Original Article

Planning special physical training for rowers in China: a randomized study

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Abstract.

Purpose: It is considered that the use of training approach for special physical training in the conditions of latent (compensated) fatigue is a necessary condition for increasing the special performance of rowers throughout the second half 2000 m racing distance. Of particular relevance is the implementation of this approach in rowing, where a high level of special performance of athletes with the development of fatigue during the racing distance is one of the key factors for achieving high sports results. **Participants.** The study included the leading rowers of the province - members and candidates for Shandong provincial rowing team. Total - 40 man athletes at the age from 18 to 23 years. Studies were conducted in the water sports centre of Shandong Province (China) during the competition period. **Results:** These data indicate that the increase in the effectiveness of competitive activity has resulted from an increase in the special performance of rowers in the second half of the course during the period of hidden (compensated) fatigue. There is reason to believe that one of the factors for increasing the special performance in the second half of the distance is the use of the training effects system presented in the work, including exercise groups, where the parameters for determining the work parameters were strictly individual and resulted from monitoring the functional support of the special rowers in developing fatigue typical of the second half of the competition distance. In the process of controlling the passage of the competition distance, the time to throughout the 1000–1500 m, 1500–2000 m and the entire distance trail decreased by 2.9 ± 0.2 s, 4.2 ± 0.3 s, 7.1 ± 0.4 s in the process of overcoming the 2000 m racing distance in the natural conditions of training.

Keywords: rowing, functionality, working capacity, loads, special physical training.

Purpose.

In the scientific and methodological literature considered content of sports training of qualified athletes in rowing in the special preparatory period of training, as well as factors affecting the special performance of rowers in the context of developing fatigue in the process of overcoming a 2000 m racing distance, to present quantitative and qualitative characteristics of the special performance and functionality in the process of training and competitive activities rowers [C. Gore at al. (1996); A.Y. Dyachenko (2007)].

The content of special physical training of rowers was considered taking into account fatigue compensation factors [T. Tomiak (2008); J. Tran at al. (2015)]. Systematic training approaches aimed at improving the functional support of the special performance of the rowers [R. Kropta at al. (2017); V. Bohuslavskaya at al. (2017); Kong Xianglin at al. (2019); A. Diachenko at al. (2020)].

To reveal the role and place of training approaches aiming at increasing the special working capacity of rowers in conditions of developing fatigue throughout the 2000 m racing distance [G. Russell at al. (2002); A. Yu. Dyachenko (2007); Pralay Majumdar at al. (2017)]. Assessing fatigue compensation, quantitative and qualitative rowers' performance features, cardio-respiratory system reactions and energy supply of work in conditions of latent (compensated) fatigue [U. Hartmann at al. (1993); V. Mishchenko at al. (2010)]. It is considered that the use of training approach for special physical training in the conditions of latent (compensated) fatigue is a necessary condition for increasing the special performance of rowers throughout the second half 2000 m racing distance [A. Yu. Dyachenko (2004); Kong Xianglin at al. (2018)]. Of particular relevance is the implementation of this approach in rowing, where a high level of special performance of athletes with the development of fatigue during the racing distance is one of the key factors for achieving high sports results [S. A. Ingham at al. (2002)].

Methodology of research.

Participants.

Materials and methods. Studies were conducted in the water sports centre of Shandong Province (China) during the competition period. The study included the leading rowers of the province - members and candidates for Shandong provincial rowing team. Total - 40 man athletes at the age from 18 to 23 years.

Procedure In the group of ergometry and physiological methods included methodological means and tests to evaluate ability on special ergometry equipment (Concept-II) and in the appropriate training conditions on the rowing channel. In addition, the methods and equipment were used to measure the response of the rowers' cardiorespiratory system and energy supply response under the conditions of fatigue throughout the second half race distance (see below). The fundamental complex of ergometry tests is to proposed the high class athlete and to approved. The composition of the test was taking into account the possibility of assessing the features of special working ability in conditions of latent (compensated) fatigue and features throughout the 2000 m race distance. The first test was developed before and is now widely used in the system for assessing the special ability of oarsmen [A. Yu. Dyachenko (2004)].

