Original Article

Functional support of the first part of competitive distance in cyclic sports with endurance ability: rowing materials

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Abstract.

Purpose: Given the differences in the duration of a distance, and as a result, differences in the duration and intensity of the first half of a distance, the variants of the initial part of the competitive activity in cyclic endurance kinds of sports are analyzed. *Participants.* The study included the leading rowers of the province - members and candidates for Shandong provincial rowing team. Total - 28 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:* Achieving of the maximum power of work in the segment is connected with the use of special modes of starting activity realization at which the formation of the most generalized and specialized properties of endurance of the rowers with respect to the starting and other segments of competitive activity happens. These properties include the development and maintenance of the reactive properties of organism under conditions of fatigue, as well as the development and maintenance of the mechanisms of fatigue overcoming, which include, in turn, reactions of compensation of non-metabolic and metabolic acidosis. The implementation of such conditions is to a great extent concerned with the layout of forces oriented at the relatively long - 120 s - starting acceleration. However, the individual assessment of the structure of functional support of the beginning of the race, in particular, the evaluation of the dynamics of the mentioned above mechanisms of performance, especially the kinetics of CRS reactions, could make a substantial correction in the duration and intensity of the starting segment of the race.

Keywords: rowing, functional support, working capacity, competitive distance, cyclic kinds of sports.

Introduction

Purpose.

Parameters of the functional support of performance, presented in this work, reflect the ability of athletes to maintain a high level of performance under conditions of hard physical work of cyclic nature. They are the result of systematization of researches of functional potential in a number of cyclic kinds of sports of 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), van der Zwaard at al. (2017), S.Martin at al. (2017), Tiago Turnes at al. (2019), F. Silva at al. (2020) They are associated with the characteristic features of stress functions at the start, in the middle of the distance, under conditions of severe fatigue influence on the performance in many sport disciplines [C. Gore at al. (1996); A.Y. Dyachenko (2007); Tomiak (2008); J. Tran at al. (2015); A. Yu. Dyachenko (2004); Kong Xianglin at al. (2018, 2020) G. Russell at al. (2002); A. Yu. Dyachenko (2007); Pralay Majumdar at al. (2017)].

It provides the universal characteristic features of functional abilities that are the basis for all cyclic sports with endurance ability. Their versatility lies in the fact that they provide the basic conditions for functional support, common to all endurance cyclic kinds of sport. It should be emphasized that in this context the components of competitive activity functional support are considered from the point of endurance ability, i.e. in the conditions of increasing fatigue during intense motor activity [A.Y. Dyachenko (2007); Kong Xianglin at al. (2018, 2019, 2020); A. Diachenko at al. (2020)]. These conditions include:

At the beginning of the distance – a rapid deployment of anaerobic energy reactions and an increase of the share of effective aerobic energy supply in the total energy balance on this basis; optimization of anaerobic glycolytic energy supply in order to maintain a sufficient level of power characteristics of performance and stimulate the reaction of the cardiorespiratory system;

In the middle of the distance – maintaining the reached levels of reaction and their support on this level during the long phase of stable performance of athletes;

In the second half of the race – activation of the mechanisms of metabolic acidosis compensation; overcoming fatigue and sufficient level of performance on this basis; preserving the conditions for anaerobic reserve realization in the process of finish acceleration.

Rapid deployment of functional reactions at the beginning of a race not only stimulates the performance, but also creates the conditions for realizing of the athlete's potential in other segments of the race. Indicators at the beginning of a competitive distance provide characteristics of functional support, taking into account the role of the initial reactions in the effective passing of a competitive distance in general [A.Y. Dyachenko (2007); Tomiak (2008); Kong Xianglin et al. (2018, 2020)].

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 - 28 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).

For standardizing the measurements of special performance, the Concept-II ergometer was used. 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 in the water sports centre of Shandong Province (China).

Physical Characteristics, Gas exchange, HR, and blood lactate measurements.

Minute ventilation ($\dot{V}_E$), oxygen consumption ($\dot{V}O_2$), CO_2 production ($\dot{V}CO_2$), and RER were determined on a breath-by-breath basis using an Oxycon mobile (Jaeger) metabolimeter. The metabolic unit was calibrated a gas of known composition (16.00% O_2 , 4.00% CO_2), respectively.

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 +) on a blood sample obtained from the ear lobe at the end of the submaximal test and at 1-4 minutes after the maximal 60 s test (100% of the race speed).

All the sportsmen performed an incremental exercise test on separate days, with at least 24 hours and no longer than 3 days between.

Research protocol.

