ORIGINAL ARTICLE

CONTENTS

Comprehensive evaluation of efficiency to identify deficiencies in muscle activity in different modes in team sports

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ABSTRACT

Aim: To concern the scientific substantiation of a complex ergometer tests of aerobic and anaerobic character and quantitative criteria for assessing the condition of female handball players` respiratory and power supply systems in the maximum.

Materials and Methods: Descriptive analysis, correlation analysis, factor analysis. In order to solve those tasks within the framework there were measured the indicators of two hundred young female handball players at the pre-basic training stage.

Results: The outcomes of the research allow us to recommend the program for handball players` potential capabilities assessment that will help to characterize the state of power supply systems of the body under aerobic and anaerobic conditions. At the same time, the results of the testing can be used to identify strengths and weaknesses in the structure of handball players` special readiness indicators and to individualize the process of players' preparation at the subsequent stages.

Conclusions: As a result of experimental data, the quantitative criteria and the scale for the assessment of handball players' working capacity in ergometer maximum tests of aerobic-anaerobic character have been developed. On the basis of these tests, it is possible to analyze objectively the individual characteristics of children before making a final decision.

KEY WORDS: Handball, Female Players, Indicators' Performance, Ergometer Maximum Tests, Work Capacity

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INTRODUCTION

Many scientific studies for youth handball focuses on the result of sports performances and competitions [1, 2]. There should be research into the scientific aspects of the tests already validated and used for educational [3]. Sports selection is viewed as a social, economic and pedagogical concern for the society, basic concepts of which have been formulated in the works of many professionals [4]. Selection includes a number of organizational activities related to solving of the main tasks during the training of athletes at each stage [5, 6].

Several studies have been dedicated to mass observation and testing, aiming to determine children's potential in relation to the specific requirements in handball; selection of promising athletes to sport perfection teams and the formation of club teams; the selection of National teams [7]. Researches make it possible to obtain objective information regarding the most promising group of athletes from the total number of participants [8], reveal empirical and definitional flaws of the early specialization, deliberate play [9].

An important link in the overall chain of events for the selection of talented children and adolescents is the substantiation of complex testing programs, standardization and unification of athletes` capacity evaluation criteria. At the same time, researchers focus their attention on the specific requirements and objectives of the preparation stages [10]. Therefore, it is fundamentally important to study the age characteristics of physical development of children by conventional motor tests of team sports [11], as well as by motor tests adapted to the specific characteristics of handball [12]. Taking into account the general trend of handball development towards the game activity intensification, we anticipate a significant increase in requirements for the special physical preparedness. This includes those systems of the body which limit the anaerobic, aerobic-anaerobic and aerobic work capacity. Thus, filling this gap can help both in selecting and developing female handball players in future.

AIM

Aim of the study: to concern the scientific substantiation of a complex ergometer tests of aerobic and anaerobic character and quantitative criteria for assessing the condition of female handball players` respiratory and power supply systems in the maximum.

MATERIALS AND METHODS

The participants of the study consisted of two hundred young female handball players of Ukrainian Children's Youth Sports School at the pre-basic training stage (age=10-11 years). All athletes volunteered to participate in the research. Prior to the testing, the procedures were explained to all of them, including possible risks involvement, and, after the explanation, an informed consent form was signed. The athletes were free from any injuries or neuromuscular disorders.

The research was approved by the Institutional Ethics Committee, complied with all relevant national regulations and institutional policies, followed the tenets of the Declaration of Helsinki, and has been approved by the authors' institutional review committee. Exclusion criteria were a history of injury or disease that would prevent participants from safely performing the research protocol. All participants were asked to refrain from alcohol and physical exercises 24 hours prior to participation and abstain from food intake and beverages that contain caffeine, for 2 h prior to participation.

A systematic science review was applied in accordance with the Preferred Reporting Items for systematic reviews and meta-analyses. Electronic databases: Scopus, Web of Science, PubMed – were searched for relevant publications. The publications included met the following criteria and principles: included handball players; contained relevant data concerning in handball; were written in English, Poland, Ukraine.

