующихся в спринте. Установлены характерные черты строения тела легкоатлетов, которые могут способствовать достижению высоких спортивных результатов. Рассмотрена модель оценки показателей индивидуальных особенностей организма спортсменов, среди которых особый интерес представляют антропоморфологические признаки. Дана оценка существующим принципам спортивного отбора в легкой атлетике и основным этапам этого процесса. Использование комплексной оценки антропометрических и функциональных качеств существенно повышает эффективность при отборе для занятий спортом. В