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ORIGINAL SCIENTIFIC PAPER

The Use of Ergometry in the Kayakers´ Special Physical Conditioning

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Abstract

The main objective of this research was to determine the individual parameters of the ergometric working capacity, aimed at increasing the functionality and special performance of kayakers. Subjects in the research were 20 elite male kayakers, leading athletes of Jiangxi provinces, age =21.9±2 years. Testing of special working capacity and functional readiness of kayakers, shows the individual and statistical characteristics of ergometric power and energy supply of work corresponding to the level of training of skilled athletes. A number of indicators (VO_2max – 6.0 $l{\cdot}min^{-1}$, La test 30 s– 12.0 $mmol{\cdot}l^{-1}$. La test CP – 16.0 $mmol{\cdot}l^{-1}$) indicated the high potential of kayakers who corresponded to the world-class model. The given individual and statistical characteristics of the kayakers' readiness testify that the increase of efficiency of functional maintenance of a particular area affects the working capacity and functional capabilities of the kayakers in the process of overcoming all segments of the competition distance. Increasing special working capacity based on the relationship between the structure of special functional readiness and the structure of competitive activity is one of the most effective ways to form and to realize functional reserves of special readiness of kayakers.

Keywords: *kayakers, ergometric power, aerobic power supply capacity, functionality testing, working capacity*

Introduction

The main condition for effective functional training is the formation of training load modes, which are based on the high accuracy of measuring the parameters of the work and functional capabilities of athletes in accordance with the structure of the functional support of the special performance of athletes in a specific competitive discipline (Droghetti et al., 1998). Observance of high accuracy of measurement makes it possible to form modes of training exercises in which the highest (necessary) level of the body's reaction was achieved (Lysenko, Shinkaruk, & Samuilenko, 2004). This can be achieved only through the implementation of control as a system component of management of the training process, when its functions allow assessing the level of training, to form the direction of sports training, and to determine individual parameters of training work (Mac Dougall, Wenger, & Green, 1991).

The special literature presents the means and methods of testing athletes, which make it possible to form load conditions, where the components of the functional support of special working capacity are fully manifested. The special literature presents testing methods, which show the conditions of implementation of the components of anaerobic energy supply - anaerobic lactate and lactate power and capacity (Mac Dougall et al., 1991), aerobic power (Diachenko et al., 2020), aerobic capacity (Bourgois & Vrijens, 1998; Droghetti et al, 1998), functionality in terms of compensation for fatigue during critical power loads (Hill, 1993) and others.

The problem is that with a wide choice of testing methods, the issue of applying test results in practice remains little studied. The test results are focused on assessing the readiness of athletes, who, as a rule, determine the direction of correction of the training process.

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There is a clear lack of methods that allow simulating training loads in accordance with the individual level of the athlete's response. Training loads, as a rule, are focused on the maximum parameters of intensity (power) and duration of work. At the same time, the individual norms of the body's reaction to specific training and competitive ones, which underlie the optimization of the "dose-effect" ratio of the impact, are little taken into account. This negatively affects the formation of training effects. This is well illustrated by the example of the development of aerobic energy supply. The development of aerobic energy supply requires the exact correspondence of the work parameters to the functional support of working capacity in the threshold zones of the reaction of the cardiorespiratory system and aerobic energy supply (AT, VO_2max). It is well known that exceeding the level of reaction leads to a change in the structure of the reaction and, accordingly, to a change in the effects of training tools (Bourgois & Vrijens, 1998; Michael, Rooney, & Smith, 2008; Paquette, Bieuzen, & Billaut, 2018).

