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ERGOMETRIC AND PHYSIOLOGICAL CHARACTERISTICS OF SPECIAL PHYSICAL FITNESS OF ATHLETES IN SPORTS WITH ENDURANCE

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Purpose: to determine the individual parameters of the training work modes on the rowing ergometer for the development of specific components of the functional support of athletes in sports with the manifestation of endurance.

Material and methods: the study involved 25 kayakers, members of the Shandong Province, Jiangxi (China) teams. The Dansprint rowing ergometer (Denmark) was used to measure the ergometric power in real time. Oxygen consumption (VO_2), CO_2 emission level (VCO_2), pulmonary ventilation (VE) were determined for each respiratory cycle using an Oxycon (Jaeger) mobile gas analyzer.

Results: indicators of ergometric power, recorded in accordance with the level of response of the cardiorespiratory system in the process of modelling the components of the functional support of the special kayaker's performance. On this basis the modes of training means, and also the program of their target use in system of special functional training of rowers are developed.

Conclusions: the effectiveness of the program of special functional training of rowers is proved. The result is an increase in the ergometric power and response of the cardiorespiratory system when modelling the components of the functional

support of the special performance of rowers - fast kinetics, steady state and fatigue compensation.

Keywords: functional training, special physical fitness, ergometry, ergometric power, cardiorespiratory system.

Introduction

Modern scientific and methodological foundations for the development of the functional capabilities of athletes are aimed at the formation of an integral structure of the functional support of the special performance of athletes [1]. A characteristic feature of this process is the allocation of the main components of competitive activity, providing fast kinetics, a steady state and compensation for fatigue during overcoming the competitive distance [2].

In the presence of a wide range of ergometric and physiological characteristics of functional readiness, attention is drawn to the reactive properties of the cardiorespiratory system (CRS), which have a significant impact on the level and structure of the functional support of the special working capacity of athletes [3]. The response of pulmonary ventilation to a change in partial pressure (VE • $PaCO_2$-1), the release of CO_2 (VE • VCO_2-1), consumption of O_2 (VE • VO_2-1) in different periods of competitive activity affects the structure of the functional support of special working capacity, increases the possibilities realization of the existing functional potential of athletes, in particular the power and capacity of energy reactions [4].

At the same time, there was an understanding that the implementation of the results of control and assessment of functional capabilities into practice requires the accuracy of measuring the reaction, as well as high accuracy of modeling physical loads in accordance with the quantitative and qualitative individual characteristics of the athletes' reaction to competitive loads [7]. In the presence of a wide range of means and methods for monitoring the assessment and interpretation of its results, data related to the modeling of individual parameters of training work, based on the analysis of the reaction of the system of functional support of competitive activity, are presented extremely insufficiently. This is largely due to the lack of methodological approaches to the conversion of test loads in training, the complexity of the transfer of load parameters, at which the required levels of reaction are achieved in real training work.

As a tool for the implementation of such an approach, methodological approaches have been proposed that allow the use of ergometers as a means of individualizing the parameters of training work in accordance with the level of reaction of the cardiorespiratory system and energy supply [12]. Particular successes in this direction were achieved when modeling the conditions for the realization of the power and capacity of aerobic and anaerobic energy supply [8]. The issues of modeling the parameters of competitive activity, taking into account the dynamics of the functional support of special working capacity, remain largely open. It is obvious that in the presence of common approaches to the organization of control, the choice of indicators, the uniqueness of the structure of special functional readiness requires a special analysis for almost every kind of sport and type of competition [13]. This is especially important for cyclic sports, where differences in the duration and intensity of overcoming the competitive distance form the differences in the functional support of the initial segment, middle and second half of the distance [9]. They are especially expressive on the example of rowing in kayaks, where the differences in the structure of the functional support of special working capacity associated with the duration of the distance (200 m, 500 m, 1000 m), the type of competition (kayak and canoe), qualifications and article of athletes [2].

An important component of the control, assessment and interpretation of indicators of functional capabilities and special working capacity is to determine the quantitative and qualitative characteristics of the integral structure of the functional support of special working capacity, where an increase in the effectiveness of each component affects the general condition of athletes, in particular, the effectiveness of competitive activity in model or natural conditions of its implementation. [11]. In the presence of a significant amount of data on the power and capacity of aerobic and anaerobic energy supply, quantitative and qualitative characteristics of the body's reactive properties, which reflect the ability of athletes to quickly, adequately and fully respond to training and competitive loads, the scientific literature is insufficiently covered. The reactive properties of CRS form the parameters of training loads, which are modeled in accordance with the level of reaction and energy supply of work

On the example of rowing sports, the conditions for registering the parameters of training work are shown in accordance with the indicators of competitive activity of athletes, in particular, the conversion of test loads in training [3]. The conversion tool was the use of special rowing ergometers of the latest generation, which make it possible to reproduce individual ergometric parameters of working capacity while maintaining the kinematic and dynamic structure of rowing locomotions, as well as parameters of ergometric power of work, at which a certain level of functional support of special working capacity was achieved [8].

In this regard, the **purpose of the work** was formulated - to determine the individual parameters of the training work regimes on the rowing ergometer for the development of specific components of the functional support of athletes in sports with a display of endurance.

