KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

KINETIČKI POKAZATELJI METODA TRENINGA I SELEKCIJA MLADIH VESLAČA

Željko M. Rajković[1], Darko N. Mitrović[1], Vladimir K. Miletić[1] and Petar M. Spaić[2]

[1] *Faculty of Sports and Physical Education University of Belgrade, Belgrade, Serbia.*
[2] *Elementary school "Gavrilo Princip", Zemun, Serbia.*

Original scientific paper
doi:10.5550/sgia.211701.en.rmms
UDC:797.123.015.1
Received: 13.08.2021.
Approved: 27.09.2021.
Sportlogia 2021, 17(1), 13-24.
E-ISSN 1986-6119

Correspodence:
Associate Professor Željko Rajković, PhD,
University of Belgrade, Faculty of Sports and Physical Education,
Blagoja Parovića 156, 11000 Belgrade, Serbia
+381 65 2009 026,
E-mail: rajkoviczeljko@yahoo.com

ABSTRACT

Modern diagnostics in rowing enables more and more possibilities for recording, and comparing numerous stroke variables. At the same time, many coaches fall into the trap of strict respect for the prescribed norms, ratios, and temporarily results, which the athlete must achieve if he wants to stay in the world of competitive rowing. On the example of the comparison of rowing schools RC "Danubius" and RC "Partizan", descriptive indicators are on the side of RC "Danubius" at a time of 2000m, average force and average power. No significant differences were found in average force (sig = 0,167) between rowers of RC "Danubius" and RC "Partizan", while statistically significant differences were recorded in time at 2000m (sig = 0,036) and power (sig = 0,02) in favor of rowers of RC "Danubius". On the other hand, a higher correlation of average force (-0,955) and power (-0,928) with time on 2000m was achieved by RC "Partizan" than RC "Danubius" (-0,931) and (-0,896). The correlation between the average force, and the average power within one team shows a higher correlation for RC "Partizan" (0,95) compared to RC "Danubius" (0,755). The obtained results are not enough for single rower or crew elimination from competition to recreational section in the process of too frequent and strict selection of rowers, considering different possible ways of building rowing techniques and numerous parasitic factors that may affect measured variables, specialy at the age under 14 and novice rowers in general.

Key words: *rowing, rowing ergometer, speed, force, power.*

INTRODUCTION

Rowing is a sport of endurance, but also represents one of cyclic sports, because the movement of rowers is based on repeating the cycle of identical movements (Macanović, 1975). Rowing involves cyclic movements and, above all, it shows the force of the flexor, the arm of the torso extensor and the extensor of the lower extremities (Farfelj, 1972). Rowing belongs to a group of sports that is mainly characterized by the development of endurance with optimal investment of power of different intensity. The technique is aimed at saving the consumption of physical power and increasing the effects of optimal investment of force (Harre, 1973). Rowing is a sport in which a combination of several skills and characteristics (technique, endurance, rhythm, balance, etc.) is required to achieve a sport result. The length of the rowing race is 2000m, which lasts between 5 and 7 minutes. This fact has the consequence is that only persons of a certain genetic predisposition have the ability to achieve top sporting results in rowing (Lukač et al., 1999).

The cyclical character of the rowing technique enables the construction of a rowing ergometer that faithfully simulates the movement in a boat, of all components except balance (Liquori, 1986). The first patents for rowing trainers date back to 1871. As early as 1901, a hydraulic rowing machine was constructed. The company "Concept II" from Morrisville (USA) modernized the rowing trainer in 1981 by making a special aluminum disc with fins (for loading) and installing a mini computer. With constant training, the rowing machine "Concept II", through models "B", "C" (1994), "D" (2003) becomes the most common and adequate device for training and checking the physical and functional abilities of competitors in rowing (Dreissigacker, 2003).

Training machines have a great contribution in training programming, evaluation of training effects and evaluation of results (Group of authors, 1976). The study found that neuromuscular coordination in imitation of stroke movements on a rowing ergometer is approximately equal to that in a boat (Nowicky et al., 2005). The manufacturer of the ergometer, Concept, made it possible for the achieved speed and other values of biomechanical variables on the rowing ergometer to correspond to the conditions of rowing in a coxless four (Dreissigacker 2003).