Ergometrical indexes that specified on efficiency of implementation of components of the special capacity 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 with difference of the starting segment of the distance - 60 s, 90 s or 120 s, and maximal 60 s test (100% of the race speed), test by protocol MAOD [J. Melbo (1996)].

The test program also created the conditions for the display of the cardiorespiratory system (CRS) reactive properties and the power of aerobic energy supply for the work.

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, standard deviation - σ , as well as indices of individual differences – variability index V. The data was verified in accordance with the normal probability law (applying the Shapiro Wilk criteria). If the data allocation complied with the normal probability law, then in order to define the statistical validity of discrepancies Student Criteria was applied. In case when the data has not complied with the normal probability law non-parametric criteria of Wilcoxon was applied to define the statistical validity of discrepancies. The error probability during the statistical analysis was set at the level of $p = 0,05$ (significance level).

Research results.

Possibilities of starting activity selection are considered taking into account the requirements of the duration of a competitive distance. In the process of competitive activity lasting more than 5 minutes, for example in rowing, all variants of start can be used; so, the variants of the starting activity should be chosen taking into account the individual abilities of athletes.

Given the differences in the duration of a distance, and as a result, differences in the duration and intensity of the first half of a distance, the variants of the initial part of the competitive activity in cyclic endurance kinds of sports are analyzed.

The parameters of functional support of starting activity lasting 60, 90 and 120 s are shown in Table 1. In the analysis of the duration of the starting activity it should be taken into account that the content of functional support at the beginning of a race is connected with the implementation of starting actions themselves, the transitional period of anaerobic-aerobic processes and the achievement of the initial stage of a stable

performance phase. Functional support of this part of the distance is connected with high performance and the formation of the development conditions in the subsequent sections of the race. An important aspect of the analysis is the effectiveness of the transition from a predominantly anaerobic to aerobic energy supply of the activity.

The first 60 s segment of competitive activity of athletes is based on the predominant implementation of the anaerobic reserve of the organism. This is indicated by high values of ergometric and functional indices of anaerobic power, as well as low ranges of their individual differences. However, it is well understood that the criteria of the successful start of the competitive activity in the cyclic endurance sports is not only a high performance result, but also organizing conditions for the effective passing of the second half of the distance, in particular, in respect of effective compensation of the evolving fatigue.

This is the most difficult type of start in terms of influence on functional support of performance at the follow-up distance segments. Achieved by the mobilizing of the anaerobic potential near-limit rates of lactate concentration to a greater extent have a depressing effect on the speed of deployment of cardiorespiratory system function. Effective transition from predominantly anaerobic to aerobic energy supply is achieved as a result of the use of special training means. Special attention should be paid to the trainings regime, which secures increase of the speed of the lactate release from the working muscles during maximum intensity working load.

Table 1

Indices of functional support of the starting segment of the distance in cyclic kinds of sport with endurance ability (n=28)

Indices	Duration of the starting segment of the distance		
	60 s	90 s	120 s
	Rate of indices, $\bar{X} \pm \sigma$ **		
EP max (10 s), % *	85,0 $\pm$ 6,0	84,9 $\pm$ 6,4	84,3 $\pm$ 6,2
EP mid (25-30 s),	44,4 $\pm$ 4,0	43,2 $\pm$ 1,7	43,1 $\pm$ 1
EP mid (60 s), %	44,8 $\pm$ 1,2	43,6 $\pm$ 1,1	42,6 $\pm$ 0,8
% utilization VO ₂ , %	73,0 $\pm$ 3,1	81,1 $\pm$ 39,0	91,0 $\pm$ 3,3
T ₅₀ VO ₂ , s ****	28,9 $\pm$ 2,3	29,8 $\pm$ 3,0	30,9 $\pm$ 3,9
T ₅₀ HR, s ****	24,0 $\pm$ 2,1	26,6 $\pm$ 2,9	27,0 $\pm$ 3,7
T ₅₀ V _E , s ****	26,2 $\pm$ 2,8	27,2 $\pm$ 2,8	28,2 $\pm$ 3,4
O ₂ deficiency, ml·kg ⁻¹	10,1 $\pm$ 1,5	12,3 $\pm$ 1,2	11,7 $\pm$ 0,9
Lactate, mmol·l ⁻¹	12,9 $\pm$ 1,9	13,8 $\pm$ 2,0	13,9 $\pm$ 3,1
Indices of functional support of all variants of the starting segment			
Delta lactate 1-4 minutes of restoration, mmol·l ⁻¹	2,1 $\pm$ 0,4		
MAOD, ml·kg ⁻¹ ***	56,0 $\pm$ 2,5		

Note: * - due to the difference in ergometric characteristics of performance the power levels of the load are given in percentage relative to the maximum power of performance in the zone of the anaerobic alactate energy supply realization (EP max - 10). Assessment is based on an average of the three best results.