RESEARCH METHODS

THEORETICAL METHODS

Method of analysis and systematization of domestic and foreign experience was used to study the degree of scientific research and determine the to concerned the scientific substantiation of a complex of the most informative, not difficult in the daily implementation, available to coaches control tests and quantitative criteria.

PRACTICAL METHODS

Method of practical testing at stage of preparation will allow coaches to draw conclusions regarding the advisability of continuing sports perfection, or to determine the main directions of preparation, taking into consideration the individual characteristics of young handball players.

Predominantly, the methodology of the research corresponded to the recommendations of the leading experts in the field of sports physiology. Regarding the abovementioned trends in the handball development, it is necessary to use breathing performance and energy supply indicators in the common system of tests which has already been widely used for the players` motor functions monitoring. As shown in Table 1, registered indicators of handball players in their age groups met the requirements of a regular statistical distribution.

That allowed to utilize the method of correlation analysis in order to determine a quantitative measure of the correlations between the registered performance indicators in three ergometer tests:

1. Power in 15, 60 and 240-s tests (W/kg);
2. Overall work in 15, 60 and 240-s tests (J/kg);
3. Holding time Pmax, in 16 and 60-s tests: 16 and 60 s.

The only requirement for the application of temporal criteria for the tests batching is their standardization and application under determined conditions of the athletes' preparation. Based on this factor, particular test loads were bonded to the necessity of realization of maximum intensity (depending on the time of the test task) and execution of the workload in certain time.

Tests were performed on an oval running track at a stadium in the morning, after the standard warm-up and under condition that the restoration of athletes' bodies after previous trainings with heavier workloads had been completed. Therefore, quantitative performance criteria included quantitative characteristics of distance registered during the process of performing tests.

Modern systems, the Global Position System (GPS) made it possible to establish the proportion of working time and quantitative distance lengths. During the formation of the correlation matrix, we proceeded from considerations that it was inappropriate to calculate the correlation coefficients between the derived parameters, for instance, indicators of the overall work in absolute terms – kilojoules (KJ) and relative values (J/kg); maximum and relative power in the test (W and W/kg); oxygen uptake (VO_2, $l \cdot min^{-1}$ and VO_2, $ml \cdot kg^{-1} \cdot min^{-1}$).

The statistical analysis of the actual research data was conducted using several methods. The analysis of experimental data was performed using integrated statistical and graphics packages MS Excel-7, Statistica-7. Descriptive analysis methods were used, comprising tabular representation of individual variables and calculating the arithmetic mean values – X, and standard

deviation – S. To separate the leading components of functional readiness structure, the factorial analysis was provided [13].

Thus, in order to substantiate the minimum complex of the most informative indicators which allow objectively and highly informatively characterize the state of main components of female handball players' motor function, correlation analysis method was used. Utilizing a large number of tests for female handball players, correlation analysis was applied to study the results of primary examinations. Then, the correlation matrices were processed by methods of factor analysis which allowed to study the players` physical readiness factor structure, select tests and certain indicators that were highly informative and, as a result, recommend the optimal content control. Correlation analyses of players` achievements in these tests were conducted for each age group separately in accordance with metrological requirements. One must not forget the importance of creating a harmonious environment, to have a correct reliability of the results.

In order to achieve the goal and the objectives of this research and to update the informative tests, the correlation between the results of different general and specific test exercises of female handball players were studied. Furthermore, the correlations between the control parameters for quantification of the linear dependence between different parameters were shown when the Pearson correlation coefficient was calculated. Preliminarily, the regular distribution of the registered indicators for the athletes had been conducted. Therefore, we decided to limit ourselves to the study of the distribution character by the rule of three sigmas.

