

Modeling of kayak athletes' competition activity

Kolumbet A.N., Dudorova L.Y., Babina N.A., Bazulyuk T.A., Chernovsky S.M.

Kiev National University of Technology and Design, Ukraine

Abstract

- Purpose:** determination of correlations between parameters of special and technical fitness of kayak athletes' on 500 meters' distance.
- Material:** in the research 29 elite athletes participated. We studied characteristics of athletes' coordination structure in natural conditions and laboratory experiment.
- Results:** significant influence of specific adaptive reactions on workability dynamic and sport results is noted. Constant reduction of power is connected with lactate, pyruvate and other under-oxidation products' accumulation in athlete's muscles. 500 meters' distance passing in alternative regime of motor activity permits for athletes to achieve higher level of special workability. We studied four variants of 500 meters' competition distance passing. Most of athletes pass this distance by third variant (46% of all tested athletes) 21% - by the first variant; 14% - by second variant and 19% by the forth.
- Conclusions:** achievement of high sport result is facilitated by optimal structure of competition functioning, which corresponds to the following: speed power qualities and special endurance; individual features of athletes; specific of physical qualities' manifestation, when passing definite distance.
- Keywords:** rowing, kayak, motor technique, bio-mechanics, lactate, blood.

Introduction

Perfection of elite athletes' training implies improvement of their results on competition distance [17, 29]. It requires objective information about dynamic of athletes' special and technical fitness indicators, when they pass distance [8]. High results in rowing are conditioned by psychic and physical qualities' level; by athletes' technical fitness [5]. Athletes' technical fitness is regarded as a component of one, in which technical decisions are closely interconnected with athlete's other potentials [10, 16]. Besides, it is necessary to consider environmental conditions, in which sport action is fulfilled [3, 13].

Of not less importance are the following factors:

- Optimization of physical loads [11, 12, 28];
- Consideration of athlete's individual characteristics [6, 7, 30];
- Selection of adequate means of pedagogic control [19, 26];
- Consideration of workability dynamic in recreation processes [23, 24];
- Simulation of athletes' training process and separate elements of movements [9, 14];
- Prediction of athlete's successfulness in sport activity [21, 22, 27];
- Consideration of training's didactic laws [1, 2, 4].

In practice of training there is acute demand in informative, scientifically substantiated criteria for assessment of athletes' technical fitness. They required for operative, current and stage-by-stage control. Besides, they are important for working out and implementation of new modern means and methods of movements' correction. Means of increase of elite rowers' rowing technique shall also be studied.

In scientific works qualitative and quantitative changes of athletes' technique under influence of complex of factors have been found [25, 29]. These factors determine conditions of realization of athletes' motor potential in competition process [15]. But factors, conditioning high

distance speed in the state of fatigue still remain to be not cleared [8].

Besides, working out of bio-mechanical pre-conditions for optimization of competition activity's structure is of practical importance [31]. This problem touches wide circle of questions, connected with searching of laws of individual adaptive reactions' manifestation in system of movements [18]. Their differentiated character depends on structure of different physical qualities' development [32].

The purpose of the work is determination of correlations between parameters of special and technical fitness of kayak athletes' on 500 meters' distance.

Material and methods

Participants: in the research 29 elite athletes participated.

Organization of the research: coordination structure of athletes' movements was studied in natural conditions and laboratory experiment.

The loads were created by row ergo-meter «Paddlelite». The athletes fulfilled the following regimes of work: 1) alternative regime at low speed of boat and power of work on start (A); 2) alternative regime at low speed of boat and power of work on finish (B); 3) alternative regime at high speed of boat and power of work on start and finish and low – in the middle of distance (C); 4) even mode of passing distance (D).

In our work we used complex method of biomechanical researches. We studied: dynamic of kinematic and dynamic forces, applied to paddle; pressure on kayak seat; goniogram of torso's work; acceleration grams of hands' movements in frontal and vertical axes; instant speed of boat; bio-electrical activity of arms', torso's, back and abdomen muscles. Amplitude and frequency of bio-potentials' oscillations; rhythm structure of bio-electrical activity; integrative bio-electrical activity of muscles were registered. We calculated indicators of motor functioning's effectiveness and efficiency, as well as variability of movements [9].

