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Original Article

Special strength training using an innovative kayak ergometer during an offseason period

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Abstract
Problem Statement: Kayak rowing is a sport discipline with a great importance of specific force qualities, in particular in 200 and 500 m races. *Approach*: Special strength training at high velocities should be preferred to resistance training at low velocities to train more specifically during the offseason. *Purpose*: The aim of this research is to study the influence of a special strength training using an innovative kayak ergometer during an offseason period on the sport competition results in water rowing in 200 and 500 m races. *Material*: Sixteen 15–18-year-old male kayak rowers were involved in this research (body mass: 75.9 ± 4.3 kg, body length: 175.7 ± 3.0 cm). All participants were healthy and trained according to the program of kayak rowing for sport schools. *Results*: A decrease in time in the 200 m competition race in the experimental group (1.6 s) was 0.7 s greater compared to the control group (0.9 s). Similar results were observed in the competition results in the 500 m race with 1.7 s difference between the experimental and control groups' competition results ($p < 0.001$). Very strong Pearson correlation was observed between competition results in 200 and 500 m races: $r = 0.959$ in November and $r = 0.949$ in March ($p < 0.001$). According to the results of two-way ANOVA, a strongly significant bias appeared between competition results in 200 m distance ($p = 0.021$) and 500 m distance ($p < 0.001$). Corresponding quarter of variance equals 17.2% and 40.8%, respectively. These parameters confirm a significant decrease in time of overcoming the two studied distances in March compared to November competitions. *Conclusions*: A special strength training using an innovative kayak ergometer during an offseason period (November–March) resulted in a strongly significant ($p < 0.001$) increase in the sport competition results in water rowing in 200 m (0.7 s) and 500 m (1.7 s) distances.
Keywords: kayak, rowing, ergometer, training, strength, endurance

Introduction

Kayak rowing is a sport discipline with a great importance of specific force qualities, in particular in 200 and 500 m races (Alecu, 2017). Special strength training at high velocities should be preferred to resistance training at low velocities to train more specifically during the offseason. The specific training of international rowers has to account for approximately 70% of the whole training time (Shalar et al., 2020). Rowing ergometers were designed with a purpose of simulating rowing indoor exercises. During the last several decades, rowing ergometers revolutionized the training and testing of kayak sportsmen (Fleming et al., 2012; Gomes et al., 2015).

Currently, the problem of strength testing and training using the ergometer rowing performance in the flat water kayak sport during an offseason period is of interest. A model based on the relationship between the ergometer and on-water performance competition rowing shows rather good validity of the strength testing and training in the on-water kayak sport (Michael et al., 2012; Zanevskyy et al., 2019). Maximal strength was sustained when infrequent (e.g., one or two sessions a week) but intense (e.g., 73–79% of maximum) strength training units were scheduled; however, it was unclear whether training adaptations should emphasize maximal strength, endurance, or power to enhance performance during the competition phase (Van Someren et al. 2003; Lawton et al., 2013).

In kayak rowing, the factor of non-standard directions in the methodological and technical support of each stage of training is directly related to special strength increase and the possibility of aerobic energy supply and the kinetic capabilities of the cardiovascular system in conditions of actively increasing metabolic acidosis. Decisive changes appeared in the nineties of the last century in kayak rowing, when at the main international competitions the distance of 10,000 meters gave way to the sprint of 200 meters, which significantly increased the requirements for athletes' strength training. The possibilities of one of the devices for the development of special strength of the kayaker are presented in this article. The object of research has a simple design, but at the same time is an extremely effective device (Training Platform) that allows to develop the special strength of a kayaker (Chodinow & Kaca, 2010; MacDiarmid & Fink, 2017; Amat et al., 2020).

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Research hypothesis

A special strength training using an innovative kayak ergometer during an offseason period leads to the significant increase in the sport competition results in water rowing in 200 and 500 m races (Tran et al., 2015).

Purpose

The aim of this research was to study the influence of a special strength training using an innovative kayak ergometer during an offseason period on the sport competition results in water rowing in 200 and 500 m races.

Materials and Methods

Participants

Sixteen 15–18-year-old male kayak rowers were involved in the research (body mass: 75.9 ± 4.3 kg, body length: 175.7 ± 3.0 cm). All participants were healthy and trained according to the program on kayak rowing for sport schools (Vorontsov et al., 2017).

The study was approved in advance by Ethical Committee of Lviv State University of Physical Culture. Eighteen-year-old sportsmen or parents of younger sportsmen voluntarily provided written informed consent before participating. The procedures were followed in accordance with the ethical standards of the Ethical Committee on Human Experimentation.