The analysis of the correlations of indicators was as follows. During the first cycle of statistical operations it was registered that the athletes` control indicators corresponded to the normal, regular character and Gaussian distribution. In the case of normal distribution of the experimental data, the subsequent statistical operations – correlation and factor analysis were applied. Average values and standard deviations of the control indicators were used as criteria for normal statistical distribution. This made it possible to characterize the frequency distribution of all the variants that fall within the range of $\pm 3\sigma - \pm 1\sigma$. The method is recommended for solving similar problems in the science of sport which emphasizes that the regular distribution registered during the athletes' motor functions analyses is very common. Generalized estimate of working capacity can be calculated by summing the estimates in points obtained in each control test, using the following formula:

$$WCC = (I1 + R10 + I2 + \dots (I7 + R7),$$

where WCC – generalized working capacity criteria; I1…I7 – number of points for each indicator; R1 …R7 – ratios in connection with the value of the indicator.

The use of a single scale for players of a different age required an application of the differentiated approach in order to formulate the qualitative characteristics of the working capacity on the basis of the test outcomes. We determined the levels: low – lower than 14 points; average – 15-19 points; above the average – 20-24 points; high – 25 points or more. In order to get an opinion on one or another level of working capacity, 10-11-year-old athletes need to score a certain amount of points. Therefore, players aged 10 or 11 years need to earn 25 points to prove a very high level of working capacity. For the players of older age groups these requirements are higher.

RESULTS

The standardization of the control programs and the unification of athletes` assessment criteria should proceed in accordance with specific requirements of the team sports and preparation stages' tasks [14]. Therefore, as a result of several experiments, analysis of empirical experience from scientists and specialized literature data, the algorithm of sports system principles` implementation, as well as specific scientific and methodical bases for handball players training process organization have been generated [15, 16].

The results of the statistical distribution analysis are shown in Table 1. In our research, practical significance is given to the information about the correlations of working capacity indicators that were registered in three tests, due to different mechanisms of athletes` power supply.

Handball is a dynamic team game, characterized by high-intensity movements with passes, sprints, jumps, changes of direction, stops, throws on goal, and body tackles, interspersed with walking and standing, when relative workload – 75–85% of the maximal oxygen uptake (VO_2max) [17]. Handball highly taxes the neuromuscular and cardiovascular systems, stimulates adaptations oxygen utilization and skeletal muscle capacities. The presence or absence of the correlation between the working capacity indicators in anaerobic, aerobic-anaerobic and aerobic modes have fundamental importance for the formation of a complex of control tests for assessment of specific working capacity of female handball players. The results of the analysis are presented in Table 2.

It should be noted that the correlation matrix contains common regularities (the calculation was based on the female handball players` data). Working capacity indicators in relative terms in 15, 60 and 240-s tests

Table 1. Characteristics of the Statistical Distribution of Indicators for the Players Performance in Maximum Ergo-Metric Tests

Indicators	Characteristics of the statistical distribution of the data in the range of three sigma, %			
	±1δ	±2δ	±3δ	Σ
Work (J/kg), 15-s test	63.5	23.7	5.1	92.3
Work (J/kg), 60-s test	71.8	21.2	3.1	96.1
Work (J/kg), 240-s test	63.9	30.1	4.5	98.5
Power (W/kg), 15-s test	62.7	27.3	6.2	96.2
Power (W/kg), 60-s test	64.6	26.2	5.2	96.0
Retention time Pmax, 15-s test	60.9	26.7	6.8	94.4
Retention time Pmax, 60-s test	64.7	24.3	5.7	94.7
VO_2 1·min·^{1} /KJ/kg, 240-s test	62.9	25.2	5.6	93.7
VO_2 1·kg·^{1}·min·^{1}, 240-s test	66.5	25.4	4.8	96.7
Pulmonary ventilation, 1·min·^{1}	64.8	23.3	5.8	93.9

Table 2. The Outcomes of Correlation Analysis of Indicators' Performance of Handball Players to Maximum Ergo-Metric Tests (n=200)

