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Original Article

Characteristics of the power of aerobic energy supply for paddlers with high qualification in China

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Abstract
Background: Determine the level of maximum consumption of O_2 in the process of modeling the functional support of special performance at a distance of 200 m, 500 m and 1000 m by paddlers. **Material and methods:** 30 highly qualified paddlers, age = 23 ± 3 years; height = 181 ± 6 cm; bodyweight = 86,5 ± 4,1 kg. **Equipment**. Oxycon mobile (Jaeger), Biosen S. line lab +, canoe ergometer-Dansprint. **Results:** The article shows that measuring the power of aerobic energy supply of paddlers requires consideration of age, qualifications and specialization at a distance of 200 m, 500 m and 1000 m. A high level of aerobic power supply of high-class paddlers can be achieved in various load conditions that simulate performance of special speed capabilities or endurance during the period of fatigue compensation. Individual differences in the $VO_{2\ max}$ indices are noted in the "120 s" test, the "90 s" test and in the test performed according to the $VO_{2\ max}$ measurement protocol. 14 paddlers reached $VO_{2\ max}$ in the process of implementing special speed capabilities, 14 paddlers in the process of performing test loads aimed at showing endurance, 2 paddlers had the same performance in the process of performing test loads of two types. Individual differences were $VO_{2\ max}$, registered in the conditions of the implementation of special speed capabilities and endurance ranged from 3.2 % to 4.3%. **Conclusions:** The analysis of the conditions for the implementation of VO_2 max influences the choice of specialization in canoe, as well as the modes of training work aimed at realizing the energy potential of paddlers. This requires individualization not only in conditions for paddlers testing , but also the development of training facilities system, taking into account the individual reactive properties of athletes.
Keywords. Paddlers, aerobic power supply capacity, functionality testing, VO_2 measurement max.

Introduction.

In canoe, a high level of aerobic power is a prerequisite for successful sports improvement over the entire period of a long-term athletic career. Its characteristics make it possible to assess the reserves of functional preparedness, the prerequisites for realization of paddler's energy potential in the process of competitive activity. In the structure of functional preparedness of athletes in cyclical sports, increasing of economical aerobic energy supply in the overall energy balance can improve the quantitative and qualitative characteristics of special performance in the process of developing speed capabilities [11, 18], increase the period of steady state and the possibility of compensating fatigue in the development of endurance [6, 7]. The high level of O_2 consumption by paddlers, its development, taking into account the integral structure of the energy supply reaction, affects the performance of rowers at a distance of 200 m and 500 m, is a factor in the stability of the functional support of work at a distance of 1000 m [1, 2].

In the system of diagnostics of the energy potential of paddlers, the leading place is occupied by the measurement, evaluation and interpretation of the maximum O_2 consumption indicator ($VO_{2\ max}$), the integral characteristic of the efficiency of the oxygen supply system and the production of aerobic energy during intense training and competitive activities [17, 19].

In the practice of measuring $VO_{2\ max}$, a method based on the use of a step-increasing test has been widely used [10]. It is characterized by a linear accumulation of anaerobic metabolism products, the achievement and preservation of the level of lactate acidosis, which has a stimulating effect on the kinetics of the cardiorespiratory system (RS) response and O_2 consumption. Its use allows you to standardize the conditions for measuring, evaluating and comparing O_2 consumption indicators. However, there is reason to think that this method, better extent, allows us to assess the potential capabilities of young athletes [5].

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It is well known that high-class athletes have an individual structure of energy supply reactions, and, as a rule, react differently to the standard measurement conditions characteristic of a step test [1]. In the high-class paddlers, the structure of the reaction of energy supply in the process of overcoming the distances of 200 m, 500 m and 1000 m in canoe is different [12]. Performance of the reaction components - anaerobic alactate and lactate, aerobic types of energy supply are largely associated with the individual characteristics of the paddlers. Individual performance of the physiological reactivity of the organism on the neurohumoral stimul ("drives") have a particular effect [4]. The degree of development of hypoxia, the rate of increase of hypercapnia, the amount of accumulation of anaerobic metabolism products affect the speed of deployment and the achievement of $VO_{2\ max}$ at a specific competition distance [1, 3, 14]. These factors largely determine the possibility of implementing an individual reaction structure, taking into account the duration and intensity of work at a particular competitive distance.

As a rule, taking into account the individual reactivity of cattle, its influence on the implementation of the energy supply response structure determines the specialization of paddles at a particular distance, forms a specialized focus of special physical training and an arsenal of training tools [1, 4, 8].