Many authors associate the solution with the use of ergometry as a control of functional readiness and a tool for managing training loads (Bourdin, Messonnier, Hager, & Lacour, 2004; Carrasco, Martinez Diaz, De Hoyo, Sanudo Corrales, & Ochiana, 2010; de Klerk, Velhorst, Veeger, van der Woude, & Riemer Vegter, 2020). Modern ergometry is based on the use of special simulators, which, according to the kinematic and dynamic structure of locomotion, simulate the conditions of competitive activity and allow real-time recording of work parameters (Dal Monte, Faina, & Menchinelli, 1992; Steer, McGregor, & Bull, 2006; Šarabon, Kozinc, Babič, & Marković, 2019). In the control system and in the process of training in cyclic sports, simulators are used that allow an athlete to independently (without program correction) develop the ergometric power of work in accordance with his individual efforts. This opens up new possibilities for the implementation of the main principle of functional training - the use of conditions for achieving and maintaining the level of reaction necessary for the development of athletes' functional capabilities.

In kayaking, the “Dansprint” ergometer simulator is widely used. The technical parameters of the ergometer make it possible to model the parameters of the competitive activity of kayakers at distances of 200 m, 500 m and 1000 m, as well as the conditions for the implementation of the components of the functional support of special working capacity (Carrasco et al, 2010; Wang, Rusanova, & Diachenko, 2019). Comprehensive testing of kayakers using ergometry and biological methods of measuring functional capabilities allows determining with high accuracy the parameters of work at which kayakers have reached maximum power and reaction capacity. Under the conditions of testing with the use the “Dansprint” ergometer, informative characteristics of the threshold of anaerobic metabolism (AT), maximum consumption of O_2 (VO_2 max), pulmonary ventilation (VE), CO_2 release (VCO_2), calculated reaction characteristics (EqO_2 and $EqCO_2$) and other reaction characteristics were recorded organism on model loads (Diachenko et al., 2020). An important condition for the implementation of ergometry as a tool for monitoring and modeling training loads is the measurement of changes in reaction in the process of a steady state and compensation of fatigue. The use of ergometry makes it possible to measure with high accuracy and apply in practice the working conditions aimed at the development of these highly specific manifestations of the functional support of special working capacity. In theory and practice, such approaches are presented in the process of modeling various load cases “critical” power (CP) work (Hill, 1993).

This gives grounds to use the data of testing functional capabilities for the formation of individual parameters of training work and use them in accordance with the patterns of stimulation of adaptation processes under the influence of intense physical loads.

Purpose of the study was to determine the individual parameters of the ergometric power of work, aimed at increasing the functionality and special performance of kayakers.

Methods

Subjects

Twenty (20) elite male kayakers, leading athletes of Jiangxi provinces, age =21.9±2 years. All participants were informed of the requirements prior to the study, and gave their informed written consent to participate. The local research ethics committee in the spirit of the Declaration of Helsinki approved all procedures.

Research protocol

For standardizing the measurements of special performance, the “Dansprint” kayakers´ ergometer were used VO_{2max}, La, and ergometric power (EP) of work were recorded. The specialists of the Scientific Sports Management Research Centers in Shandong Province (Jinan) and Jiangxi (Nanchang) carried out the measurements of the reaction of the cardiorespiratory system and blood sampling for lactate measurement.

Variables measured

Gas exchange, HR, and blood lactate measurements.

Oxygen consumption ($\dot{V}O_2$), CO_2 production ($\dot{V}CO_2$), minute ventilation ($\dot{V}E$), and RER were determined on a breath-by-breath basis using an Oxycon mobile (Jaeger) metabolimeter. HR was recorded every 5 s with an HR monitor (S610 Polar Electro, Kempele, Finland).The blood lactate concentration ([La]b) was determined using a portable lactate analyzer (Biosen S. line lab +).

The content of the testing program (Vogler et al, 2010; Wanget al 2019) is presented in Table 1.

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

Statistical Analysis

In order to assess and analyze the data received the Statistical Package (SPSS 10.0) was used. Descriptive statistics suggested defining arithmetical average - $\overline{x}$, standard deviation - SD, as well as median - Me, maximal (Max) and minimal (Min) indices, 25% and 75% indices. Correlation analysis used. The data was verified in accordance with the normal probability law (applying the Shapiro Wilk criteria). If the data were normally distributed, then in order to define the statistical significance, Student t-Criteria was applied. In case the data were not normally distributed, non-parametric criteria of Wilkinson was applied to define the statistical significance. The error probability during the statistical analysis was set at the level of p=0.05 (significance level).