A high correlation was observed between water rowing and the "CONCEPT II" rowing ergometer (Lamb, 1989). This ergometer showed certain advantages over the others, but the differences are insignificant from the point of view of kinematics (Steer et al., 2006) and electromyography (Nowicky et al., 2005). Ergometers differ from training machines in that they can measure the work done (Rajković, 2015). The force and power variables are usually monitored on the ergometer display during training and testing, in addition to pace and speed. Proper distribution of force and power enables sufficient and proper muscle relaxation during the passive phase of the stroke (Mitrović, Rajković, 2020).

Periodic control of rowers is necessary to obtain feedback on the reaction of athletes to training, as well as to accurately determine the intensity of subsequent loads in training (Grujić et al., 1988). In sculling and sweep rowing, we can talk about a unique technique of performing a sports task. This unique rowing technique can be achieved in several ways depending on the discipline, weather conditions, water characteristics, waves, etc. Thus, we can assume that the biomechanics of rowing can be observed through sports specialization (age categories, gender, scull and sweep, larger - smaller boat, a certain rowing school, etc.) and that the improvement of technique leads to the formation of a flexible motor program of the same basic rowing technique. (Mitrović, 2003a). While the age group of 11-14 is considered the best to start rowing training, the period from 14 to 16 is considered the best for the specialization process so that top results can be expected between the ages of 22 and 25. (Bompa, 2001). Rowing is one of the sports of late specialization. Athletes are recommended to participate in various activities and sports before specializing in rowing.

The athlete's specialization in rowing before reaching the age of 10 can lead to uneven and inadequate physical development, as well as incomplete development of sports skills, injuries due to overload and early quitting (Taylor, 2010). An additional unknown is introduced by the sensitive periods of motor skills development, which individually and depending on the intensity of stimulans, affect the development of young athletes. The development of several very important motor skills (for men) such as explosive power (13-17 years), maximum power (14-18 years), endurance in power (11-17 years) and aerobic endurance extends through three competition categories. (15-18 years), (Meinel, Schnabel, 1976; Martin, 1980; Volkov, 1986; according to Issurin, 2009). Information on which biomechanical parameters play a leading role in competitive rowing is important for researchers and coaches. They are sometimes decisive in the early selection of rowers, which often interrupts the careers of promising rowers or rowers whose coaches have embarked on a long-term development path rather than on the path of quick and easily achievable results. Different time norms at 2000m, force, power and other variables are used at the club, age and representative level. Often the correct and patient work of the coach leads his team to regression from competitive to recreational crew, while fast results without a good basis extend which later leads to a stalemate in progress. This article is an attempt to discover the regularities of the relationship between force and power, but also by comparing the similarities, and differences between the two rowing schools to emphasize possible generalization errors, under the influence of numerous parasitic factors.

METHODS

A Fitrower instrument from Weba Sport, which is connected to a computer with a probe, is placed on the rowing ergometer. The measuring instrument measures the time, force and length of movement of the handle. As a result, the computer calculates the power from the obtained data. Force and power are recorded in this way at each moment of the stroke, so the average force and power are obtained as the arithmetic mean of the measured forces and power during one stroke, or during the entire rowing interval. Experiment participants received verbal advice from the coach on how fast to row in order to achieve their best result on the 2000 m test. The sample consisted of 19 rowers age under 14, 7 from RC "Danubius" and 12 from RC "Partizan". These clubs were chosen because they represent the bearers of the quality of rowing in Serbia, RC "Danubius" in Vojvodina, and RC "Partizan" in Belgrade. In almost all rowing clubs in Serbia, training is done in a similar way. The variables used to assess the quality of rowing are average force and average power. Based on the collected data, descriptive statistics, central tendency measures and variances for the measured variables were calculated. Statistical significance was checked by T-test for independent small samples, while due to a clearer understanding of the relationship between the stroke variables, the bivariate correlation method was used, where Pearson's correlation coefficients with numerical expression of significance were calculated. All statistical data were processed by the statistical software package SPSS Statistics 20.