There is reason to believe that measuring $VO_{2\ max}$ requires the use of special testing conditions that provide a high level of reaction for athletes with different types of physiological reactivity and energy supply structure depending on the duration and intensity of competitive activity [1, 9, 18]. The application of special testing conditions is particularly relevant for canoe, where the functional support of special performance and the conditions for implementing $VO_{2\ max}$ at a distance of 200 m, 500 m and 1000 m have significant differences.

Purpose. Determine the level of maximum consumption of O_2 paddlers in the process of modeling the functional support of special performance at a distance of 200 m, 500 m and 1000 m.

Materials and methods.

Subject. 30 highly qualified paddlers, men, leading athletes of Shandong and Jiangxi provinces, winners, prize winners and participants of the final races of the China Kayak and Canoe Racing Championship took part $\bar{x} \pm S$, age = 23 ± 3 years; height = 181 ± 6 cm; mass = 86.5 ± 4.1 kg).

Research protocol. The Oxycon mobile (Jaeger) gas analyzer was used to register $VO_{2\ max}$, and the Biosen S. line lab + laboratory complex was used to determine blood lactate. For standardization of measurements of special performance, the Dansprint canoe ergometer was used. $VO_{2\ max}$, La, and ergometric power (EP) of work were recorded. Measurements of the reaction of the cardiorespiratory system and blood sampling for lactate measurement were carried out by the specialists of the Scientific Sports Management Research Centers in Shandong Province (Jinan) and Jiangxi (Nanchang).

Paddlers completed two testing programs. Program "A" simulated modes of operation at a distance of 200 m and 500 m; program "B" - at a distance of 1000 m.

Program "A" included a warm-up (standard load with EP work 1.2 W · body weight), test "acceleration 30 seconds", recovery period 7 minutes, test "120 seconds", which was performed with maximum intensity.

The program "B" included warm-up (standard load with EP work 1.2 W · body weight), test "acceleration 30 seconds", recovery period 7 minutes, step-increasing test ("step – test" performed according to $VO_{2\ max}$ measurement protocol [10]), the recovery period is 1 minute, "test 90", performed with the maximum intensity of work. EP I steps "step – test" - 1.2 W · body weight + 20 W, increase in EP operation at the step + 20.0 W. The test "acceleration of 30 seconds" was performed to develop "acute" hypoxia and stimulate the response of the cardiorespiratory system. The "90 sec" test was performed against the background of fatigue development and modeled the conditions of the second half of the 1000 m distance.

To assess the power of aerobic energy supply, we analyzed the highest VO_2 values in the steady state period within ± 0.1 l / min ($VO_{2\ max}$ / kg) with a duration of at least 20 s.

Statistical Analysis. Statistical analyses is using the Statistical Package for the Social Sciences (SPSS 10.0). The following methods of mathematical statistics are: descriptive statistics, selective method, criterion of consent of Shapiro Uilki, self-reactance criteria of Student's test and non-parametric criteria of Manna-Uyutni. The methods of descriptive (descriptive) analysis, including tabular presentation of separate variables and calculation of mean arithmetic value has been used - $\bar{x}$, standard deviation - S, and also indexes of individual differences - coefficient of variations of V. the sample data for compliance has been tested with the normal distribution law, Shapiro Uilki. To determine the statistical significance of the differences between the samples, the distribution of which corresponded to the normal law, the Student's test was used. To determine the statistical significance of the differences between samples, the distribution of which corresponded to the normal law, nonparametric criteria for small samples were used (Wilcoxon test). A significance level (that is, the probability of error) was assumed to be p = 0.05. The informativeness of the tests and indicators was recorded, evaluated under standard conditions of measurement.

Results.

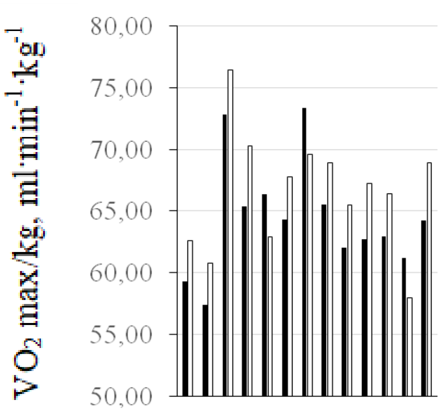
In the process of executing the “A” control program, O2 consumption indicators were recorded during the “120 seconds” test. In the process of executing the “B” program, O_2 consumption indicators were recorded during the “step – test” process and the “90 s” test.