№	Indicators	1	2	3	4	5	6	7	8	9	10
1	Work (J/kg), 15-s test	x	893	715	899	411	573	217	315	118	530
2	Work (J/kg), 60-s test		x	700	600	891	799	613	603	717	611
3	Work (J/kg), 240-s test			x	215	593	11	702	910	877	899
4	Power (W/kg), 15-s test				x	600	713	210	411	393	517
5	Power (W/kg), 60-s test					x	017	503	619	010	714
6	Retention time Pmax, 15-s test						x	270	511	417	273
7	Retention time Pmax, 60-s test							x	853	814	902
8	VO_2 1·min·^{1} /KJ/kg, 240-s test								x	849	814
9	VO_2 1·kg·^{1}·min·^{1}, 240-s test									x	900
10	Pulmonary ventilation, 1·min·^{1}										x

NB: For convenience, all the coefficients are multiplied by 1000.

Table 3. Optimal Quantitative Criteria of Readiness for Handball Players of 10-11 Years Old the Maximum Ergo-Metric Tests

Indicators and measurement units	M	min	max
Work (J/kg), 15-s test	108	0,97	120
Work (J/kg), 60-s test	313	296	360
Work (J/kg), 240-s test	134.2	115	153
Power (W/kg), 15-s test	8.41	7.78	9.26
Power (W/kg), 60-s test	6.21	5.35	8.04
Retention time (Pmax, s), 15-s test	4.78	1.57	7.41
Retention time (Pmax, s), 60-s test	10.21	4.17	16.50

Table 4. The Expression Method in Points of Handball Players Achievement in Maximum Ergo-Metric Tests

Indicators	K	Absolute values and points									
		1	2	3	4	5	6	7	8	9	10
R1 Work (J/kg), 15-s test	1.2	0.97	102	107	112	120	130	140	150	160	168
R2 Work (J /kg), 60-s test		285	300	310	320	330	340	350	360	370	380
R3 Work (J/kg), 240-s test		50	70	80	90	100	115	130	140	150	160
R4 Power (W/kg), 15-s test		7.8	8.2	8.6	9.0	9.4	9.8	10.2	10.6	11.2	12..0
R5 Power (W/kg), 60-s test	1.3	5.2	6.0	6.4	6.8	7,0	7.2	7.4	7.8	8.2	8.6
R6 Retention Time(Pmax, s), 15-s test		1.5	2.5	3.5	4.0	4,5	5.0	5.5	6.0	7.0	8.0
R7 Retention time (Pmax,s), 60-s test	1.5	1.7	3.5	5.0	6.5	8.0	9.5	11.0	12.5	15.0	17.0

Note. R1-7: according to the formula, symbols for calculating the generalized estimation.

showed a high correlation (r – 0.715-0.899), reflecting the general level of physical condition of participants. High correlation coefficients of 0.899 and 0.891 were found in ergometer tests (15 and 60 s), between indicators of work in relative units of J/kg and the relative value of the maximum power W/kg.

The character of such distinctive features was affirmed in specialized literature data. However, the ability, as the duration of the maintenance of the maximum power Pmax in these tests, doesn't depend on the absolute values of work and indicators of the maximum power. The correlation coefficients between these parameters were statistically less significant and ranged between 0.573-0.613.

The high correlation was detected between the indicators of work in ergometer test for 240 s, and the ability of female handball players to maintain high efficiency for a long time Pmax at 60-s test (r-0.70). It could be assumed that this ability appeared mostly due to the same physiological mechanisms that determined the high level of working capacity in the aerobic test at the duration of 240 s. The high correlation paired coefficients between indicators of oxygen consumption, the pulmonary ventilation and work in the aerobic mode 0.814-0.902 can be taken as evidence of it.