Material and Methods of research

Material. The study involved 25 qualified rowers in kayaks, members of the combined teams of Shandong and Jianshi provinces (PRC). The age of the athletes is 23,1 ± 2,0 years. Rowing experience 10,2 ± 1,5 years.

Methods. Ergometry. A rowing machine Dansprint (Denmark) was used to measure the ergometric indicators of the power of work in real time.

Gas exchange measurements. Oxygen consumption (VO_2), CO_2 removal (VCO_2), pulmonary ventilation (VE) were determined using a mobile gas analyzer Oxycon (Jaeger).

The experimental part of the study was carried out by specialists from the laboratory for monitoring sports training in water sports of the General Administration of Sports of China (Nanchang, Jianshi Province, China) with the participation of specialists from the National University of Physical Education and Sports of Ukraine (Kiev, Ukraine).

Statistical analysis. A statistical package (SPSS 10.0) was used to evaluate and analyze the data obtained. Descriptive statistics offered to determine the arithmetic mean - $\bar{x}$, standard deviation - S, maximum (max) and minimum (min) indices, 25% and 75% indices.

Results of the research

The test was attended by rowers on kayaks of a homogeneous group (according to the indications of aerobic power, VO_2 max – 5,4 ± 0,3 $l \cdot min^{-1}$), anaerobic capacity (La test 30s – 10,2±1,9 $mmol \cdot l^{-1}$) and anaerobic capacity (La test 120 s - La test 30 s – 10,2±1,9 $mmol \cdot l^{-1}$).

In the process of testing, test loads were simulated, which ensured the implementation of the components of the functional support of the special working capacity of rowers at a distance of 1000 m - fast kinetics, steady state and fatigue compensation. Individual indicators of ergometric power, cardiorespiratory system (CRS) and energy supply of work were recorded. Physiological characteristics of work are presented in table 1.

Table 1

Physiological characteristics of the special working capacity of qualified kayak rowers (n=25)

Test	Components of functional support of competitive activity	Indicators	Measurement conditions
Test 30 s	Rapid kinetics of the initial part of the competitive distance	$V_E \cdot PaCO_2^{-1}$ $V_E \cdot VCO_2^{-1}$	The highest value of the indicator
Test 120 s	Steady state	$V_E \cdot VO_2^{-1}$ $V_E \cdot VCO_2^{-1}$	The period of stability of the reaction within 30 s
Critical power load (CPL): test 90 s	Fatigue compensation	$V_E \cdot VO_2^{-1}$ (тест 120) / $V_E \cdot VO_2^{-1}$ (НКП) *100% $V_E \cdot VCO_2^{-1}$ (тест 120) / $V_E \cdot VCO_2^{-1}$ (НКП) *100%	The CPL was performed one minute after the step test according to the protocol for determining VO_2 max

Table 2 shows the indices of special working capacity and physiological reactions characterizing the specific manifestations of the reactive properties of CRS at different segments of a distance of 1000 m in rowing in kayaks before and after the execution of the experiment program. The experiment included a program of training sessions aimed at increasing the reactive properties of CRS in a competitive distance. The modes of training work simulated the conditions for testing rowers. The training sessions included work segments of 30 s, 120 s and 90 s. The parameters of work in the segments of 30 s and 120 s corresponded to the individual indicators of ergometric power of work and above, recorded during the initial testing. The ergometric parameters of work in the 90-s sections were carried out in accordance with the testing parameters, and the number of sections was regulated by the ability to maintain the specified work parameters (work to failure). Rest intervals increased after each segment was performed. The program was completed over 8 weeks (48 training sessions, six times a week). The focus of the classes is presented in table 2.

Table 2

Program of training sessions aimed at developing the components of the functional support of the special working capacity of qualified rowers

Weeks	Parameters of work on a segment		
	Working time on a segment with a duration of 30 s; recovery time 30 s, +15 s after each segment (Mode A)	Working time on a segment lasting 120 s; recovery time 180 s, + 30 s after each segment (Mode B)	Working time on a segment with a duration of 90 s; recovery time 60 s, +60 s after each segment (mode C)
	Number of training session per week		
1	A – 3 training session	B – 2	C – 1
2	A – 3	B – 2	C – 1
3	A – 2	B – 2	C – 2
4	A – 2	B – 2	C – 2
5	A – 1	B – 2	C – 3
6	A – 1	B – 1	C – 4
7	A – 2	B – 2	C – 2
8	A – 2	B – 2	C – 2

Table 3 shows the results of testing athletes before and after the implementation of the training program aimed at developing the components of the functional support of the special working capacity of kayak rowers specializing at a distance of 1000 m.