Statistical analysis of the results of the implementation of program A showed the level of communication between the power index of aerobic energy supply and ergometric work power ($p < 0.05$): r $VO_{2\,max}$ and W 120 s = 0.51, r La and W 120 s = 0.75; programs B: r $VO_{2\,max}$ and W 90 s = 0.83, $VO_{2\,max}$ / kg, and W and W 90 s = 0.83, r La and W 90 s = 0.60. These data indicate the in formativeness of the characteristics of the power of aerobic energy in the process of performing the test “120 s” and the test load “90 s” performed against the background of the development of fatigue. The average values of indicators and their statistical characteristics are presented in Table 1. From the table it can be seen that the O_2 consumption indicators had high average $VO_{2\,max}$ values. High average values of ergometric power and concentration of blood lactate indicate a high degree of implementation of the functional support of the rowers. However, the absolute and relative characteristics of aerobic capacity, recorded in two tests, did not differ significantly. The table also shows that in the absence of differences in average indicators, the characteristics of $VO_{2\,max}$ had a high range of individual differences. Figure 1 shows schematically the differences in the maximum O_2 consumption ($VO_{2\,max}$ / kg).

Table 1

Indicators of O_2 consumption by paddlers, registered during the implementation of the program "A" and "B" (n = 30)

Statistics	Program A data				Program B data			
	$VO_{2\,max}$	VO_2 max/kg	$\bar{w}$, Watts	La, mmol·l^{-1}	VO_2 max	VO_2 max/kg	$\bar{w}$, Watts	La, mmol·l^{-1}
$\bar{x}$	5,63	65,20	277,93	14,89	5,66	65,56	280,13	14,94
Me	5,60	64,30	279,50	14,70	5,60	66,17	276,00	14,85
S	0,24	4,40	15,40	1,64	0,29	4,46	33,93	1,97
min	5,20	57,45	250,00	12,10	5,20	57,95	234,00	11,50
max	6,20	75,11	305,00	18,80	6,30	76,42	389,00	19,50
25%	5,50	62,39	264,00	13,60	5,50	62,06	251,00	13,40
75%	5,80	67,42	290,00	15,70	5,90	68,88	294,00	16,60
CV	4,22	6,75	5,54	11,02	6,41	6,80	12,11	13,19



Individual VO_2 max indicators in tests “120 s” “90 s”

Fig. 1 Indicators of the relative maximum consumption of O_2 (VO_2 max / kg), registered in the tests "120 s" and "90 s":

- $VO_{2\,max}$ / kg values recorded in the “120 s” test;
- $VO_{2\,max}$ / kg values recorded in the 90 s test

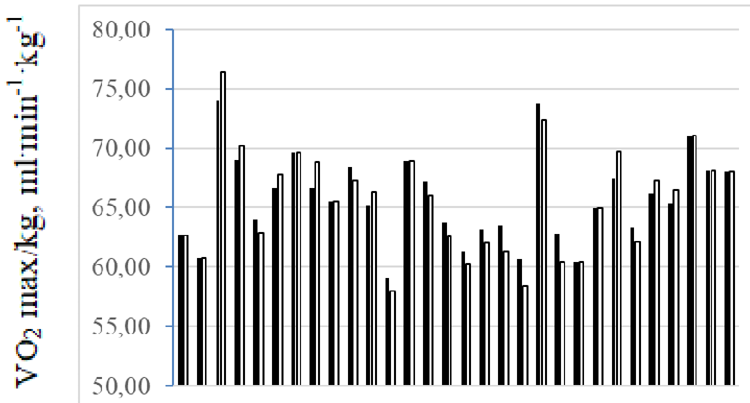
The figure shows that one group of athletes had the highest characteristics in the test “120 s” (n = 13), the other - in the test “90 s” (n = 15). Two rowers registered the same $VO_{2\,max}$ values in two tests.

Table 2 shows the statistical characteristics of the maximum consumption of O_2, registered in the process of performing the step test and the test "90 s" (program B). The table shows that there were no statistically significant differences in the average values of $VO_{2\,max}$ and $VO_{2\,max}$ / kg. Figure 2 shows schematically the individual indicators recorded in the two tests. The figure shows that the individual $VO_{2\,max}$ / kg, each paddler does not differ or differ slightly. There is a trend (r $VO_{2\,max}$ / kg and w¯90 s = 0.43), in which a high level of ergometric power of work is associated with maintaining or a slight increase in $VO_{2\,max}$ / kg in conditions of development of fatigue (test “90 s”) compared with the level of the indicator recorded in the step test. These data are presented in table 3.