RESULTS WITH DISCUSSION

The category of age under 14 is initially characterized by a large number of participants in the rowing school, where numerous differences are manifested, which are gradually less manifested by the influence of training. Some of the rowing technique pattern are learned very quickly, which is concluded at the level of absolute values, as well as the significance of differences, variability and correlation (Rajković, 2015).

Table 1. *Descriptive statistics for rowers from RC "Danubius"*

RC „Danubius“ age under 14							
	Hight (cm)	Age (month)	Weight (kg)	Sport experience (year)	Time 2000m (s)	Fsr (N)	Pstr (W)
average	181.86	172.71	70.43	1.14	453.74	384.93	286.18
st dev	2.79	4.15	10.29	0.38	9.92	31.70	28.14
var coef	0.015	0.024	0.146	0.331	0.022	0.082	0.098
min	178.00	166.00	60.00	1.00	439.60	345.84	232.71
max	186.00	177.00	88.00	2.00	465.70	426.15	314.67
range	8.00	11.00	28.00	1.00	26.10	80.31	81.97

Table 2. *Descriptive statistics for rowers from RC "Partizan"*

RC „Partizan“ age under 14							
	Hight (cm)	Age (month)	Weight (kg)	Sport experience (year)	Time 2000m (s)	Fsr (N)	Pstr (W)
average	176.00	163.58	66.00	1.42	481.26	352.34	232.34
st dev	6.32	9.39	10.07	0.79	38.84	54.04	50.54
var coef	0.036	0.057	0.153	0.560	0.081	0.153	0.218
min	166.00	152.00	56.00	1.00	432.80	268.40	167.30
max	185.00	177.00	92.00	3.00	531.90	422.40	325.93
range	19.00	25.00	36.00	2.00	99.10	154.00	158.63

Table 3. *T-test for time at 2000 m, average force and average power of rowers RC "Danubius" and RC "Partizan"*

T-test for Equality of Means										
Variables		Levene's Test for Equality of Variances							95% confidence interval of difference	
	Equal variances	F	Sig	t	df	sig	Mean diff.	Std. Err. Diff.	Lower	Upper
T 2000m (s)	assumed	23.43	0.000	1.82	17	0.086	27.515	15.121	-4.388	59.419
	not assumed			**2.327**	13.295	**0.036**	27.515	11.823	2.03	53.001
Fav (N)	assumed	2.778	0.114	**-1.445**	17	**0.167**	-32.558	22.53	-80.092	14.976
	not assumed			-1.655	16.975	0.116	-32.558	19.672	-74.068	8.951
Pav (W)	assumed	4.417	0.051	**-2.575**	17	**0.02**	-53.837	20.906	-97.945	-9.73
	not assumed			-2.982	16.997	0.008	-53.837	18.055	-91.93	-15.744

Comparing the two rowing schools, or in some other case two rowers at an early age is hampered by the fact of sudden and turbulent changes during the age under 14, which can significantly limit the interpretation of the obtained results, which is the main message of this study. Comparing the time at 2000m, force and power between the two clubs, it can be concluded that RC "Danubius" achieves better values in all three variables, while a statistically significant difference was recorded at time on 2000m and power, while there are no statistically significant differences in average force, which is expected considering the results of previous research. In the review of previous research, a great difference of results is noticed in different researchers, when it comes to maximum force, average force, work performed and average power of rowers (Zatsiorsky, Yakunin 1991). It is also stated that the force in the boat has been measured in different ways in the past, on the oarlock, the footstretcher, oar grip and the blade. The results were often surprising because some rowers who achieved less force had higher average boat speeds (Filter, 1997). It is also stated that the average force on the oar handle of top skiers is around 500N. According to Archimedes, when this force is calculated with respect to the ratio of the size of the inner and outer arm of the oar, a force of about 200N is obtained on the paddle blade. Very interesting is the large range in the obtained maximum and average tensile forces manifested on the handrail of rowers in recognized researchers, (Zatsiorsky, Yakunin 1991). The character of the force curve changes over time depending on the section being paddled, the pace, the speed of the boat, the heart rate and the energy sources. Thus, the trapezoidal shape of the force-time curve corresponds to aerobic energy sources, low pulse, sections of about 15 km, continuous training method, low power values, large force values and small boats (skiff).

