Journal of Physical Education and Sport ® (JPES), Vol. 21 (3), Art 168, pp. 1325 - 1330, May 2021
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Functional and physical capacity indicators of kayakers racing 1000, 500, and 200 m distances: a randomized study

ANDRII DIACHENKO[1], OLGA RUSANOVA[2], ZIJIAN HUANG[3], XUEYAN GAO[4], JIA GUO[5], CHENQING YE[6]
[1,2,3,4,5,6]– National University of Physical Education and Sport of Ukraine, UKRAINE

Published online: May 31, 2021
(Accepted for publication May 15, 2021)
DOI:10.7752/jpes.2021.03168

Abstract.
The article proposes a systematic approach to modeling the strength and capabilities of qualified kayakers by developing and implementing generalized, group and individual models of readiness. **Participants.** Depending on the purpose of the research phase, the theoretical and experimental parts of the research were conducted at different training periods at the national aquatic sports training centers in Rizhao. 120 junior kayakers of 16-17 years old and 180 qualified kayakers of 19-23 years old are in the process of assessing the level of functionality, among them a group of elite athletes, the members of the Chinese national team. **Results:** The generalized models include the characteristics of young qualified kayakers who are in the process of preparing for higher achievements. Interpretation of power and capacity characteristics of aerobic and anaerobic energy supply (VO_2 max rel, VO_2 max abs, MAOD, $VO_2 \cdot HR^{-1}$, $V_E \cdot VCO_2^{-1}$, La) and ergometric power (30 s; AT, VO_2 max, T VO_2 max) is aimed at improving the efficiency of selection and sports orientation for kayaking. The group models contain the characteristics of qualified kayakers specializing in distances of 200 m, 500 m and 1000 m. The interpretation of the characteristics of aerobic and anaerobic energy supply (VO_2 max rel, VO_2 max abs, $V_E \cdot VCO_2^{-1}$, La) and ergometric power (*W* ergometric power) work capacity in the test 30 s. The ergometric power work in the test 4 min) is aimed at assessing the level of readiness, search for reserves to improve special performance, correction of the training process with paddlers' specialization. Individual models include the quantitative characteristics of elite kayakers, having the highest (unique) individual indicators.
Keywords. Kayakers, aerobic energy supply, anaerobic energy supply, special performance.

Introduction.

The issues of the content of physical training and structure of functional provision of the qualified kayakers' special performance are widely discussed in the special literature (Bazzucchi I., 2013; Bishop D., 2004; Bishop D. et al., 2002). There grounded the characteristics of kayakers' endurance, velocity and power (Ackland T.R.et al., 2003; Nikonorov A., 2015; López-Plaza D. et al., 2017). In many respects, the functional potential of paddlers on canoes and kayaks is determined by the availability of high capacity energy supply systems (Tesch P.A., 1983; van Someren K.A. et al., 2003; Borges T.O. et al., 2015; Kong X., et al., 2018, 2019). The system for diagnosing the power of the energy supply system for paddlers of high qualification at different distances is presented before (Guo P. et al., 2020; Diachenko A. et al., 2020).The characteristics of the reaction of the cardiorespiratory system and the energy supply of qualified athletes' of different age, gender, specialization and qualification in kayaking and canoeing performance are revealed (Sousa A. et al., 2014; Zamparo P. et al., 1999; Muehlbauer T. et al., 2011; Hagner-Derengowska M.et al., 2014).

This requires the clarification of the requirements for the kayakers' functional level in rowing and canoeing. The need to increase the requirements for the functional preparedness level was confirmed by the data of steady increase of power and capacity indicators of energy supply, presented in the special literature in recent decades. Thus, the data presented by J.S. Michael (2008), A. Nikonorov (2015), etc., pay attention to a higher level of VO_2 max and lactate, registered in elite kayakers. The characteristics of VO_2 max abs reached the level of 6.4 $l \cdot min^{-1}$ (4.5 $l \cdot min^{-1}$ in women), VO_2 max rel - 70,0-72,0 $ml \cdot min^{-1} \cdot kg^{-1}$ (64.0 $ml \cdot min^{-1} \cdot kg^{-1}$ in women), La max - 18.0–21.0 $mmol \cdot l^{-1}$ (13.5–16.0 $mmol \cdot l^{-1}$ in women). The interpretation of the performance of aerobic power supply (VO_2 max abs and VO_2 max rel) requires clarification. In the special literature on rowing, one of the indicators usually represents the absolute and relative characteristics of aerobic power .