Table 2

Indicators of O2 consumption by rowers on kayaks, registered during the execution of the program "B" in the step test and the test "90 s" (n = 30)

Statistics	Step test		test “90 s”	
	VO_2 max	VO_2 max/kg	VO_2 max	VO_2 max/kg
$\bar{x}$	5,67	65,72	5,66	65,56
Me	5,60	65,45	5,60	66,17
S	0,20	3,75	0,29	4,46
min	5,40	59,05	5,20	57,95
max	6,10	73,99	6,30	76,42
25%	5,60	63,18	5,50	62,06
75%	5,80	68,11	5,90	68,88
CV	5,67	65,72	6,41	6,80



Individual indicators of VO2 max in the step test and in the test "90 s"

Fig. 2 Indicators of the relative maximum consumption of O2 (VO2 max / kg) registered in the step test and the “90 s” test:

- VO2 max / kg values registered in the step test;

- VO2 max / kg values recorded in the 90 s test

From table 3 it can be seen that 18 paddlers had a higher or the same (as compared with the indicator registered in the step test) the VO_2 level max / kg, 12 – lower. There is reason to think that this is due to the mobilization of functional reserves of the body and the compensation of fatigue in the process of performing the 90 second test task.

Table 3

Characteristics of ergometric power of work of rowers with high and reduced levels of aerobic power in the test "90 s"

Statistics	Ergometric power characteristics in the test "90 s", ($\bar{w}$), Watts	
	Paddlers with high level of VO_2 max/kg (n=18)	Paddlers with lover level of VO_2 max/kg n=12
$\bar{x}$	298,17	253,08
Me	291,00	248,50
S	31,16	14,29
min	263,00	234,00
max	389,00	278,00
25%	279,00	243,50
75%	308,00	265,00
CV	10,45	5,65

Discussion.

The results of measurement, evaluation and interpretation of the characteristics of $VO_{2\ max}$, blood lactate concentration, ergometric power of work ($\bar{x}$) testified to the high level of functional readiness of paddlers and group homogeneity. It took into account the fact that the ability to achieve $VO_{2\ max}$ in the process of training and competitive loads is one of the factors for the development and realization of the energy potential of the paddlers.

It is well known that the realization of the aerobic potential is associated not only with the achievement of peak reaction values. An important factor in its implementation is the high speed of deployment and the stability of the reaction, the maintenance of the achieved level of VO_2 (some increase in the reaction is possible) in the process of compensating fatigue [12, 15]. The structure of aerobic energy supply, the significance of each component of the reaction differs, depending on the duration and intensity of work at a distance of 200 m, 500 m and 1000 m [1]. This requires a more detailed analysis to determine the conditions for the realization of the power of aerobic energy supply, taking into account the individual structure of the paddlers' reaction.

The measurements showed that the average statistical values of $VO_{2\ max}$ and $VO_{2\ max}$ / kg ($\bar{x}$) in the process of performing all the test options did not differ much. At the same time, an important result of measuring the power of aerobic energy supply is a high range of individual differences in $VO_{2\ max}$ and $VO_{2\ max}$ / kg. The analysis showed that such differences are associated with individual differences in $VO_{2\ max}$ and $VO_{2\ max}$ / kg, recorded in different testing conditions.

The statistical characteristics show that for 14 paddlers high $VO_{2\ max}$ values were recorded during the execution of test loads focused on the manifestation of special speed capabilities, for 14 paddlers in the development of endurance, where the accumulation factor of fatigue played a decisive role. For 2 paddlers, indicators recorded in different conditions did not differ. It should be noted that the individual $VO_{2\ max}$ indicators registered during the simulation of 200 m, 500 m and 1000 m distances differed from those recorded according to the $VO_{2\ max}$ protocol. This indicates that the measurements of the power of aerobic energy supply, carried out according to the $VO_{2\ max}$ measurement protocol for highly qualified paddlers, do not fully reflect the individual possibilities for the realization of aerobic power in conditions close to the competitive ones. This is due to the fact that the registration of the characteristics of the power of aerobic energy supply, carried out according to the $VO_{2\ max}$ measurement protocol, is focused on standard testing conditions. A distinctive feature of the measurement of aerobic power, carried out according to the $VO_{2\ max}$ measurement protocol, is the conditions under which the degree of hypoxia and hypercapnia development, the accumulation rate of anaerobic metabolism products differ from the cardiorespiratory system response structure and the aerobic energy supply in the process of performing types of competitive loads in rowing [13, 16]. Obviously, the degree of impact of neurohumoral stimul in the process of overcoming distances of 200 m, 500 m and 1000 m is a stronger stimulus for the response of the cardiorespiratory system and energy supply of work [15, 18].