It included performing 60 seconds' acceleration and working with maximum intensity for 6 minutes (on the Concept II paddle ergometer). The recovery period between tasks was 10 minutes. Complex of tasks that were used in the process of control and estimation of the special performance of rowers in the conditions of the latent (compensated) fatigue included:

1. Test for the estimate the special performance and functional abilities of rowers in the designed 2000 m race distance (test of "MZD 2000"). The work designed to finish the 2000 m race distance with the individual tactical variation.

2. Complex of tests for measuring of potential (to reserve) of the special performance and functional abilities on ergometer of Concept II, that included next test tasks:

-Standard six minutes work on rowing ergometry (Concept - II). Set up the work power 2,5 W per kilogram bodyweight with 28 stroke rate as the initial load, increasing 30 W every 2 minutes on the initial work power and end up with the 2 minutes' maximal work 1 minute after the step-growing test. In the process of modelling experimental test tasks, the length of the rest intervals between the tests was important. In experimental test tasks, which included series of loads simulating the conditions of fatigue, the growing rest interval between the stepwise-increasing load and the maximum loads was one minute. The rest interval between warm-up and tests aimed at the realization of power or capacity of anaerobic energy supply is 6 minutes. In a series of test tasks, which consisted of a one-minute maximum test and a special 6-minute test, which simulates (by the layout of forces) throughout the race distance, the interval of rest was 10 minutes. Physiology methods of estimation of urgently adaptation reactions and dynamics of capacity included measuring registered functional indicator which providing the special performance of academic rowers. For the group of rowers in a boat-racing the complex testing was conducted with the ergometer, estimation of level of blood lactate concentration.

Ergometerical indexes that specified on efficiency of implementation of components of the special endurance of rowers were estimated: speed-power potential (starting acceleration), efficiency of drawing on anaerobic reserve on distance, efficiency of work on distance in the conditions of accumulation of fatigue, general ability on distance; physiology indexes of cardiorespiratory system reaction and energy supply. The system of test tasks is a single complex, including simulation of the 2000 m race distance ("MZD 2000") and a set of task tests aimed at assessing the functionality and special performance of rowers. The content and composition of the test construction tasks assumed an estimation of the sides of the functional potential (reserve) of the organism and the ability of its realization with an increasing during the second half race distance. The results of the measurement made it possible to determine the individual parameters of the regimen of training exercises, as well as in determining the power and the duration of work when the "threshold of fatigue" occurred. The control of special ability and functionality was conducted within two days. On the first day in the process of modeling the racing activity featured the ergometerical power indicators, which characterized the effectiveness of the starting acceleration, the first stage and the second half distance. During the performance of the "MZD 2000" test, the cardiorespiratory reaction and energy supply of work were recorded, which reflected the efficiency of the functional support of the workload in the second half of the distance. It was considered that the informativeness of physiological indicators grows as a result of comparison with the characteristics registered in the testing conditions to ensure reaching the highest reaction level.

The following research equipment was used:

1. For registration of indexes of the special performance and functional ability of rowers there was the used gas analyzer of Metamax 3b (Germany).

2. "Polar" (Finland) from telemetric registration of HR during loading and Hr- analyzer for the computer processing of data.

3. Laboratory complex for determination of lactate of blood of LP 400, "Dr Lange" Germany. The blood sample was researched by the specialists of Centre of scientific researches in sport of province Shandong. The obtained data were used and analysed in relation to the tasks of work.

4. For standardization of measuring of the special performance rowing of "Concept II" (The USA) was used. The dynamic and average ergometerical power, time throughout the trail was registered. "drag factor" progressed in accordance with gravimetric parameters and individual's rowing style.