The presented principles for using in the process of modeling a number of reaction characteristics of the cardiorespiratory system and energy supply of work characterize the capacity of energy supply and reserves of increasing the power of energy reactions in specific conditions of competitive activity. It is shown that traditional for special analysis of power and capacity characteristics of power supply (VO_2 max and La) can be supplemented by indicators of accumulated O_2 deficiency (MAOD), specific characteristics of pulmonary

Corresponding Author: . OLGA RUSANOVA, E-mail: rusanova2080@gmail.com

ventilation response, CO_2 release ($V_E \cdot VCO_2^{-1}$), O_2 consumption and heart rate abbreviations ($VO_2 \cdot HR^{-1}$) (Melbo J. ,1996; Messonnier L. et al., 2005; Vogler A.J. et al., 2010).

The first problem is the orientation of modeling the special physical training on the specific characteristics of power and capacity of energy supply. The second one is their interpretation taking into account the target guidelines of stages of long-term training, athletes' gender, their specialization at distances of 200 m, 500 m and 1000 m (Zamparo P. et al., 1999; Muehlbauer T. et al., 2011; Nikonorov A., 2015).

An important role is played by the fact that many Chinese talented athletes participate in the training of elite kayakers, which has helped to improve the normative basis of functional preparedness in rowing (Hao Wu et al., 2010; Chul-Ho K. et al., 2016).

Purpose. Develop a systematic approach to modeling the power and capacity of skilled kayakers by developing and implementing generalized, group and individual preparedness models.

Methods and organization of studies.

Depending on the purpose of the research phase, the theoretical and experimental parts of the research were conducted at different training periods at the national aquatic sports training centers in Rizhao. The research was conducted with the participation of experts from the Shandong Sport University and specialists from the National University of Ukraine on Physical Education and Sport.

120 junior kayakers of 16-17 years old and 180 qualified kayakers of 19-23 years old are in the process of assessing the level of functionality, among them a group of elite athletes, the members of the Chinese national team. All participants were informed of the requirements prior to the study, and their parents and coaches gave their informed written consent for them to participate. All procedures were approved by the local research ethics committee in the spirit of the Declaration of Helsinki.

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

Minute ventilation ($V^{\cdot}_E$), oxygen consumption ($V^{\cdot}O_2$), CO_2 production ($V^{\cdot}$ CO2), 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 test.

A modified kayak-ergometer (Dansprint PRO, Denmark) was used. Ergometric power (EP) of work were recorded. All the sportsmen performed an incremental exercise test on separate days, with at least 24 hours and no longer than 3 days between. The incremental exercise test was designed to establish the linear relationship between the work intensity (power in W) and the VO_2 for each individual. This linear relationship would be used later for the calculation of energy contribution al required by MAOD (Melbo J., 1996).

The testing program is built in the form of test battery, each test solving a task to assess certain component of anaerobic and aerobic abilities of athletes and cardiorespiratory system response:30 s and 90 s, 60 s(girls, women) and work with maximum intensity - 4 min. Test tasks were performed in a strictly determined sequence. It was important to preserve the parameters of the ergometric power of work which provided for the energy release in anaerobic alactate and anaerobic lactate (glycolytic) way, as well as the length of the rest intervals. The rest interval between 30 s and 90 s , 60 s (girls, women) and work with maximum intensity provided the conditions for the release of lactic acid into the blood and the increase of the concentration of blood lactate in the muscles before the final maximum work.

Methods of mathematical statistics. The following methods of mathematical statistics were applied: descriptive statistics, selective method, Shapiro- Wilk's normality test, non-parametric Mann- Whitney test. Methods of descriptive analysis were used, including tabular presentation of separate variables, calculation of mean arithmetic value (M), standard deviation (SD). The sample data for normality were tested with the normal distribution formula and the Shapiro-Wilks test. The level of $p \leq 0.05$ (the probability of error) was assumed statistically significant. Determining the model parameters of cardiorespiratory system reaction rates, energy supply and special workability is based on the statistical method - the three-sigma rule.

Results.

In the course of the research the special ability and functionality of the kayakers was evaluated. For modeling the control means, complexes of test tasks, informative criteria of estimation and directions of energy supply indicators interpretation, and special operability of young skilled kayakers at the stage of specialized basic training and qualified athletes specializing in 500 m and 200 m distance were developed.

Table 1 summarizes the individual and individual models of power and capacity for providing the performance of young skilled kayakers (boys and girls). Tables 2 and 3 show group and individual models of skilled kayakers specializing in distances of 200 m, 500 m and 1000 m.