We also registered the following: pulse (f_h); oxygen consumption (VO_2) and release of carbon dioxide; quantity (A) and power (N) of fulfilled work. Besides, we found lactate level (Lac) in athlete's blood (on 30th, 60th and 90th seconds). After finishing work we determined oxygen debt and took blood samples. After every stop and recreation the work was repeated from the start and the following was found: oxygen value of unit of work (VO_2/A); oxygen demand for the fulfilled work (ZO_2); oxygen deficit (DO_2).

Statistical analysis: in processing of experimental data we found: mean values of indicators and their errors ($X \pm m$); difference between mean values and confident of differences (t, p) as well as the value of dispersion around mean value (σ, CV). Also we found correlation between the studied indicators (r).

In our complex pedagogic, bio-mechanical and biological testing we followed legislation of Ukraine on health protection, Helsinki declaration 2000, directive №86/609 of European community about human participation in medical-biological researches.

Results

The following indicators have confident level of dependence on boat speed on all the distance:

- Power, released by athlete in stroke and in rowing cycle;
- Time of forces application in stroke; boat's run during stroke;
- Rowing temp;

Athlete's power is of decisive importance at the beginning of distance and in its middle. By the end of the distance effectiveness of athlete's forces (boat's run during stroke and time of forces application in stroke) take the first place.

Significance of rowing temp has average correlation and reduces at finish. Maximal forces, applied to paddle blade, and pulse have confident correlation with boat speed only at the beginning of distance (50-150 m from start). The quantity of work in rowing cycle and mean value of forces in strokes lose their significance on finish. Difference in maximal forces between strokes from

left and right sides confidently correlates with boat speed only at the end of distance.

In the process of competition distance passing significance of different factors of athlete's special fitness changes. The most informative indicators of special fitness are:

- on start – power; functional shifts; efficiency of work;
- On finish – effectiveness of used forces; symmetry of movements.

We found differences between correlations of dynamic of forces' application to paddle and muscles' characteristics activity. It depends on passing of one or another part of distance (50-150 m; 200-300 m; 400-500 m). Maximal forces at the beginning of distance are ensured by activity of abdomen oblique muscles. Distance speed is ensured by maximal forces, electrical activity of pectoralis major muscle and latissimus dorsi. On finish the role of rear beam deltoid muscle increases. With it, the role of the outer oblique muscles and pectoralis major muscles increases. But the role of latissimus dorsi reduces.

Passing of the beginning of distance by athlete is characterized by maximal usage of mass-inertia properties of torso rotation. In the middle of distance the pulling component of force is realized. It is ensured by activity of latissimus dorsi. With it, reaching of maximal rigidity of forces' transmission from torso to arms and paddle as accented. Achievement of maximal working effect at finish is ensured by activity of frontal and rear beam deltoid muscles. The similar tendency was noted in the character of ensuring of average forces. However, at the beginning of distance their value depends on character of pectoralis major muscles' activity.

The change of special fitness structure directly influences on the structure of athletes' competition activity. High result directly depends on athlete's physical qualities.

After period of training for non profile qualities, athletes demonstrated reduction of effectiveness of competition functioning distance component. Effectiveness of other components increased insignificantly. In athletes with prevalence of speed-power qualities effectiveness

Table 1. Dynamic of special fitness indicators on 500 meters' distance, passed by athletes with different correlation between speed-power qualities and special endurance

Athlete	Indicators	100 m	200 m	300 m	400 m	500 m
Prevalence of special endurance	Boat speed, m/sec.	5,0	4,2	3,8	3,9	4,8
	Released power, kgm/sec.	45	42	36	37	42
	Difference in forces' impulses on paddle blade in strikes from different sides of kayak, kg/sec.	0,8	0,7	0,5	0,6	2,0
Prevalence of speed-power qualities	Boat speed, m/sec.	4,5	3,9	3,5	3,45	3,35
	Released power, kgm/sec.	39	32	30	29	27
	Difference in forces' impulses on paddle blade in strikes from different sides of kayak, kg/sec	1,2	1,1	0,2	0,1	0,2

of start component of competition functioning reduced. Effectiveness of finish component increased insignificantly. The same changes took place in athletes with prevalence of special endurance. After period of speed-power qualities' training effectiveness of distance finish component reduces with insignificant increase of start. Such orientation of training process does not result in rising of sport results ($r=0.73$; $p>0.05$).