Some scientists have developed the concept of an individual anaerobic threshold, but experimental evidence is lacking [18]. The effect of aerobic capacity on the validity of the anaerobic intensity threshold can only be assessed using constant exercise tests. As a result of statistical analysis of experimental data, the quantitative criteria and the scale for assessing working capacity of female handball players during ergometer maximal tests of aerobic-anaerobic nature have been presented (Tables III and IV). Therefore, we have transferred the results of the players' examination which were expressed in different units of measurement – joules, watts and seconds, into a single rating system – in points.

Relevant information can be used in the system of a long-term players' preparation for the purpose of individualization in the training process. An integral assessment of working capacity in each of the three tests can help to identify specific flaws in an athlete's muscle activity in different modes.

DISCUSSION

Modern scientists pay special attention to analyzing the structure and effectiveness of the pre-basic training stage. It is crucial to note that at this stage of sports preparation coaches and sports specialists are trying to increase the level of functionality and sports achievements in the process of participation in the national handball championship among youth teams.

The challenge lies in determining the quantitative and qualitative characteristics of the training structure, when the handball players are able to use skills and methods of their training, which provide growth of capabilities while maintaining the positive dynamics of the technical and tactical improvements [19].

Our research presents the technology and specific criteria that can help to select promising female handball players during the formation of groups in sports organizations for children. We considered it appropriate to focus on the creation of the complex of control indicators that allows to assess the status of the main components of motor function which provide high performance of players in the specific conditions of the game activity.

This approach to preparedness evaluation meets the modern requirements of management and control organization in sport games. Because of the objective organizational difficulties, research data from handball players of various ages were processed together in a unified correlation matrix. For this reason, there arose a necessity to study the physiological mechanisms and performance profiles become relevant at the early stages of female handball players identification and selection as well as for physical development programs at future stages.

However, the ensuing discussion of energy ensuring indicators in ergometer tests was conducted strictly in accordance with the age characteristics of involved athletes, as evidenced by the data in Tables 3 and 4. Such correlations were understandable from the standpoint of well-known physiological mechanisms and additional statistical calculation was not needed. In order to improve the control methodology of special physical preparedness, the testing results of handball players were expressed in metric values and the proper scale was used. It was necessary to represent the athletes' achievements in different tests (expressed in different, not comparable with each other measurement units), in a united system in the form of points. In order to solve that problem, we decided to use the percentile scale, the most suitable for the evaluation of results of large groups of athletes in tests. In this case, information regarding the nature of the statistical distribution of the primary control materials obtained during the examination of a large number of handball players of different age was used.

According to the most control indicators, the distribution corresponded or was very close to the normal requirements. On the scale, the high and low results

in the control tests were placed on the left and on the right sides, and the average results, which were shown by the most athletes – in its middle part. The utilization of this kind of scale allowed to present the female handball players` achievements in various tests in generalized evaluation in points. The distribution of the points for the quantitative indicators, placed on the scale of a normal distribution, was considered as equable. Nevertheless, to model the scales, we had to use generally accepted guidelines [20].

Each control indicator was assigned a so-called premium rank coefficient which corresponded to its factorial validity. The concurrent use of the quantitative and qualitative criteria for the assessment of the female handball players` readiness opens new, additional opportunities to increase the objectivity of administrative decisions not only at the pre-basic training stage during the selection of talented children to practice handball, but also at the subsequent stages of long-term preparation.

CONCLUSIONS

Statistical analysis of the experimental data allowed us to substantiate the minimum testing program on the basis of the most informative indicators concerning the age peculiarities of involved players and specific requirements of the game. Additionally, we developed quantitative criteria and the scales for evaluating the anaerobic-aerobic productivity of an organism in the maximum duration of ergometer tests at 15, 60 and 240 s.

The results of our research allow to characterize the structure of the special readiness of female handball players, which offers opportunities to improve the training methodology at the level of analytical and synthetic approaches. In other words, relying on the knowledge of the structure of female handball players preparedness, there is an opportunity to selectively influence the improvement of its individual components and to optimize training loads by aligning them with the requirements of competitive activity, as well as to take into the account some features of the basic systems of vitality in the bodies of female handball players caused by genetic factors.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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