Table1. Characteristics of tests and indicators aimed at assessing the special work ability and functionality of kayakers, taking into account fatigue compensation

Test task parameters	Registered indicators
Modelling of conditions of realization of Anaerobic Alactic (AA) power- "test 10 s"	$\overline{W}$ 10 c, Watt
Recovery period - 3 minutes	
Modelling of conditions of realization of Anaerobic Power (ANP) - "test 30 s"	$\overline{W}$ 30 c, Watt; La test 30 s, mmol·$^{l-1}$ (blood sampling 3 and 7 minute recovery period); delta (Δ) lactate difference of lactate 3 and 7 minutes.
Recovery period - 10 minutes	
Modeling of conditions of realization of aerobic power - "step test". Duration of work on a step - 2 min, number of steps - individually, before decrease in EP of loading set on a step. EP of the first stage = EP of standard loading + 30 Watt; increase in EP load on the step + 30 Watt	$\overline{W}$ VO_2max, Watt VE/VO_2,c. u., V_E/VCO_2,c. u.; VO_2 max / kg, ml·min^{-1}·kg^{-1}; VO_2 max, l·хв$^{-1}$
Recovery period – 1 minute	
Modeling the conditions of fatigue - test "CP test 90 s"	$\overline{W}$ "CP test 90 s", Watt; VE/VO_2, VO_2 c. u., .; V_E/VCO_2;VO_2 c. u., VO_2 / kg, ml·min^{-1}·kg^{-1}; VO_2max, l·min^{-1} La, mmol·l^{-1} (blood sampling 3 and 7 minute recovery period); delta (Δ) lactate difference of lactate 3 and 7 minutes.

Results

Testing of special working capacity and functional readiness of kayakers was carried out. Table 2 shows the individual and statistical characteristics of the ergometric power of the kayakers ' work. The table shows that the average indicators of ergometric power and energy supply of work correspond to the level of training of skilled athletes. Several indicators (VO_{2max} – 6.0 l·min^{-1}, La test 30 s– 12.0 mmol·l^{-1}. La test CP – 16.0 mmol·l^{-1}) indicated the high potential of kayakers who corresponded to the world-class model.

Table 2. Individual data on ergometric power and functionality of kayakers, (n=20), p<0.05

№ athletes	$\overline{W}$ test 10 s	$\overline{W}$ test 30 s	La test 30 s	VO_2 max	VO_2 max/kg	$\overline{W}$ VO_2 max	$\overline{W}$ test CP 90 s	La test CP 90 s
1	461.0	392.0	10.3	4.1	50.2	187.0	212.0	15.8
2	541.0	432.0	9.1	4.7	50.0	210.0	270.0	15.8
3	405.0	410.0	9.5	6.0	64.9	227.0	229.0	15.,4
4	428.0	462.0	11.8	5.9	63.4	207.0	231.0	18.3
5	436.0	394.0	10.5	5.0	62.5	184.0	254.0	15.5
6	506.0	408.0	9.3	5.5	61.2	182.0	249.0	16.0
7	508.0	483.0	10.9	6.0	63.2	191.0	269.0	13.0
8	497.0	417.0	9.8	4.1	45.1	184.0	255.0	12.8
9	397.0	363.0	12.1	4.5	54.2	170.0	215.0	11.0
10	427.0	418.0	11.7	5.2	56.0	187.0	247.0	10.3
11	449.0	370.0	10.7	5.0	60.6	189.0	229.0	13.8
12	373.0	338.0	7.6	5.0	62.5	164.0	191.0	14.7
13	337.0	331.0	8.6	4.4	56.9	159.0	217.0	15.8
14	416.0	360.0	8.8	4.3	51.2	171.0	196.0	14.8
15	369.0	311.0	10.1	3.9	44.5	178.0	213.0	16.0
16	318.0	295.0	7.5	4.2	55.6	136.0	143.0	12.2
17	336.0	252.0	5.6	4.2	52.1	145.0	181.0	10.7
18	299.0	254.0	7.7	4.0	56.3	128.0	148.0	11.9
19	288.0	298.0	6.6	4.9	54.4	162.0	161.0	10.9
20	292.0	329.0	9.3	4.2	50.6	169.0	192.0	14.1
	404.2	365.9	9.4	4.8	55.8	176.5	215.1	13.9