** - A sufficient level of the indicator is within sigma ($\pm \sigma$), respectively, an increased level of performance is greater than the value of sigma; a reduced level is less than the value of sigma.

*** - test by protocol MAOD [J. Melbo (1996)].

****-half time of the response.

The value of the high level of the anaerobic power for the rowers's efficiency was registered in the course of performance of the starting part of the competitive activity with a running time of 90 seconds. However, one tendency is clearly seen: the role of the anaerobic energy in the course of the competitive distance increases. This is due to the increase of factors stimulating kinetics of CRS reaction – formation of maximal oxygen deficiency and the tendency to more efficient use of anaerobic alactate and glycolytic power. When analysing the interrelation of the anaerobic power, speed of the anaerobic energy development and MAOD one can clearly identify the connection of the aerobic and anaerobic processes. At the same time, a tendency to connect the leading functional and ergometric characteristics of performance with the indices determining the development of mechanisms of metabolic acidosis respiratory compensation remained depressed. Reserve of an increase of the efficiency of the functional support of the follow-up distance segments is associated with the additional stimulation of the respiratory reaction. The criterion of the enhancement of the respiratory reaction is the increase of the lungs ventilation reaction and the development of the excess ventilation reaction.

The third 120 s initial segment of the competitive activity is the optimal in terms of the performance efficiency and the impact on the endurance in the subsequent segments of the race. This is illustrated by the high level of values of aerobic and anaerobic power and kinetics and the close relationship of these reactions. These processes are associated with more efficient regulation of the anaerobic processes, in particular, with the maintaining of the high levels of acidosis stimulating CRS kinetics (level of lactate in the range of 8-12 mmol.l⁻¹), with a high rate of removal of lactate from the working muscles and strengthening of the reaction of lungs ventilation (reaction of excessive ventilation).

In this regard, we can say that in terms of endurance abilities this variant of starting activity is optimal. It is possible to use it in cyclic disciplines, the duration of which is in the range of 6-8 minutes, and competitive exercise takes place in the zone of submaximal intensity of performance.

Discussion.

The 2000-m rowing-ergometer test is the most common measure of rowing performance. Because athletes use different intervention strategies for enhancing performance, investigating the effect of preconditioning strategies on the 2000-m test is of great relevance [Tiago Turnes et al. (2019)]. Additional research is warranted to confirm the benefit of other strategies to 2000-m rowing-ergometer performance [Tiago Turnes et al. (2019)].

The results showed [Silva et al. (2020)] a strong correlation between time and power over 2000 meters with the average speed over 2000 meters, confirming that the force [Woo-Seok Hwang et al. (2019)] applied in each stroke has an influence on performance in international rowing competitions.

The effort of rowing 2000-m races requires maintaining a continual and high intensity physical activity for 320- 420 second [Ingham, S.A.at al. (2002)].

Martin, S.at al. [Martin, S.at al. (2017)] performed an association between HR (180.2 ± 4.80 b/min), and carbohydrate consumption during the sustained effort (41.55 ± 3.99 g) towards determining the energy systems involved: ATP ($3.49 \pm 1.55\%$), ATP+CP ($18.06 \pm 2.99\%$), muscle glycogen ($77.9 \pm 3.39\%$). As a result, completion time (366.3 ± 10.25 s) was significantly correlated with both Rf ($p=0.0024$), and $\dot{V}O_2$ ($p=0.0166$) being also pointed out that ≥ 5 l $\dot{V}O_2$ value is associated with an effort time of ≤ 360 s. ($p=0.040$, $RR=3.50$, $CI95\%=1.02$ to 11.96) [Martin, S.at al. (2017)]. Thus, the average activation time among muscle ATP (12.81 ± 5.70 s), ATP+CP (66.04 ± 10.17 s, and muscle glycogen (295 ± 9.5 s) are interrelated, and significantly correlated with respiratory parameters [Martin, S.at al. (2017)]. Decreased total activity time was associated with accessing primary energy source in less time, during effort, improving the body energy power. Its effectiveness was recorded by early carbohydrates access, as a primary energy source, during specific activity performed up to 366 seconds [Martin, S.at al. (2017)].

Rowing performance of Olympic rowers [van der Zwaard et al. (2017)] is excellently explained by $\dot{V}O_{2max}$ and Wingate peak power output ($R^2=0.98$) [van der Zwaard et al. (2017)]. Muscle volume, of all morphological properties, is the most important determinant of rowing ergometer performance, and endurance and sprint capacity in Olympic rowers [van der Zwaard et al. (2017)].