With the increase of rowing speed, with shortening of sections, but also with rowing in group boats, the pulse increases as the force increases, the force decreases, and the force curve takes more and more shape with a characteristic peak with a steeper force establishment curve, which is manifested through a shorter force gradient (Bachev, Neykov, 2005). Comparing the results at 2000 m (Table No. 3), it can be concluded that the rowing school of RC "Danubius" (Table No. 1) achieved slightly better results than the school of RC "Partizan" (Table No. 2). However, the difference in the results can come from several factors: the age of the rowers, the weight of the rowers, body height, sports experience, degree of constructed rowing technique, tactical skills and performance, competition experience, current fitness abilities, possible differences between the chronological and biological age of the rowers, previous selections, etc. The results may also differ due to the different approach in rowing school among beginner rowers. This is supported by the differences in the values of average force and average power, where Danubius rowers also achieve better results.

A special question can be asked about the funds used by the coaches of the two compared schools during the training. For example, the use of a galley (which is usually used in training by both clubs) - a school boat with 12 seats where rowers sit in two rows of 6 rowers, can significantly increase the amount of force and power of rowers, consequently both force and power later in the competition boat, but in case of overuse can disrupt the fine mechanisms of temporal and spatial variables of rowing (Rajkovic at all, 2011).

Table 4. *Correlation between time at 2000 m, average force and average power of rowers RC "Danubius"*

RC "Danubius"	Fav (N)		Pav (W)	
t 2000m (s)	Pearson C.	**-0.931**	Pearson C.	**-0.896**
	Sig	**0.002**	Sig	**0.006**
	N	7	N	7

Table 5. *Correlation between time at 2000 m, average force and average power of rowers RC "Partizan"*

RC "Partizan"	Fav (N)		Pav (W)	
t 2000m (s)	Pearson C.	**-0.955**	Pearson C.	**-0.928**
	Sig	**0.000**	Sig	**0.000**
	N	12	N	12

These results do not mean that the rowing school RC "Danubius" has better quality. Achieved extremely high negative and significant correlation between time at 2000 m and average force, but also time at 2000 m and average strenght in both rowers RC "Danubius" (Table No. 4) and rowers RC "Partizan" (Table No. 5) is expected because the time at 2000 m represents the reciprocal value of the speed which is directly related to the average force and power. Although the RC “Partizan” rowers recorded slightly worse results in speed (expressed here in the usual rowing manner through a rowing time of 2000m), force and power, they recorded a slightly higher degree of correlation between force and speed, and power and speed, than the RC "Danubius" rowers. A possible explanation for this phenomenon is that RC "Danubius" rowers achieve higher speed values with a smaller share of force and power, and a larger share of some other paddle variables such as: time variables (frequency, duration of active and passive paddle phase, rhythm) and paddle length. The question is what did the coaches of the mentioned clubs actually work on, or before, which way is right? Whether working first on the length of the stroke or higher force, or working at a higher pace, or a different rhythm with slightly lower values of force. This raises the question of short-term measurable results, but also proper long-term development. When, and should anyone be rejected at all in the selection process in the two mentioned clubs?

Table 6. *Correlation between the average force and the average power of the under 14 rowers of RC "Partizan" and RC "Danubius"*

RC "Danubius“	Pav (W)	
Fav (N)	Pearson C.	**0.755**
	Sig	**0.05**
	N	7
RC "Partizan"	Pav (W)	
Fav (N)	Pearson C.	**0.95**
	Sig	**0.000**
	N	12