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Table 2. Individual data on ergometric power and functionality of kayakers, (n=20), p<0.05

№ athletes	$\overline{W}$ test 10 s	$\overline{W}$ test 30 s	La test 30 s	VO_2 max	VO_2 max/kg	$\overline{W}$ VO_2 max	$\overline{W}$ test CP 90 s	La test CP 90 s
median	410.5	366.5	9.4	4.6	55.8	180.0	216.0	14.4
SD	76.8	64.6	1.7	0.7	6.1	24.2	37.8	2.2
min	288.0	252.0	5.6	3.9	44.5	128.0	143.0	10.3
max	541.0	483.0	12.1	6.0	64.9	227.0	270.0	18.3
25%	336.5	320.0	8.2	4.2	50.9	163.0	191.5	12.1
75%	455.0	413.5	10.6	5.1	61.9	188.0	248.0	15.8
CV	19.0	17.7	18.6	14.4	11.0	13.7	17.6	16.0

Legend: $\overline{W}$ test 10 s - average ergometric power of work in test 10 s; $\overline{W}$ test 30 s - average ergometric power of work in test 30 s; La test 30 s- lactate concentration after test 30 s; VO_2max -oxygen consumption; VO_2max / kg- relative oxygen consumption; $\overline{W}$ VO_2max- maximal aerobic power; $\overline{W}$ test CP 90 s - average ergometric power of work in test 90 s; La test CP90 s - lactate concentration after test 90 s

Table 3 shows a high degree of intercorrelation of indicators of ergometric power and functionality of kayakers. At the same time, attention is drawn to the fact that with a large number of reliable links, most indicators have a high level of individual differences.

The characteristics of the relationship between the kayakers' working productivity from the level of functional readiness are presented in Table 4. Noteworthy are the correlations between the indicators of ergometric power of work and physiological indicators of functional readiness.

Table 3. Correlation coefficients of indicators of functional capabilities and ergometric power of kayakers (n=20), p<0.05

Data	$\overline{W}$ test 10 s	$\overline{W}$ test 30 s	La test 30 s	VO_2 max	VO_2 max / kg	wVO_2 max	$\overline{W}$ test CP 90 s	La test CP 90 s
	1	2	3	4	5	6	7	8
1	–	0.84	0.55	0.41	0.10	0.69	0.87	0.4
2	0.84	–	0.73	0.68	0.33	0.84	0.87	0.4
3	0.55	0.73	–	0.37	0.16	0.61	0.66	0.3
4	0.41	0.68	0.37	–	0.82	0.64	0.50	0.2
5	0.10	0.33	0.16	0.82	–	0.24	0.16	0.2
6	0.69	0.84	0.61	0.64	0.24	–	0.79	0.5
7	0.87	0.87	0.66	0.50	0.16	0.79	–	0.4
8	0.36	0.42	0.28	0.25	0.19	0.53	0.37	–

Table 4. Indicators of the relationship between productivity and functionality of kayakers

The basic component of special efficiency	Physiological characteristics associated with the basic component of correlation dependence
Anaerobic alactic working performance, test 10 s	Power of glycolytic reactions
Anaerobic lactic working performance, $\overline{W}$ test 30 s	Power of glycolytic reactions, maximum consumption o_2 (absolute indicators)
Anaerobic working performance,WVO_2max	Maximum consumption o_2 (absolute indicators), power and capacity of anaerobic lactic energy supply
Work performance during fatigue compensation, $\overline{W}$ test 10 s	Power of glycolytic reactions, maximum consumption o_2 (absolute values)

On the basis of the given data, as well as modeling, it is possible to form the structures of the training process, which are based on the registration of working capacity parameters in accordance with the individual level of reaction and the use of control results in natural conditions of the training process.