In table 2 we present the data of two athletes: one athlete has domination of speed-power qualities and the second – has domination of endurance. With passing distance the first athlete demonstrates increase of forces application to paddle blade's effectiveness. Than the effectiveness reduces and on finish – again increases. The second athlete has quite opposite changes of these indicators: effectiveness of forces application to paddle blade reduces and than increases. On finish forces again reduce and motor asymmetry increases. Aptitude to development of some qualities imprints on dynamic of special fitness indicators. In the process of middle length distance passing (500 and 1000 m in kayak rowing) there are certain laws, which do not permit for athlete to fulfill all components of competition functioning at high level.

Four variants of 500 meters distance passing have been found: 1) alternative regime at low speed of boat and power of work on start (A); 2) alternative regime at low speed of boat and power of work on finish (B); 3) alternative regime at high speed of boat and power of work on start and finish and low – in the middle of distance (C); 4) even mode of passing distance (D).

Most of athletes pass this distance by third variant (46% of all tested athletes) 21% - by the first variant; 14% - by second variant and 19% by the forth.

When passing distance (in the mode of higher power at start and finish – regime C) we registered complete usage of creatine phosphate energy supply mechanisms.

Its maximal activity is reached approximately by the 50th meter of the distance. This energy supply prevalence is sustained during 100-120 m.

Specific features of such distance passing are as follows:

- Achievement of maximal oxygen consumption speed by the finish;
- Constant lactate concentration in blood;
- Higher oxygen demand on start and on finish;
- Constant reduction of oxygen deficit increment with approaching finish (see table).

When working in regime (A) after not intensive start acceleration athlete reaches maximal power of work (see table 3).

In this period, in organism maximal functional changes take place. By the middle of distance full exhaustion of creatine phosphate reserves happens as well as maximally possible accumulation of lactate in working muscles. It results in reduction of power on the next parts of distance. Reduction of power results in intensive lactate removal from working muscles (utilization with muscular contraction and diffusion in blood). On finish (see table 3) athlete can again increase the power of fulfilled work. For such regime it is characteristic the following:

- Complete usage of all athlete's potentials;
- Accumulation of great oxygen debt;
- Accumulation of great lactate concentration in blood;
- Long period of sustaining of high special workability.

Other alternative regime (B) (see table 4) is a little bit worse in comparison with previous one. It is explained by demand in higher intensity of energy supply mechanisms on start and impossibility to fulfill the work with high power on finish. But from position of tactical tasks this variant can be acceptable for athletes with speed-power qualities' prevalence.

Even passing of distance (D) is the most unfavorable,

Table 2. Bio-energetic indicators of athletes, when fulfilling two minutes' loads on row ergo-meter (regime C)

Indicators	10 m	125 m	250 m	375 m	500 m
N, kgm/min	300	500	650	850	1150
ZO ₂ , l	3,30	2,60	2,40	2,50	2,60
Lac, mg %	74	77	83	90	96
f _h , min ⁻¹	123	155	168	176	187
ΔDO ₂ , l	0,62	0,41	0,25	0,15	0,01

Legend: N – power of fulfilled work; ZO₂ – oxygen demand for fulfilled work; DO₂ – oxygen debt; Lac – lactate concentration in blood; f_h – pulse.

Table 3. Bio-energetic indicators of athletes, when fulfilling two minutes' loads on row ergo-meter (regime A)

Indicators	10 m	125 m	250 m	375 m	500 m
N, kgm/min	200	350	500	600	300
ZO ₂ , l	1,01	2,52	2,73	2,22	2,51
Lac, mg %	63	80	94	100	106
f _h , min ⁻¹	143	174	180	182	188
ΔDO ₂ , l	0,41	0,51	0,32	0,25	0,42

Legend: the same as in table 2.

Table 4. Bio-energetic indicators of athletes, when fulfilling two minutes' loads on row ergo-meter (regime B)

Indicators	10 m	125 m	250 m	375 m	500 m
N, kgm/min	200	500	600	600	650
ZO ₂ , l	2,31	2,12	2,13	1,92	1,41
Lac, mg %	70	76	87	94	98
f _{h'} , min ⁻¹	135	168	175	179	179
ΔDO ₂ , l	0,28	0,22	0,21	0,18	0,01

Legend: the same as in table 2.