Procedure

One of the tasks of this research was to determine the possibility of long-term strength increase as a result of specialized training in the offseason period and its successful transfer to training and competitions on the water. The athletes were randomly divided into two groups. In group "E" (experimental), there were kayakers who performed exercises on the presented simulator in the offseason period twice a week. In group "C" (control), the training program was similar, except for the obligatory exercises using the simulator. Group "E" training using the simulator was as follows. On Tuesday, the athletes were tasked with moving large weights in a relatively short time (15–30 s) without limiting the rest time. On Friday, smaller weights were used but for a longer period of time (30–45 s per set) with a fixed (limited) rest time. This was followed by a review of the reliability of biomechanical variables produced during the isometric mid-thigh pull and isometric squat and the reporting of normative data (Brady et al., 2020).

The research was performed during the offseason from November to March. Participants were randomly divided into two groups. The control group included eight rowers who trained according the curriculum. Strength training consisted of pressing a rod lying on a back, pulling a rod lying on the breast, pulling and jerking of the weight, exercises on the bars, and various multi-joint barbell exercises.

The experimental group consisted of eight rowers who trained according to the same program as the control group, but twice a week part of the common strength training exercises was substituted by a high-intensity strength training using ergometer rowing. The amount of strength loading of all rowers in the two groups was equal (Pickett et al. 2018).

The time of 200 and 500 m kayak competitions in flat water rowing was measured just before the offseason beginning (i.e., end of October) and just after the offseason ending (i.e., in March).

Statistical analysis

The Shapiro–Wilk test was used to evaluate the probability of normal distribution in the results of the research groups. The results were elaborated using parametric statistics of central tendency and variation.

Student's t-test for paired samples was used to determine the differences between competition results in March vs. those in November.

Two-way ANOVA was applied to determine the significance of difference between competition results in 200 and 500 m races by taking into account the bias in the control and experimental groups (Zanevskyy & Zanevska, 2017). Pearson correlation was used to study correlation between the number of repetitions and mass of loading in the experimental group as well as the correlation between competition results in races with 200 and 500 m distances. Calculations were performed using MS Excel program (data analysis) and virtual Shapiro-Wilk test calculator.

Results

Platform for the development of special strength of a kayaker

The training device used for the special strength development of a rower-kayaker is shown in detail in the scheme in Figure 1. It consists of a platform mounted vertically in its upper longitudinal space of the cross-bar (barbell). In the lower part of the platform, there is a plate; the lower end of the cross-bar is inserted into the hole of the plate. The weight of the plate, depending on one's need, can be 5, 10, 15, and 20 kg. The lower part of the platform (2000 mm × 880 mm × 50 mm) is made of densely packed boards and is the base of the device. The upper part of the platform is made of two boards (2000 mm × 400 mm × 50 mm) separated by a distance of 80 mm along the entire length of the device. Between the upper and lower parts of the platform (in the short part), there are limiters – wooden blocks (120 mm × 120 mm × 880 mm) – plate slip limiters. The collars are an element that reinforces the connection between the upper and lower parts of the platform.

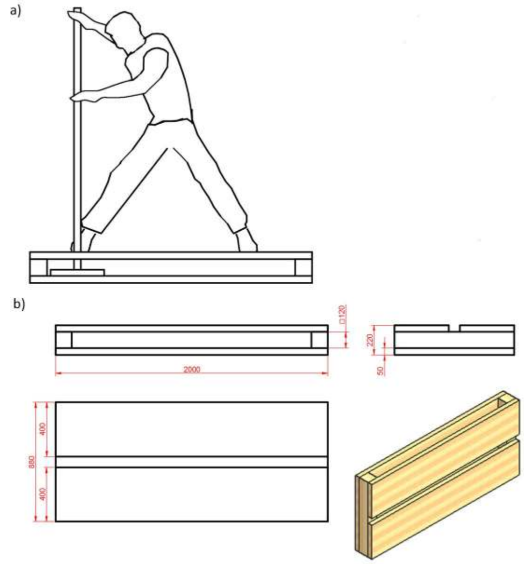

Figure 1. Schematic diagram of the training device for the special strength development of a rower-kayaker: a) overview, b) components and measurements

Exercise performing

An athlete takes a position with his/her legs wide apart on one side of the upper part of the platform, facing the slot between the two boards – composing the upper part of the platform (see Figure 1). The cross-bar is held in the vertical position. The lower end of the cross-bar fits between the halves of the upper part of the platform and is inserted into the hole of the plate lying on the lower part of the platform. The pushing hand holds the cross-bar at the top; the pulling hand does it at the bottom (the position is similar to the grip of the oar before the start of the stroke). The athlete moves the cross-bar with the plate from one extreme lateral position to another by muscular (pulling) effort. At the end of each movement cycle, the plate must rest against the limiter, after which the athlete changes the position of the hands (the pushing hand moves up, and the pulling hand moves down) and continues to move in the opposite direction (Nowak et al., 2018).