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 -, 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.

Research results.

A special training program for rowers with using the experimental approach was implemented between the two main season starts, the spring (April 21–26, Guangzhou) and the autumn (October 13–22, Xiamen) Chinese Rowing Championships.

During the period, athletes conducted a full preparation cycle until the final start of the season. In the course of preparation for the main rowers, a special physical training program was developed, which included experimental training facilities. The content of the program is presented in table 1 and table 2.

The distinguished feature of program was use significantly larger amount of training approach with a “competition-like” working intensity. At the same time, experimental training approach were integrated into the training effects system. It should be noted that the traditional Chinese training modes were also used in the system of special training. These were training approach that were focused on the training load, in intensity close to the level of the aerobic and anaerobic (glycolytic) threshold. The use of these approaches was also of an experimental nature, associated with the optimization of the time and place of their use in the system of sports training, the individualization of the parameters of training loads. From Tables 1 and 2 it can be seen that the experimental training approaches were used in accordance with the general training system and the logic of building the training in the process of implementing the integral structure of the sports training macrocycle.

The first part of the training effects was used for 45 days in the preparatory period of sports training. It was focused on increasing the power and capacity of the energy supply system, i.e. sides of the functionality of the rowers, a high level of development of which is a condition for the intensification of special physical training with regard to the requirements of competitive activity. These include increasing the functionality at the level of the anaerobic glycolytic threshold, the power and capacity of the energy supply system under the conditions of training and competitive loads of submaximal intensity.

The second part of the experimental training effects was also used for 45 days during the period of spontaneous preparation for the competition. In this period, training regimes were used to increase the efficiency of the functional support of the special performance of the rowers in the process of overcoming the second half of the distance. Experimental training effects were not used for two weeks before the first start, in the final phase of preparation for the competition, when specific training tasks for this period were solved.

The effectiveness of the use of experimental training tools, as well as the program of special physical training was tested as a result of testing athletes and testing their performance at the beginning of the preparatory period and in its final phase, two weeks before the start of the spring championship in China.

The results of the control ($n = 20$) and the main group ($n = 20$) were analyzed. The main group used experimental training effects. The control group did not use experimental means in the preparation process. Indicators of special performance (for and distance 2000 m) among all the subjects had no significant differences. Before the experiment, the athletes trained in the same system and were members of the team of the sculls, which formed the crew of the quadruple sculls, two double sculls and heavyweight octuple sculls. During the experiment, the athletes of the control group did not change the training program.

Changes in ergometrical power, functionality, special performance in the main and control groups are presented in Table 3. In the process of analysis, we used a group of indicators that were registered in a complex of tests that simulated racing distance (test “MZD 2000”).

From table 3 it can be seen that the rowers, who used training approach aimed at increasing special performance in conditions of latent (compensated) fatigue, increased the performance of ergometrical power, at which athletes reached VO₂ max and in modeling load, with a high level of fatigue development characteristic of the second half racing distance. This affected the increase in special performance in the second half racing distance and the result of throughout the entire distance of 2000 m.

This can be seen from the increase in the ergometrical power of work registered under standard conditions (modeling the 2000 m distance on the Concept II ergometer). in boats alone in the natural conditions of sports training. The test passage of 2000 m held in standard conditions of a rowing canal in the center of water sports of Rizhao, Shandong: water conditions (licensed competition distance 2000 m), permissible weather conditions - head wind not more than 5 m / s, temperature not less 15 ° C, no rain.