Table 5. Bio-energetic indicators of athletes, when fulfilling two minutes' loads on row ergo-meter (regime D)

Indicators	10 m	125 m	250 m	375 m	500 m
N, kgm/min	200	400	500	600	650
ZO ₂ , l	2,50	2,21	1,98	1,97	1,98
Lac, mg %	64	75	83	89	91
f _{h'} , min ⁻¹	85	179	184	187	190
ΔDO ₂ , l	1,25	0,90	0,57	0,40	0,45

Legend: the same as in table 2.

because actually the power of fulfilled work constantly reduces. With it, boat speed can not have tendency to reduction on finish. That is why power reduction is compensated by increase of effectiveness of forces' application to paddle blade and improvement of motor symmetry. For such regime it is characteristic:

- Constant accumulation of lactate in blood;
- Insignificant increase of oxygen consumption speed;
- Practically linear increasing of pulse;
- Stoppage of oxygen deficit increment by finish (see table 5).

Constant reduction of power is connected with accumulation of lactate, pyruvate and other under-oxidation products in athlete's muscles. Distance passing in alternative regime of motor functioning permits for athletes to achieve higher level of special workability.

Discussion

High sport results are achieved by combination of rational strike technique and athlete's high physical and functional fitness.

In the process of racing, during every stroke kayak undergoes speed oscillations at the account of athlete's dynamic movements and different values of force impulse, applied to paddle blade. S.J. Kendal, R.H. Sanders [13] found that mean speed of kayak varies in the range 4.63-5.38 m/sec. In supporting period of stroke blade plunges in water and during the whole stroke creates propulsion force (projection on horizontal plane of paddle blade's thrust). As a result boat speed increases, the frontal part of boat "comes out" of water. In not supporting period propulsion force is absent and boat "dives" again. Thus, mean speed of boat is a result of action of propulsion force and the forces resisting boat's movement in water. Specialists point at the following: propulsion coefficient is very stable indicators, while strength and endurance of muscular groups can noticeably change during racing.

Specialists found duration of stroke phases [3]. For

example, in supporting phase effective part is 54% and not effective - 19%; not supporting phase is 27% from total time of stroke. Between stroke power and boat speed there is no direct functional dependence. In some works it was determined that maximal force increment does not always result in boat speed increase. Stroke effectiveness to larger extent is determined by mean force, released in supporting phase.

The received by us results do not agree with conclusions of a number of authors that in racing the one and same groups of muscles work [8]. The muscles, participating in rowing on one boat's side are not active in not supporting phase after this stroke. They are also not active during stroke from the other side [16, 31]. It is proved by our researches.

Achievement of high boat speed by athletes is conditioned by the whole complex of interactions between parameters of motor functioning. Our research confirms the opinion of specialists about change of some kinematic and dynamic characteristics of rowers' movements.

Conclusions:

1. Sustaining of high workability level in passing all 500 meters' distance on kayaks is impossible.
2. Dynamic of workability and sport results are significantly influenced by specific adaptive reactions.
3. High sport results' achievement is facilitated by optimal structure of competition functioning.
4. Optimal structure of competition functioning shall correspond to the following:
 - Development of speed-power qualities and special endurance;
 - Athletes' individual features;
 - Specificities of physical qualities' manifestation in distance passing.

Conflict of interests

The authors declare that there is no conflict of interests.

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Information about the authors:

Kolumbet A.N.; <http://orcid.org/0000-0001-8775-4232>; re_play@3g.ua; Kiev National University of Technology and Design; st. Nemirovich-Danchenko, 2, Kiev, 14013, Ukraine.

Dudorova L.Y.; <http://orcid.org/0000-0002-6263-4995>; vykh46@i.ua; Kiev National University of Technology and Design; st. Nemirovich-Danchenko, 2, Kiev, 14013, Ukraine.

Babina N.A.; <http://orcid.org/0000-0001-9777-4827>; babynatg@3mail.ru; Kiev National University of Technology and Design; st. Nemirovich-Danchenko, 2, Kiev, 14013, Ukraine.

Bazulyuk T.A.; <http://orcid.org/0000-0002-6244-6302>; bazuluk@rambler.ru; Kiev National University of Technology and Design; st. Nemirovich-Danchenko, 2, Kiev, 14013, Ukraine.

Chernovsky S.M.; <http://orcid.org/0000-0002-1927-9203>; chernovskij.sm@knutd.com.ua; Kiev National University of Technology and Design; st. Nemirovich-Danchenko, 2, Kiev, 14013, Ukraine.

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