Table 1 Generalized and individual models of power and capacity of power supply of special ability of young kayakers, boys (n = 60) and girls (n = 60) of 16-17 years

Indicators	Statistics					
	Generalized model			Individual models		
	M± SD	Model Range Indicators (M - SD; M + SD)*		Model Range Indicators x> M+ SD		
		reduced indicators M - SD	reduced indicators M + SD	D. D.**	Ch. D***	S. B. ****
Boys						
VO_2max, ml·min^{-1}·kg^{-1}	63,3±2,3	59,3	65,5	72,1	70,0	66,5
VO_2 max, l·min^{-1}	5,5±0,3	5,2	5,7	6,3	6,1	5,8
MAOD, ml·kg^{-1}	20,3±3,3	17,1	23,1	26,1	25,7	27,2
VO_2·HR^{-1}, ml· bpm^{-1}	30,1±2,0	28,2	32,0	30,0	28,1	33,0
V_E·VCO_2^{-1}, c.u.	28,7±3,4	25,8	32,3	34,5	35,5	34,2
La max, mmol·l^{-1}	12,3±2,2	10,1	14,1	15,9	17,9	16,4
$\overline{W}$ 30 s, W	350,2±23,1	328,5	371,3	400,0	380,0	415,0
$\overline{W}$ AT, W	178,5±15,4	164,2	192,0	220,0	220,0	196,0
$\overline{W}$ VO_2 max, W	219,6±13,7	202,4	236,8	280,0	300,0	260,0
$\overline{W}$ 90 s, W	156,2±20,1	138,1	173,2	195,0	197,0	205
Time W 95-100% VO_2 max, s*****	30,2±7,1	24,5	36,3	45,0	55,0	40,0
Girls						
Indicators	M± SD	reduced indicators M - SD	reduced indicators M + SD	S. B.**	K. S.***	L. T. ****
VO_2max, ml·min^{-1}·kg^{-1}	57,9±3,4	54,2	61,4	62,0	66,4	60,5
VO_2 max, l·min^{-1}	4,0±0,2	3,8	4,0	4,2	4,4	4,0
MAOD, ml·kg^{-1}	14,3±2,4	12,1	16,1	18,0	18,5	19,9
VO_2·HR^{-1}, ml· bpm^{-1}	23,1±1,5	21,4	25,4	23,5	23,0	27,0
V_E·VCO_2^{-1}, c.u.	24,7±2,3	22,3	27,0	30,0	31,5	29,2
La max, mmol·l^{-1}	11,0±1,5	9,8	12,1	14,5	13,9	16,6
$\overline{W}$ 30 s, W	290,9±14,1	275,8	304,9	314,9	315,0	325,0
$\overline{W}$ AT, W	74,3±8,5	66,2	83,2	120,0	120,0	110,0
$\overline{W}$ VO_2 max, W	90,1±9,5	81,0	97,0	140,0	140,0	120,0
$\overline{W}$ 60 s, W т	95,2±12,1	84,1	105,0	109,0	110,0	112,0
Time W 95-100% VO_2 max, s*****	33,2±7,0	27,5	39,3	45,0	60,0	45,0

Notes: * - the values of the three lowest and highest indicators in the model range; ** - rower with high integral level of power and capacity of energy supply; *** - rower with mainly high level of capacity and capacity of aerobic energy supply; **** - rower with mostly high level of anaerobic power supply and capacity; ***** - VO_2 max ± 10.0 W deviation from ELP is allowed, ELP is ergometric load power

Table 2 Group and individual models of power and capacity of special performance for qualified kayakers specializing in 200 m and 500 m distances, men (n = 60) and women (n = 60) of 19-23 years

Indicators	Statistics					
	Group model			Individual models		
	M± SD	Model Range Indicators (M - SD; M + SD)*		Model Range Indicators x> M + SD		
		reduced indicators M - SD	reduced indicators M + SD	S. B.**	K. S.***	L. T. ****
Men						
La max-1, mmol·l^{-1}*****	7,0±1,1	6,1	8,0	10,2	9,9	10,1
La max-2, mmol·l^{-1}******	16,6±2,5	14,9	18,7	20,9	21,9	19,0
$\overline{W}$ 10 s, W	419,5±19,9	401,0	439,2	501,0	510,0	490,0
$\overline{W}$ 25-30 s (test 30 s), W	400,7±11,7	390,2	411,1	485,0	490,2	475,1
$\overline{W}$ 30 s, W	393,7±15,7	388,2	407,1	475,2	500,2	463,0
$\overline{W}$ 90 s, W	247,7±9,3	238,0	257,0	292,8	298,0	288,0