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Comparing the correlation between force and power, especially the rowers of RC "Partizan" and the rowers of RC "Danubius" (Table 6), it was concluded that the rowers of RC “Partizan” achieved values of rowing speed with a slightly higher share of force in the manifestation of power compared to Danubius rowers. In the Danubius rowers, it is possible that some other variables contributed to the speed values (length of stroke, duration of active and passive phase, pace and rhythm). The recorded results are associated with two leading world rowing schools, the Australian and the American, related to the calculation of rowing time norms, sections and pace, where one of the schools favors a slightly longer one, while the other favors a slightly stronger stroke (Ilić, Rajković, 2009). Both ways of standardizing rowing norms, which occurs in the later stages of training of mature rowers, are wrong if they are literally transcribed, and if the specific characteristics of each individual rower are not taken into account (Rajković, 2015). Comparing the rowers under 14 of the two clubs is often important during selecting process within clubs, but also when selecting for different national teams. The comparison given in this article can have great consequences for the further careers of young rowers, while the possible conclusions can be wrong due to the different way of reaching the compared values of force and power. A large number of eventual possible parasitic factors, such as the most common situation in practice, do not allow quick and one-sided conclusions. Any possible differences that can be noticed between two rowers or two groups of rowers, do not necessarily have to be significant and crucial for the harsh process of reaching different norms and selection in rowing clubs. Therefore, in the continuation of the article, emphasis is placed on several factors that may or may not affect the neglect of the observed differences in kinetic variables. Body height and weight have a great influence on the success of rowing results (Žeželj, 1978; Marinović, 1989). The greatest acceleration of the increase in body height occurs on average around the age of 12 for men. At puberty, changes in height are accelerated again and are accompanied by an exponential decrease to fully reached height in men around the age of 18. Body weight in men follows the trend of development of body height, but it is still defined a little later, around 14.5 years of age. Muscle mass naturally increases continuously with the increase of body mass up to the highest values at the time of the strongest secretion of the male hormone testosterone, during puberty. (Fratrić, 2006).During late childhood and early adolescence, athletes of the same chronological age can differ up to 5 years in their maturity. It is necessary for coaches to understand these differences in speed of development and to take them into account when designing training and selecting athletes (Taylor, 2010). What makes it difficult to make the right coaching decisions is the existence of large differences in morphological, biological and calendar age among young athletes (Ugarković, 1996).

These differences depend on various factors, of which the climatic, geographical, food, endocrine and environmental influences stand out (Medved, 1966). At a younger age, the best athletes are more mature than their peers, while at an older age, the best are those who have matured on time or those who are late in maturing (Troup, 1991, according to Issurin, 2009). During sensitive periods of development of physical abilities, it often happens that children born in the first half of the year achieve the best results, so significant differences in the assessment of children's abilities can be obtained

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within the same year with relatively close morphological and biological ages. Even the defined norms and standards for the assessment of body height, weight and physical abilities in young people become obsolete in 5 to 10 years due to the phenomenon of acceleration. The influence of biological development on sports results is evident, so it is necessary to adjust the norms and standards in a particular sport (Paranosić, Savić 1977), in this case rowing. Indicators of age, height and weight for rowers are very important, but they are not able to replace the level of preparation in terms of power, endurance, motivation and will, which along with effective technique allows to achieve top results (Bača, 1976). Comparing the results of previous studies with the results obtained in this study, it can be concluded that the numerical indicators of force and power during training and testing are not sufficient indicators for strict selection that is constantly carried out in rowing.

CONCLUSION

By comparing the force and power of the rowers under 14 of RC "Danubius" and RC "Partizan" in the 2000m rowing test with maximum intensity, we obtained results that give a slight advantage to VK "Danubius", with statistical significance of differences in time on 2000m ands power, while there is no significant difference in average force. Further analysis of the relationship between speed (time at 2000m) and force and power, obtained small differences in correlation, which may lead to conclusions of different approaches to work in clubs, but do not give enough arguments to reject one of the teams in the selection process. The correlation of force and power within both teams separately provides additional data on the construction of each stroke in terms of the contribution of individual kinetic variables, but even that does not provide significant information that can reject one of the teams and direct them from competitive to recreational treatment. All of the above should be kept in mind when selecting or postponing the selection of rowers, so coaches should be patient and wait for the maturation of their athletes. In doing so, transient goals do not always correspond to the ultimate goal or the model to be pursued. First of all, coaches need to know what the goal of certain periods in training is in terms of development, or it can be said in terms to learn optimal values of force and power involved in boat speed as a final results. In addition to the initially measured and final focused values of the measured biomechanical variables of rowing during a single rowing or average values during rowing of differently selected sections, transient values and periodic changes that must be monitored by the coach are very important. At the same time they should not attach much importance by imposed norms or in comparison with previous generations. Each individual rower should be given the chance to build their rowing skill in their own specific different way, given the mentioned large differences in a number of parasitic factors related to the comparison in this study.