Table 3

Ergometric and physiological characteristics of the reaction of the cardiorespiratory system of qualified rowers (n=25)

Test	Indicators	Before the program					After the program				
		Statistics									
		$\bar{x}\pm S$	min	max	25%	75%	$\bar{x}\pm S$	min	max	25%	75%
Test 30 s	$\overline{W}$, W	369,9±19,0*	335	515	345	390	422,9±15,0*	379	540	406	438
	$V_E \cdot PaCO_2^{-1}$, c. u.	3,5±0,9	1,8	5,0	2,6	4,3	3,7±0,5	2,5	5,1	3,0	4,0
	$V_E \cdot VCO_2^{-1}$, c. u.	30,0±4,0	23,1	39,3	26,4	32,4	33,0±3,0	25,1	41,0	28,1	35,1
Test 120 s	$\overline{W}$	250,7±11,8*	229	295	238	264	287,9±10,0*	257	324	288	298
	$V_E \cdot VO_2^{-1}$, y. o.	29,6±3,9	20,7	35,9	23,8	35,8	34,9±4,1	21,9	38,0	24,0	36,9
	$V_E \cdot VCO_2^{-}$, c. u.^{1}	33,6±3,2	26,2	39,0	30,0	36,9	36,6±3,0	29,2	41,0	23,1	39,9
Critical power load (CPL): test 90 s	$\overline{W}$	235,5±11,5*	218	282	224	248	265,0±9,2*	235	300	243	274
	$V_E \cdot VO_2^{-1}{}_{test\ 120}$ / $V_E \cdot VO_2^{-1}{}_{CPL}$ *100%, %	8,6±5,3	2,4	15,8	5,3	14,3	9,3±3,3	5,4	15,8	5,8	13,0
	$V_E \cdot VCO_2^{-1}{}_{test\ 120}$ / $V_E \cdot VCO_2^{-1}{}_{CPL}$ *100%, %	7,6±4,3	2,4	12,6	4,0	10,3	12,6±2,3	5,4	21,6	10,2	17,3

As a result of the implementation of the program of special functional training, the rowers' indicators of ergometric power of work increased ($p < 0.05$). An increase in the ergometric power of work was accompanied by an increase in the reaction of the CRS in all athletes in all parameters. This is most clearly seen in the specific indicators of pulmonary ventilation and the release of carbon dioxide when performing the "90 s test". An increase in the response of pulmonary ventilation against the background of the development of fatigue indicates an increase in the response of respiratory compensation of metabolic acidosis ($V_E \cdot VCO_2^{-1}{}_{test\ 120}$ / $V_E \cdot VCO_2^{-1}{}_{CPL}$*100% i $V_E \cdot VO_2^{-1}{}_{test\ 120}$ / $V_E \cdot VO_2^{-1}{}_{CPL}$ *100%) in 22 rowers. An increase in the response of pulmonary ventilation to the release of CO_2 is accompanied by an increase or maintenance of the level (95-97% VO_2 max) of the maximum consumption of O_2. To the experiment, this type of reaction was observed only in 11 athletes.

<u>Conclusions / Discussion</u>

The analysis showed that each component of the CRS response is a condition for the formation of an integral structure of the functional support of special performance. An increase in rapid kinetics is an incentive to achieve and maintain a stable state, an increase in the reaction of compensation for metabolic acidosis, including during the period of active development of fatigue.

The given data confirm the well-known ideas about the criteria of the athletes' functional readiness. Changes in athletes' working capacity under the influence of intense physical training are accompanied by an increase in the reaction of the cardiorespiratory system and energy supply of work. Optimization of the reactive properties of athletes in accordance with the structure of the functional support of special working capacity in the special literature is considered as an informative criterion for a favorable adaptation of the body to intense physical activity. This phenomenon is confirmed by the example of the application of the program of special physical training of rowers, implemented on the basis of measuring ergometric parameters of work in accordance with the level of rapid kinetics, steady state, fatigue compensation [1, 2, 9].

An increase in the level of special working capacity of athletes in the process of modeling the initial segment, middle and second half of the distance was accompanied by an increase in the reaction of the cardiorespiratory system to the development of hypoxia, hypercapnia, accumulation of products of anaerobic metabolism.

The most expressive during the work of the "critical" load power (modeling the second half of the distance during the development of fatigue - load of the "critical" power "test 90 s") is the increase in special performance ($\overline{w}$) CPL – by 11,3%), increased reaction of CRS ($VE \bullet VCO_2$-1test 120 / $VE \bullet VCO_2$-1 CPL*100% – by

39,7%), maintaining the stability of consumption O2 (VE • VO_2-1test 120 / VE•VO_2-CPL * 100% – by 7,5%).

Strengthening the compensation of fatigue is a condition for the effective development of functional capabilities in sports with the manifestation of endurance [6]. The given data, as well as the data presented in the special literature, indicate that the mechanisms of fatigue compensation are considered as a composite integral structure of functional readiness [5]. Its manifestations depend on the effectiveness of the initial part of the reaction, a steady state, which provide not only high performance of athletes at specific segments of the distance, but also a high degree of efficiency of transient processes of anaerobic-aerobic energy supply, hypoxia - hypercapnia - a high degree of accumulation of anaerobic metabolism [14, 15, 16].

The given data form new possibilities for improving special physical training in sports with the manifestation of endurance, taking into account the specific characteristics of the competitive activity of athletes.

Prospect of further research is the determination of the quantitative and qualitative characteristics of the functional support of competitive activity in the natural conditions of training athletes in sports with manifestations of endurance.

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