VO_2max, ml·min^{-1}·kg^{-1}	64,1±2,9	61,2	67,0	71,1	66,2	68,0
VO_2 max, l·min^{-1}	5,3±0,3	5,0	5,5	6,2	5,5	6,0
Women						
Indicators	M± SD	reduced indicators M - SD	reduced indicators M + SD	B. H.**	S. J. ***	B.M. ****
La 1, mmol·l^{-1}*****	5,9±1,1	4,3	7,2	7,9	9,7	8,7
La 2, mmol·l^{-1} ******	11,3±2,3	9,1	13,3	16,1	18,9	17,1
$\overline{W}$ 10 s, W	285,1±24,9	262,0	310,1	348,2	360,0	342,1
W 25-30 s (test 30 s), W	261,2±30,2	232,2	290,5	341,4	348,0	331,5
$\overline{W}$ 30 s, W	264,7±25,5	242,2	289,0	330,3	340,0	310,0
$\overline{W}$ 60 s, W	180,1±17,4	186,0	197,9	210,0	220,0	201,8
VO_2max, ml·min^{-1}kg^{-1}	55,5±3,0	52,8	58,1	63,1	60,2	64,5
VO_2 max, l·min^{-1}	3,7±0,3	3,4	3,9	4,2	4,0	4,3

Notes: * - the values of the three lowest and highest indicators in the model range; ** - kayaker with high score in the distance of 200 m and 500 m; *** - rower with high score at a distance of 200 m; **** - kayaker with high score at a distance of 500 m; **** - - kayaker with high score in the distance of 200 m and 500 m; *** - kayaker with high score in the distance of 200 m and 500 m; ***** - La – 1, blood sampling for lactate was performed at 3 and 7 minutes of the recovery period (the highest values were recorded) after 30 s of acceleration; ****** - La max – 2, lactate blood sampling performed at 3 and 5 minutes of recovery period (highest recorded) after testing

Table 3 Group and individual models of power and capacity of special performance for skilled kayakers specializing in the distance of 1000 m, men (n = 60) of 19-23 years

Indicators	Statistics					
	Group model			Individual models		
	M± SD	Model Range Indicators (M - SD; M + SD)*		Model Range Indicators x> M + SD		
		reduced indicators M - SD	reduced indicators M + SD	L. C. **	G. M. ***	P. Ch. ****
La –1, mmol·l^{-1}*****	7,5±1,0	6,8	8,3	9,7	10,3	10,0
La – 2, mmol·l^{-1}******	14,4±1,8	12,8	16,0	18,4	21,7	19,1
$\overline{W}$ 30 s, W	340,2±20,1	322,5	365,9	390,0	398,0	409,0
W 4 min, W	169,1±14,0	155,0	183,3	195,3	190,0	201,0
VO_2max, ml·min^{-1}·kg^{-1}	65,0±2,6	63,1	66,5	67,7	67,2	70,0
VO_2 max, l·min^{-1}	5,5±0,3	5,2	5,7	6,0	5,7	6,2
V_E·VCO_2^{-1}–1, c.u.*******	28,9±2,9	26,2	31,1	31,0	30,2	31,9
V_E·VCO_2^{-1}–2, c.u.********	31,0±3,9	27,1	35,0	35,0	34,8	38,9

Notes: * - the values of the three lowest and highest indicators in the model range; ** - kayaker with high integral level of power and capacity of energy supply; *** - kayaker with mostly high level of anaerobic energy supply and capacity; **** - kayaker with mainly high level of capacity and capacity of aerobic energy supply; ***** - La – 1, blood sampling for lactate was performed at 3 and 7 minutes of the recovery period (the highest values were recorded) after a 30 second acceleration; ****** - La max – 2, blood sampling for lactate was performed at 3 and 5 minutes of the recovery period (the highest values were recorded) after the testing program; ******* - average values of V_E • VCO_2^{-1} - I, during the period 90,0-120,0 s of work in the test 4 minutes; ******** - average values of V_E • VCO_2^{-1} - II, during the period 180,0-210,0 s of work in the test 4 minutes

The Tables show that generalized, group and individual models are cut off in quantitative and qualitative characteristics, target guidelines for their implementation.

Discussion.