At the same time, the coaches and club management should show a certain amount of patience, and wait for the natural maturation of the rower and his multi-layered mastery of rowing technique, tactics and fitness. The rapid progress in the category of age under 14 and age between 14 and 16 is a particularly important phenomenon. It happens very often and is characterized by alternating breakthroughs in the notions of rowing, technique, fitness, values of force, power, pace…

Every sudden progress in one area disrupts the fine relationships between systems, so it takes some time to manifest the new quality at the speed achieved on the ergometer or the speed of the boat (Rajković, 2015). In doing so, commitment for two extremes, such as the American or Australian system, or any attachment to numerous values of force, power and speed, should by no means be a reference point solely on the basis of sympathy, available literature or coach experience and corresponding prejudices. A simple but rarely applied approach is to adapt tasks and passing goals to each individual athlete while keeping records of, among other things, the achieved kinetic variables of the stroke and patient continuous work, and waiting for the natural maturation of the athlete, without strict selection and rejection of young rowing athletes when they have not even maturated as persons and athletes. The direction of future research could be in the longitudinal monitoring of kinetic variables of rowers, where different patterns of reaching the transient and final normalized values of kinetic variables of rowing are expected.

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KINETIC INDICATORS OF TRAINING METHODS AND SELECTION OF YOUNG ROWERS

SAŽETAK

Savremena dijagnostika u veslanju omogućava sve više mogućnosti za beleženje i poređenje brojnih varijabli zaveslaja. Pri tom mnogi treneri padaju u zamke strogog poštovanja propisanih normi, odnosa i prolaznih rezultata, koje sportista mora ostvariti ukoliko želi da ostane u svetu takmičarskog veslanja. Na primeru poređenja veslačkih škola VK "Danubiusa" i VK "Partizan", deskriptivni pokazatelji su na strani VK "Danubius" kod vremena na 2000m, prosečne sile i prosečne snage. Prosečna sila, ne beleži značajnost razlika između veslača VK "Danubius" i VK "Partizan" (sig=0,167), dok su zabeležene statistički značajne razlike kod vremena na 2000m (sig=0,036) i snage (sig=0,02) u korist veslača VK Danubiusa". S druge strane veću korelaciju prosečne sile (-0,955) i snage (-0,928) sa vremenom na 2000m ostvarili su veslači VK "Partizan" od veslača VK "Danubius" (-0,931) i (-0,896). Korelacija između prosečne sile i prosečne snage unutar jedne ekipe pokazuje veću korelaciju kod veslača VK "Partizan" (0,95) u odnosu na veslače VK "Danubius" (0,755). Dobijeni rezultati nisu dovoljni da se jedna od ekipa ili pojedini veslač u nekom sličnom poređenju izbaci iz takmičarskog pogona u procesu previše čestih i strogih selekcija veslača, obzirom na različite moguće puteve izgradnje veslačke tehnike i brojnih parazitarnih faktora, koji na navedene varijable mogu uticati, posebno u uzrastu pionira i veslača početnika uopšte.

Ključne reči: *veslanje, veslački ergometar, brzina, sila, snaga.*

Primljeno:13.08.2021.
Odobreno:27.09.2021.

Korespodencija:
Vanredni profesor dr **Željko Rajković**,
Univerzitet u Beogradu, Fakultet sporta i fizičkog vaspitanja,
Blagoja Parovića 156, 11000 Beograd, Srbija,
+381 65 2009 026,
E-mail: rajkoviczeljko@yahoo.com
https://orcid.org/0000-0002-7948-8293