Discussion

Ergometry is most widely used in cyclic sports, where special ergometers have been developed and are successfully used in the practice of control and training work, which simulate the kinematic and dynamic structure of locomotion and allow real-time recording of work parameters.

This allowed to simulate test and training loads in accordance with the structure of competitive activities and the general patterns of implementation of functional support of special working capacity (Vilaça-Alves et al., 2016). These can be test loads aimed at implementing the integral structure of special working capacity in the process of modelling a competitive distance or its individual components - the initial segment, the middle and the second half of the distance (Wang et al., 2019). In this case, we are talking about taking into account the specific components of the functional support of special working capacity - a high speed of deployment of reactions, a steady state and compensation for fatigue (Mishchenko & Suchanowski 2010).Depending on the duration and intensity of competitive activity (Nikonorov, 2015), functional readiness (Mishchenko & Suchanowski, 2010), individual reactivity of athletes to neurogenic, hypoxic and acidemic stimuli (conditions that accompany athletes in the process of performing competitive loads) differ in the structure of the reaction and parameters of athletes' performance (Warren, 1986; Miyamoto, Nakazono, & Yamakoshi, 1987; Mishchenko, Lysenko, & Vinogradov, 2007).

The body's response to physiological stimulus forms an individual structure of the functional support of special working capacity, which depends both on the individual capabilities of athletes and on the course of adaptation processes under the influence of training loads that simulate these states. Determination the parameters of such work is possible only on the basis of a comprehensive ergometric and physiological testing, which will make it possible to determine the parameters of work in accordance with the level of reaction and use the registered parameters in the process of standardizing the modes of training work (Withers, Van der Ploeg, & Finn, 1993). An important role is played by the accuracy of measuring the indices of special performance in accordance with the response of the cardiorespiratory system and the energy supply in the process of modeling a specific distance (Ward, Lamarra, & Whipp, 1996).

The proposed methodology allows to allocate the leading components of the functional support of special working capacity, to differentiate the conditions for their registration and to determine the parameters of training work in accordance with the individual body's response to the load. Standardization of measurement conditions allows to control changes in special working capacity during the training period, to check cumulative changes in functional capabilities after a certain period of the training cycle of athletes.

The technique allows to develop and apply in practice types of load, which allow the directed development of the power of anaerobic alactic and lactic energy supply, the power of aerobic energy supply, the possibilities of compensation of fatigue. Optimization of parameters of work and reaction of an organism according to "dose-effect" of influence will allow to stimulate necessary level of the body's reaction, as well as perform the required amount of training work in accordance with the requirements of the structure of the functional support of special working capacity, taking into account the group differences in athletes' readiness.

Obviously, in the process of developing training programs, it is necessary to take into account general and special factors that affect the formation of a specialized orientation. In the process of developing training programs, at the very beginning, it is necessary to determine the structure of the functional support of special working capacity in accordance with the structure of the competitive distance, to highlight its leading components and the conditions for their implementation. After that, develop test tasks in accordance with the conditions for the implementation of the components of the functional support of special operability. As a result of testing, register the indicators of ergometric power and physiological characteristics of the reaction. In the process of modeling training loads, use individual indicators of ergometric power of work in accordance with the recorded characteristics of work.

Conclusion

Ergometry is an effective tool for the development and implementation of the body's functional reserves. This modern method of control and management of training loads allows you to determine the parameters of training work in accordance with the individual level of the body's response to the load.

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Conflict of Interest
The authors declare that there are no conflicts of interest.

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