It is accepted that the use of modern approaches to modeling the power and capacity of energy supply is a prerequisite for improving special physical training in rowing and kayaking (Ingham, S.A. et al., 2002; Tran J. et al., 2015; Guo P. et al., 2020; Diachenko A. et al., 2020; Kong X.et al., 2020)

The implementation of this approach is particularly relevant in kayaking, which differs significantly from the normative requirements for the functional preparedness of young kayakers preparing for the main competitions and qualified kayakers specializing in distances of 200 m, 500 m and 1000 m (Borges T.O. et al., 2015; Michael J.S. et al., 2008).

The data obtained during 1990-2000 differed from the performance characteristics presented in recent decades. In the period of 2000-2018, there was a steady tendency to increase the requirements to the functional readiness level, in particular to the characteristics of power and capacity of power supply of kayakers' special performance. According to the data presented by D. Hahn (1988), G. Tesch (1983), P. Zamparo (1999), T.R. Ackland (2003), the model characteristics of maximum consumption O_2 (VO_2 max abs VO_2 max rel) and blood lactate concentrations in skilled kayakers were in the range of 4.7–5.2 l · min^{-1} and 4.0 l · min-1 in women (VO_2 max abs), 62, 0–64.5 ml · min^{-1} · kg-1 and 52.0–56.5 ml · min^{-1} · kg^{-1} (VO_2 max rel), 14.0–18.5 mmol · l^{-1} and 9.0–12.5 mmol · l^{-1} in women (La).

Conclusions:

The generalized, group and individual models of characteristics of power and capacity of power supply of kayakers' special performance are developed. The generalized models include the characteristics of young skilled kayakers who are in the process of preparing for higher achievements. Interpretation of power and capacity characteristics of aerobic and anaerobic energy supply (VO_2 max rel, VO_2 max abs, MAOD, $VO_2 \cdot HR^{-1}$, $V_E \cdot VCO_2^{-1}$, La) and ergometric power (30 s; AT, VO_2 max, T VO_2 max) is aimed at improving the efficiency of selection and sports orientation for kayaking. The group models contain the characteristics of skilled kayakers specializing in distances of 200 m, 500 m and 1000 m. The interpretation of the characteristics of aerobic and anaerobic energy supply (VO_2 max rel, VO_2 max abs, $V_E \cdot VCO_2^{-1}$, La) and ergometric power (*W* ergometric power) work capacity in the test 30 s. The ergometric power work in the test 4 min) is aimed at assessing the level of readiness, search for reserves to improve special performance, correction of the training process with kayakers' specialization. Individual models include the quantitative characteristics of elite kayakers, having the highest (unique) individual indicators, and these indicators are higher than the characteristics of generalized and group models.

Reference

Ackland, T.R., Ong, K.B., Kerr, D.A., Ridge, B.R. (2003). Morfological characteristics oh Olimpic sprint canoe and cayak paddiers. Jornal of Science and Medicine in Sport. 3:285-294.

Bazzucchi, I.(2013). Cardio-respiratory and electromyography responses to ergometer and on-water Kayak in elite rowers. Eur. J. Appl. Physiol. ;113(5):1271-7.

Bishop D. (2004). The validity of physiological variables to assess training intensity in kayak athletes. International journal of sports medicine, 25(1): 68–72. https://doi.org/10.1055/s-2003-45233

Bishop, D., Bonetti, D., Dawson, B .(2002). The influence of pacing strategy on V̇ O2 and supramaximal kayak performance Medicine & Science in Sports & Exercise. 34(6):1041-1047. https://doi.org/10.1097/00005768-200206000-00022

Borges, T.O., Dascombe, B., Bullock, N., Coutts, A.J. (2015). Physiological characteristics of well-trained junior sprint kayak athletes. *Int J Sports Physiol Perform*., 10(5): 593-599.

Chul-Ho, K., Courtney, W.M., Mehrda,D.B., Bruce, J.D. (2016)The effect of aging on relationships between lean body mass and VO2 max in rowers. PLoS One.11(8).

Diachenko, A., Guo Pengcheng, Wang Weilong, Rusanova, O., Kong Xianglin, Shkrebtiy, Y. (2020). Characteristics of the power of aerobic energy supply for paddlers with high qualification in China. Journal of physical education and sport, vol 20 (supplement issue 1), art 43: 312 – 317. Doi:10.7752/jpes.2020.s1043

Guo Pengcheng, Kong Xianglin, Rusanova, O., Diachenko, A., Wang Weilong. (2020). Functional support of the first part of competitive distance in cyclic sports with endurance ability: rowing materials. Journal of Physical Education and Sport, Vol.20 (5), Art 373: 2745 – 2750. DOI:10.7752/jpes.2020.05373.