Table 1

Contents of the program of sports training of rowers in China in the preparatory period

Characteristics of training work	Special performance	Special endurance			Aerobic capacity above the anaerobic threshold		Anaerobic capacity at anaerobic threshold			Aerobic capacity			
Paddle stroke, rate per minute	34-36-38	32-34	30-32	28-30-32	28-30		26-27	24-25	22-24	20	19	18	17
Boat speed, %	100%	98%	96%	94%	92%	90%	88%	86%	84%	83%	82%	80%	75%
% VO ₂ max (HR), %	100%	98%	95%	93%	91%	89%.	85%	83%	80%	78%	75%	70%	60%
Total working time, min	6 – 8	8 - 10	10-12	12-13	15	20	30	40	50	60	70	80	90
Distance, km	2	2.5	2.5-3	3-4	5-6	6-8	8	10	12	14	16	18	20
Lactate, mmol • l ⁻¹	16 – 10	10	9	8	8-6		4,8-3,5			3-1,8		2-1	
Work time on the segment, min	7	2	3	4	5		6	8	10	-			
Recovery time between segments, min, s	20 min	10 – 7 min			5-3 min		30 s	20 s	10 s	-			
The accumulation period of training effects, hour	96	72			48					6 - 8 (everyday)			

Note: the gray indicates the structure elements of the sports training when experimental training tools were used

Table 2

Content of the program of sports training of rowers in China at the stage of preparation for the competition

Characteristics of training work	Special performance			Aerobic capacity above the anaerobic threshold		Anaerobic lactate performance						Anaerobic alactate abilities	
						Increase glycolytic energy supply			Increased endurance at anaerobic work (special speed capabilities)				
Paddle stroke, rate per minute	34- 36- 38			35 - 38		34-36	36-38		38-40			40-44	
Boat speed, %	101%	102%	103%	104%	105%	106%	107%	108%	109%	110%	112%	114%	116%
% VO ₂ max (HR	87-89%			92 - 95%		90 -95%			95-100%			100%	
Distance, m, m	1000- 1500 m			1000 - 750 m		500 m			250 m			150 m	
Lactate, mmol • l ⁻¹	6 - 9			8-12	9	10	12	10-12	9	7	5	3 - 4	
Work time on the segment, min, s	4 min	3 min	2 min	5 min	2 min	2 min 30 s	2 min	1 min 30 s	1 min	50 s	40 s	30 s	20 s
Recovery time between segments, min, s	15 min			5-7 min		6 min	4 min	50 s	2 min	1 min	30 s	10 s	
The accumulation period of training effects, hou	72			96					48				

Note: the gray indicates the structure elements of the sports training when experimental training tools were used

Table 3

Indicators of ergometric power of work when passing the second half of the distance

Indicators	Main group (n=20)							Control group (n=20)						
	Before the experiment			After the experiment			p	Before the experiment			After the experiment			p
	Me	25%	75%	Me	25%	75%		Me	25%	75%	Me	25%	75%	
test "MZD 2000"
(1000-1500 m), Watts	468	453	479	491	476	496	p < 0.05	465	454	474	470	458	484	p > 0.05
(1500-2000 m), Watts	488	455	496	512	505	518	p < 0.05	486	453	495	495	470	502	p > 0.05
(2000 m), Watts	482	462	501	495	482	512	p < 0.05	480	463	488	485	466	492	p > 0.05
step-growing test and 2 minutes' maximal work
(step-growing test), Watts	430	415	435	440	430	445	p < 0.05	430	420	435	430	415	430	p > 0.05
«2 minutes' maximal work», Watts	475	457	497	499	477	515	p < 0.05	471	450	507	484	439	495	p > 0.05
the control of passing the distance of 2000 m in water														
Time (1000-1500 m), s	90.5	91.0	90.1	90.0	90.5	89.4	p < 0.05	94.6	96.0	92.1	92.0	93.9	91.1	p > 0.05
Time (1500-2000 m), s	88.6	89.2	88.1	87.5	87.9	87.0	p < 0.05	94.0	95.8	93.0	93.4	94.6	92.5	p > 0.05
Time (2000 m), s	350	348	358	344	352	348	p < 0.05	377	379	374	371	374	368	p > 0.05