Load dosing during the exercise is achieved using the "kayak" training platform. The aim of the exercise is to move the cross-bar of the barbell together with a plate of a certain weight as many times as possible from one limiter to another and back in a given period of time. The weight of the plate and the time for performing the exercise are selected depending on many factors (e.g., age, gender and training level of the athletes, their somatic parameters, strength level, level of mastering the technique of exercise performing, task, and stage of preparation).

Processing

Zero hypothesis regarding normality of the competition results in all eight samples was approved using the Shapiro–Wilk test ($3.39 < b < 5.05$, $p > 0.201$); therefore, Student's t-test parametric statistics were applied.

During the 200 m races, competition time decreased in the experimental group by approximately 1.6 s (3.3%), and in the control group – by 0.9 s (1.8%) (Table 1). For the 500 m race, the differences were similar – 3.6 s (2.6%) and 1.9 s (1.5%), respectively. Improvements in the competition results were strongly significant ($p < 0.001$).

Table 1. Competition results for 200 m (upper numbers in cells) and 500 m (lower numbers) races

Statistics[+]	Competitions*			
	E1	E2	C1	C2
b, s	3.894 4.351	3.389 3.519	3.474 5.054	3.495 4.624
p	0.769 0.853	0.201 0.942	0.438 5.054	0.569 4.624
M, s	49.2 138.6	47.6 135.0	48.7 137.7	47.8 135.7
SD, s	1.5 1.7	1.4 1.4	1.4 2.0	1.4 1.8
delta_ M, s	1.6 3.6		0.9 1.9	
%	3.3 2.6		1.8 1.5	

Notes: *E1, C1 – November; E2, C2 – March; [+]b is the value in the Shapiro–Wilk test statistics; p – significance; M – arithmetic mean; SD – standard deviation; delta_M is the difference in competitions results between November and March; % – difference in percentage

Very strong Pearson correlation was noticed between the competition results of races with 200 and 500 m distances: $r = 0.959$ in November and $r = 0.949$ in March ($p < 0.001$).

A decrease in the time of the 200 m competition race in the experimental group (1.6 s) was 0.7 s greater than that in the control group (0.9 s, $p < 0.001$). Similar results were noted in competition time in the 500 m race with 1.7 s difference in the competition results between the experimental and control groups ($p < 0.001$).

Distributions of additional mass load and number of repetitions are presented using similar functions (Figure 2).

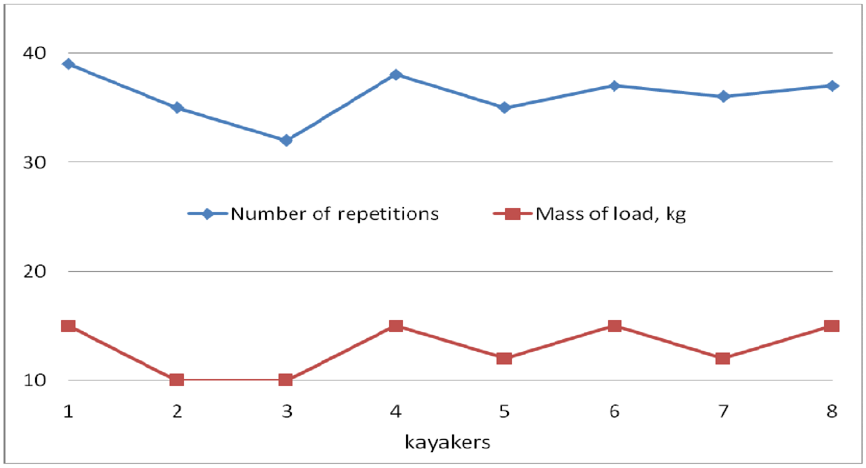

Figure 2. Number of repetitions and additional mass load

Strong Pearson correlation was revealed between the number of repetitions and the mass of load in the experimental group ($r = 0.872$, $p < 0.003$).