The degree of the impact of physiological stimuli of the reaction, and as a result, the degree of severity of the power of aerobic energy supply at each distance depends on the individual characteristics of the paddlers, the structure of the reactive properties of the body [4, 12]. Therefore, in the process of measuring the power of aerobic energy supply, an important role is played by the correct choice of test load modes, which take into account the structure of the functional support of special performance at each distance and individual reactive properties of the body, which manifest themselves by the body's response to developing hypoxia, progressive hypercapnia accumulation of anaerobic metabolism products. This fully applies to the selection of training and competitive work modes, which ensure the ability of athletes to quickly, adequately and fully respond to physiological stimuli of the reaction. Performance of individual reactivity of the organism can be corrected by the system of extra-training and training effects that the athlete used in the process of many years of preparation. Modes of training, selected adequately to the individual reactivity of the body of athletes, are one of the factors for the development and realization of the potential of athletes.

According to the literature, paddlers with a hyperactive type of cardiorespiratory system reaction can have a higher level of $VO_{2\ max}$ at a distance of 500 m [4]. The high speed of development of $VO_{2\ max}$ in the process of performing high-speed loads increases the integral power level of the power supply system, increases the share of economical aerobic power supply in the total energy balance [3]. This is a factor in increasing the energy efficiency of training and competitive work for rowers who specialize in distances of 200 m and 500 m [19].

Special attention in canoe attract athletes who have the same performance of aerobic power, achieved in conditions of high-speed loads and in the process of performing endurance tests. As a result of testing, such characteristics were noted in two paddlers. At the same time, they took into account the performance of one athlete, whose $VO_{2\ max}$ and $VO_{2\ max}$ / kg levels reached high values in the “120 s” and “90 s” test - 5.7 l $\cdot min^{-1}$ and 71.1 ml$\cdot kg^{-1} min^{-1}$. This indicates the uniqueness of such characteristics, confirms the need for a differentiated analysis of the conditions for the implementation of aerobic capacity. According to the literature, the paddlers with the norm and hypoactivity type of cattle reactivity reach the highest aerobic power indices in the second half of the 1000 m distance [4]. At the same time, the factor of development of fatigue and the possibility of its compensation in the process of overcoming the second half of the distance matter. As a result of the research conducted, attention is drawn to the fact that the paddlers, who had a higher level of performance in terms of development and compensation for fatigue), had higher levels of aerobic power supply in the “90 s” test, compared to indicators registered during the step-test, which was performed according to the VO_2 measurement protocol max.

Thus, it can be stated that the measurement, evaluation and interpretation of the characteristics of aerobic power, carried out in accordance with the individual characteristics of the reactivity of the workout, increase the specialized focus of the training process based on improving the efficiency of selection and sports orientation of the paddlers, clarifying the specialization in the form of sports, individualizing training modes.

Conclusions. Measurement of the power of aerobic energy supply of paddlers requires consideration of age, qualifications and specialization at a distance of 200 m, 500 m and 1000 m. The average statistical indicators of $VO_{2\ max}$ did not differ significantly in the process of performing all types of tests. Individual differences of indicators in the test “120 s”, test “90 s” and in the test performed according to the $VO_{2\ max}$ measurement protocol are noted. 14 paddlers reached $VO_{2\ max}$ in the process of implementing special speed capabilities, 14 paddlers in the process of performing test loads aimed at showing endurance, 2 paddlers had the same performance in the process of performing test loads of two types. Individual differences were $VO_{2\ max}$, registered in the conditions of the implementation of special speed capabilities and endurance ranged from 3.2% to 4.3% In tests for endurance, a higher level of special performance was shown in paddlers, who reached a higher level of $VO_{2\ max}$ in conditions of development of compensated fatigue (test "90") compared to paddlers, who reached higher values of aerobic power supply in the test performed according to the VO_2 measurement protocol max. A high level of power aerobic energy supply of paddlers of high class can be achieved in various load conditions that simulate the performance of special speed capabilities or endurance, during the period of compensating for fatigue. This is due to the individual reactivity of the body to the severity of hypoxia, hypercapnia, accumulation of anaerobic metabolism products, characteristic of each competitive distance. Analysis of the conditions for the implementation of $VO_{2\ max}$ influences the choice of specialization in canoe, as well as the modes of training work aimed at realizing the energy potential of paddlers. This requires individualization not only of the conditions for testing the paddlers, but also the development of a system of training facilities, taking into account the individual reactive properties of athletes.

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