The maximal aerobic power ($\dot{V}O_{2max}$) and maximal anaerobic capacity (AODmax) of 16 female rowers were compared to their peak aerobic power ($\dot{V}O_{2peak}$) and peak anaerobic capacity (AODpeak, respectively) during a simulated 2-km race on a rowing ergometer [Pripstein, L.at al. (1999)]. Each subject completed three tests, which included a 2-min maximal effort bout to determine the AODmax, a series of four, 4-min submaximal stages with subsequent progression to $\dot{V}O_{2max}$ and a simulated 2-km race. Aerobic power was determined using an open-circuit system, and the accumulated oxygen deficit method was used to calculate anaerobic capacities from recorded mechanical power on a rowing ergometer. The average $\dot{V}O_{2peak}$ ($3.581 \cdot \text{min}^{-1}$), which usually occurred during the last minute of the race simulation, was not significantly different ($P > 0.05$) from the $\dot{V}O_{2max}$ ($3.551 \cdot \text{min}^{-1}$) [Pripstein, L.at al. (1999)]. In addition, the rowers' AODmax (3.40 l) was not significantly different ($P > 0.05$) from their AODpeak (3.50 l). The average time taken for the rowers to complete the 2-km race simulation was 7.5 min, and the anaerobic system (AODpeak) accounted for 12% of the rowers' total energy production during the race [Pripstein, L.at al. (1999)].

The given analysis of options for starting activities in cyclic kinds of sport gives additional information for thought and heuristic modelling. On the one hand, the high level of anaerobic power is the main factor of high performance at the beginning of the race. On the other hand, the maximum display of anaerobic power under conditions of close to competitive load, are closely linked to the dynamics of reactions that determine the development of other components of endurance. Such connections can stimulate or depress the reactions of CRS, depending on the selected mode of load intensity. Analyzing the opportunities of creating the optimal conditions for the functional abilities realization at the start, we should strive to the implementation of anaerobic power, under condition of stimulation of kinetic properties of the organism. High kinetics of the initial reactions of organism implies the development of the speed of CRS reactions deployment and the development of mechanisms of fatigue overcoming that are important for the next segments of the distance. Preconditions for such an approach realization are usually created under conditions of peak load lasting from 90 seconds to 120 seconds. During this period, the maximum speed of the deployment of the reactions of CRS, the compensation of acidosis and maintenance of the levels of acidemic shifts stimulating the reactions of CRS in the organism are reached. This coincides with the well-known views on the deployment of functional mechanisms ensuring performance efficiency, and with the associated reactive properties of the organism, which are based on the development and preservation of sensitivity and kinetics of the CRS reactions under conditions of increasing fatigue and expressed acidemic shifts the body [Mishchenko, Lusenko, Vinogradov 2007, Murgatroyd et al 2011]. It is important to note that this analysis allows identifying the components of endurance in relation to specific test load. However, it is well known that the reactive properties of the organism largely determine the type of athlete's individual response to the load, including those at the beginning of the intensive motor activity.

Therefore it is obvious that the structure of the competitive activity at the beginning of the distance can be adjusted individually, taking into account individual dynamics of aerobic and anaerobic energy supply, under conditions of the mandatory development of the outlined above (in 120 s test task) components of special endurance.

Conclusion.

The analysis conducted gives grounds to say that the effective start of the competitive activity implies not only the realization of certain components of endurance, typical of the start segment of the distance in rowing, but also the formation of preconditions for the effective passing of other segments of the distance, especially under conditions of severe fatigue.

Achieving of the maximum power of work in the segment is connected with the use of special modes of starting activity realization at which the formation of the most generalized and specialized properties of endurance of the rowers with respect to the starting and other segments of competitive activity happens. These properties include the development and maintenance of the reactive properties of organism under conditions of fatigue, as well as the development and maintenance of the mechanisms of fatigue overcoming, which include, in turn, reactions of compensation of non-metabolic and metabolic acidosis.

The implementation of such conditions is to a great extent concerned with the layout of forces oriented at the relatively long - 120 s - starting acceleration. However, the individual assessment of the structure of functional support of the beginning of the race, in particular, the evaluation of the dynamics of the mentioned above mechanisms of performance, especially the kinetics of CRS reactions, could make a substantial correction in the duration and intensity of the starting segment of the race.

The implementation of this approach will allow not only assessing the level of development of endurance components, but also, to a large extent, individualizing the training process, developing of a more specialized complex of training. Specialized training tools can be focused on the differentiated development of the components of the starting activity – anaerobic power, the kinetics of CRS reactions, development of the fatigue compensation mechanisms, as well as the comprehensive implementation of these components of endurance.

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