According to the results of two-way ANOVA (Table 2), a strongly significant bias appeared between the competitions results for 200 m ($p = 0.021$) and 500 m ($p < 0.001$) distances. The corresponding quarter of variance equals 17.2% and 40.8%, respectively. These parameters confirm a significant decrease in the time of overcoming the two studied distances in March compared to November competitions.

Contrary to the time bias, no significant differences were noted between the competition results of both groups: $p = 0.842$ for 200 m distance and $p = 0.878$ for 500 m distance with a quarter of variance of approximately 0.1%. These results have good correlation with corresponding quarters within group dispersion (80.9, 55.7%).

Table 2. Results of two-way ANOVA: 200 m (upper numbers in cells) and 500 m (lower numbers) races

Source of dispersion	SS^+, s^2	df	MS, s^2	F*	p	Q%
Competitions	11.76 60.23	1	11.76 60.23	5.95 20.50	0.021 0.000	17.2 40.8
Groups	0.08 0.07	1	0.08 0.07	0.04 0.02	0.842 0.878	0.1 0.0
Interaction	1.20 5.20	1	1.20 5.20	0.61 1.77	0.442 0.194	1.8 3.5
Within groups	55.38 82.24	28	1.98 2.94	–	–	80.9 55.7
Total	68.42 147.74	31	2.21 4.77	–	–	100.0

Notes: $^+$SS – sum of squares, df – degree of freedom, MS – variance,
F – Fisher statistics, p – significance, Q – quarter of variance; F* (0.05, 1, 28) = 4.20

Discussion

The influence of a special strength training using an innovative kayak ergometer during an offseason period on the sport competition results in water rowing in 200 and 500 m races has been discovered. In high performance sport (elite sports), there is a rule according to which the main quality (in this case, special strength) must be developed and constantly improved, “hitting one point with a variety of means”. A wide range of technical and methodological capabilities is required (Kolumbet et al., 2017; Majumdar et al., 2017; Pickett et al., 2019).

In kayaking, especially after the World Federation eliminated the width limits of the sport boat, the ability to use your own body weight to propel the boat forward is an important factor. Therefore, it is not the general strength of the rower that is important, but the special one. Specifically, during the offseason, the development of the qualities of strength and strength endurance should be rationally linked, taking into account the influence of training efforts on the development of the strength of the necessary muscle groups, a specific sense of balance, which directly affects the ability to use body weight to move the boat forward (Akca, 2014; Piekorz et al., 2018).

In this study, group "E" athletes mastered the new simulator, positive results were recorded, and the athletes achieved certain sporting success. Most importantly, thanks to the innovation, group "E" athletes showed the best time indicators in the spring control competitions in kayak races at 200 and 500 m distances.

The effectiveness of the development of special strength using the presented simulator in training during the offseason period (from November to March) was confirmed and, occasionally, during the competitive period, by a group of rowers-kayakers specializing in competitions at 200 and 500 m distances. In the first month of the experiment, the most successful training range (exercise time and weight) was identified for each athlete (Kolumbet et al., 2018).

Corresponding recommendations regarding training with the proposed apparatus were provided. Because the athletes had different height and body weight, during circuit training, the weight load should be selected individually (within the range of 5–20 kg). During the training with the objective to complete the exercise in a short period of time with a near-limiting weight, the task should be set to move the cross-bar with the greatest possible resistance without distorting the structure of the movement. The control should be based on the results of autumn competitions during 200 and 500 m races. The second control competition should be held in the spring of the next year.

This study was conducted among male kayakers; a similar study should be also conducted on female kayakers. The training apparatus proposed in this study can be used in its original option, but the training procedure (number of repetitions and mass load) should be reduced to match the female fitness level. This study can be performed in the future according to Van der Zwaard et al. (2018).

Another direction of future research is to conduct a study on kayaker performance on canoes, but taking into account the asymmetrical geometry of canoe rowing (Zharmenov et al., 2019).

Conclusions

A special strength training using an innovative kayak simulator during an offseason period (November–March) resulted in a strongly significant ($p < 0.001$) increase in the sport competition results in water rowing at the distances of 200 m (0.7 s) and 500 m (1.7 s). Very strong Pearson correlation was observed between competition results in races at 200 and 500 m distances: $r = 0.959$ in November and $r = 0.949$ in March ($p < 0.001$) as well as correlation between the number of repetitions and mass of load in the experimental group ($r = 0.872$, $p < 0.003$), which confirmed the effectiveness of new proposed apparatus and corresponding methods of training during the offseason period. The new ergometer can be recommended for use in the training process of young kayakers during an offseason period.

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