In the rowers of the main group, as a result of the implementation of the program of special physical training, an increase in the special working capacity in the second half of the course was noted ($p < 0.05$). The most significant changes are shown as a result of overcoming the 1500-2000 m distance segment. The analysis of the changes was carried out by the median (Me) and the range of individual differences of the indicators - the upper and lower quartiles (25% and 75%). The data presented show that an increase in the special working capacity on this segment of the competitive distance is associated with maintaining the speed of the boat under conditions of latent (compensated) fatigue and with its increase when the final acceleration is carried out. As a result of testing, higher ergometrical work power was recorded when VO₂ max was reached and in a two-minute maximum test under conditions of a high degree of fatigue development — by $2.3 \pm 0.4\%$ and $4.8 \pm 0.5\%$ ($p < 0.05$). This made it possible to increase the indices of special working capacity in the process of modeling the competition distance on the Concept II propeller on segments of 1000–1500 m and 1500–2000 m and the entire distance, respectively, by $4.4 \pm 0.4\%$, $3.6 \pm 0.4\%$, $4.4 \pm 0.5\%$ ($p < 0.05$).

In the process of controlling the passage of the competition distance, the time to throughout the 1000–1500 m, 1500–2000 m and the entire distance trail decreased by 2.9 ± 0.2 s, 4.2 ± 0.3 s, 7.1 ± 0.4 s ($p < 0.05$) in the process of overcoming the 2000 m racing distance in the natural conditions of training (Table 3).

These data indicate that the increase in the effectiveness of competitive activity has resulted from an increase in the special performance of rowers in the second half of the course during the period of hidden (compensated) fatigue. There is reason to believe that one of the factors for increasing the special performance in the second half of the distance is the use of the training effects system presented in the work, including exercise groups, where the parameters for determining the work parameters were strictly individual and resulted from monitoring the functional support of the special rowers in developing fatigue typical of the second half of the competition distance.

Discussion.

Data on the characteristics of the structure of competitive activity and factors affecting the increase in the special performance of athletes in competitive activities in cyclical sports with manifestations of endurance, which supplement the data of V. N. Platonov (1997, 2015), R.J. Shepard (1998), A. Yu. Dyachenko (2004), L. Messonnier, S.E. Aranda-Berthouze, M. Bourdin (2005), T. Tomiak (2008), V. Mishchenko, A. Suchanowski (2010), V.V. Kleshnev (2011), I. Bazucchi (2013).

The materials of the presented studies complement the data and expand the understanding of the relationship between the special performance of athletes with the abilities of compensating for increasing fatigue in terms of the training and competitive activities of athletes.

Obviously, training process needs to take into account the specific features of the rower's functional support for the special performance in the second half race distance when developing and applying the training approach. It is about accounting for the specific reactive attribute of cardiorespiratory system [V. Mishchenko et al. (2010)]. Transient processes, characteristic for the functional support of the rowers' special work during the entire period of race distance, are characterized by the individual reactivity of the cardiorespiratory system and the energy supply of work to the increasing hypoxic and acidemic shifts [M. Bourdin et al. (2004)]. An important component of the structure of the reactive attributes of the rower's organism is the ability to respond quickly and adequately to the growing fatigue throughout the race distance. A certain type of reaction of the cardiorespiratory system, aerobic and anaerobic energy supply of the operation characterizes the degree of increase or decrease in the function of fatigue compensation, in particular, is characterized by the degree of activation of the respiratory compensation reaction of metabolic acidosis.

Conclusion.

The development of training effects aimed at improving the special performance of rowers in conditions of fatigue, increasing in the second half racing distance, as well as the substantiation for the program of their aims use in the preparatory period training in rowing provided the basis for changing the structure of the training process and conducting a pedagogical experiment in outdoor conditions training of qualified rowers of China. The results of the experiment showed significant changes in the specialized features of the functional support of the special performance of the rowers in the second half racing distance in conditions of fatigue. This affected the speed of throughout the third and fourth segment of the distance, influenced the effectiveness of competitive activities in general.

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