Hagner-Derengowska, M., Hagner, W., Zubrzycki, I., Krakowiak, H., Słomko, W., Dzierżanowski, M., Rakowski, A., Wiącek-Zubrzycka, M. (2014). Body structure and composition of canoeists and kayakers: analysis of junior and teenage polish national canoeing team.*Biol Sport.*, 31(4): 323-326.

Hahn, A.G., Pang, P.M., Tumilty, D.M. and Telford, R.D. (1988) General and specific aerobic power of elite marathon kayakers and canoeists. Excel 5, 14- 19.

Hao Wu, Xing Huang, Bing Li Jian.(2010). Effects of respiratory muscle training on the aerobic capacity and hormones of elite rowers before Olympic Games. Medicine & Science in Sports & Exercise.42(5):695.

Ingham, S.A., Whyte, G.P., Jones, K., Nevill, A.M. (2002). Determinants of 2,000 m rowing ergometer performance in elite rowers. Eur. J. Appl. Physiol. 88: 243–246.

Kong Xianglin, Guo Pengcheng , Wang Weilong , Rusanova, O., Diachenko, A. (2020).Planning special physical training for rowers in China: a randomized study. Journal of Physical Education and Sport (JPES), Vol.20 (4), Art 229: 1688 – 1694. DOI:10.7752/jpes.2020.04229

Kong Xianglin, Guo Pengcheng, Rusanova, O., Diachenko, A. (2019). Reaction of the organism to repeated training loads, directed to improve the performance of the qualified rowers of China. Journal of Physical Education and Sport , Vol 19 (Supplement issue 2), Art 66: 453 - 460. DOI:10.7752/jpes.2019.s2066

Kong Xianglin, Rusanova, O., Diachenko, A., Kosticova, S. (2018). Description of functional support for special performance throughout the race distance of well-trained rowers in China. Journal of Physical Education and Sport, 18(4), Art 351:2324 – 2330. DOI:10.7752/jpes.2018.04351

López-Plaza, D., Alacid, F., Muyor, J.M., López-Miñarro, P.Á.(2017). Sprint kayaking and canoeing performance prediction based on the relationship between maturity status, anthropometry and physical fitness in young elite paddlers. J Sports Sci. Jun;35(11):1083-90.

Melbo, J. (1996). Is the maximal accumulated oxygen deficit on adequate measure of the anaerobic capacity ? Can. J. Appl. Physiol. 21:370-83.

Messonnier, L., Aranda-Berthouze, E., Bourdin, M., Bredel, Y., Lacour, J.R. (2005). Rowing performance and estimated training load. Int. J. Sports Med. 2):376-82.

Michael, J.S., Rooney, K.B., Smith, R. (2008)The Metabolic demands of kayaking: a review. J Sports Sci Med. 7(1):1-7.

Muehlbauer, T., Melges, T.J. (2011).Pacing patterns in competitive Kayak adopted in different race categories. Strength Cond Res.25(5):1293-8.

Nikonorov, A. (2015).Paddling Technique for 200 m sprint kayak. In: Isorna Folgar M, et al. Training Sprint Canoe. 2.0 Editora :187-202.

Sousa, A., Ribeiro, J., Sousa, M., Vilas-Boas, J.P., Fernandes, R.J. (2014). Influence of prior exercise on VO_2 kinetics subsequent exhaustive Kayak performance. PLoS One. 9(1).

Tesch, P.A. (1983). Physiological characteristics of elite kayak paddlers. Canadian Journal of Applied Sport Sciences. 8: 87-91.

Tran, J., Rice, A.J., Main, I.C., Gastin, P.B.(2015). Convergent validity of a novel method for quantifying rowing training loads. J. of Sport. Sci. 33(3):268-76.

van Someren, K. A., Palmer, G. S. (2003). Prediction of 200-m sprint kayaking performance. Canadian journal of applied physiology = Revue canadienne de physiologie appliquee, 28(4): 505–517. https://doi.org/10.1139/h03-039

Vogler, A.J., Rice, A.J., Gore, C.J. (2010)/ Physiological responses to ergometer and on-water incremental Kayak tests. International Journal of Sports Physiology & Performance.5(3):342-58.

Zamparo, P., Capelli, C., Guerrini, G. (1999). Energetics of kayaking at submaximal and maximal speeds. Eur J Appl Physiol Occup Physiol. 80: 542-8.