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Original Article

Improvement of the motor structure of the paddle technique of qualified female athletes in rowing

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Abstract
The article is devoted to solving the problems of improving the motor structure of the technique of rowing qualified female athletes in women's single skulls boats in the yearly circle at the stage of specialized basic training in rowing. In the study 36 female rowers (qualification – members of the national team of Ukraine) were investigated. Using high-quality SONY Didgital 8 cameras and Lumax software, quantitative and qualitative characteristics of the rowing technique for female athletes of different qualifications were determined. As a result of comparative analysis, significant differences in the biomechanical structure of the rowing locomotion technique of female rowers of different qualifications were established on the basis of which average group statistical models of technical preparedness were developed. In order to improve the technique of rowing of the athletes of the junior national team of Ukraine in single skulls boats we have justified and developed a training program. In order to approve it, a forming experiment was carried out, which involved 12 female rowers. Dividing of athletes on the control and the experimental group was carried out by random selection of six female athletes who at the beginning of the experiment had no statistically significant differences in technical parameters. The data obtained as a result of the pedagogical experiment confirmed the effectiveness of our proposed program to improve the kinematic structure of rowing technique in single boats in female athletes of the experimental group.
Keywords: rowing academic, skilled female athletes, kinematic characteristics, rowing technique, models, program.

Introduction

At the modern stage of the development of sports science, many leading experts point out the priority importance of technical training in achieving high sport results (V. Kleshnev, 2013; O. Shinkaruk, 2015; V. Platonov, 2015). In this regard, there is a natural need to find new means and methods of intensifying the training process.

The issue of improving of technical training in rowing has been considered by many authors who recommend improving the quality of technical training by studying the kinematic structure of movements of athletes of different qualifications (V. Gamali, 2015; K. Xianglin, 2018; K. Bogatyryova, 2019). Kolumbet A., Babina N. (2018) consider that there are three main factors which influence the speed of distance going: the pressure of water on the paddle, the stability of the boat and the acceleration of the overall center of mass of a rower during performing the paddle. Baudouin A., Hawkins, D. A. (2002) analyzed the technique of rowing, linking biomechanical, biological and mechanical systems.

The estimate of the change in kinematic indices and the coordination of lower limb movements during the going of the 2000 m rowing distance at ergometer were examined by Fara Liana Zainuddin, Amirah Zahiran (2019). Bogush V. (2015) and Getmantsev S. (2015) developed a method of measuring the effect of training actions, the use of which allowed to reveal the quality of mastering technical elements, the formation of skills, the acquisition of more complex motor skills of women athletes of different age and qualifications.

The analysis of literary sources shows that in the scientific works on the theory and methods of training of athletes in rowing issues related to the peculiarities of rowing locomotion technique in skilled single women in boats, as well as the regularities of restructuring of the technique of rowing training studied insufficiently, what adversely affects the efficiency of the training process and their technical preparedness.

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Material and methods

Participants. The study involved 36 female athletes specializing in rowing (qualification – members of the junior national team of Ukraine, members of the national team of Ukraine, participants of European and World Championships).

Organization of research. Before conducting the ascending experiment, we studied the features of technical training in rowing, conducted sociological (interviews of coaches and athletes, questionnaires) research. The purpose and tasks of the work were formulated, the methods of research are selected and tested according to the purpose and tasks.

We used the method of pedagogical experiment during all stages of the study. The method of anthropometry (height meter, medical scales, centimeter tape) allowed us to determine: height, body weight, leg length, arm span, body proportions of female athletes.

Video recording (2 video-cameras SONY Didgital 8, shooting at 50 frames per second) was used to record the competitive activity of female athletes at competition and for obtaining the kinematic characteristics of the technique of rowing movements of female athletes of different qualifications and the velocity of the boat during the rowing cycle. The first camera was set at a point of 1000 m and the second camera was set at a point of 100 m before the finish. The camcorders were equipped with a zoom that allows to change the focal length of the subject with constant image sharpness, which allowed us to record subjects at different distances of 10-40 meters. During filming, the metrological conditions in which the competition took place were taken into account: a tailwind with a speed not exceeding 2 $m \cdot s^{-1}$ and a flow velocity of 0.05 m s^{-1}, the direction of which coincided with the direction of the boat turn, which is a valid condition for registration the sports results. The longitudinal axis of the camera lens was perpendicular to the motion of the subject. To determine the real coordinates of the studied points two systems of reference space were used: the external – buoys, which are located at a distance of 10 m from each other, relative to the internal reference system the size of the boat's bracket was used – 0.75 m.

Biomechanical analysis of kinematic structure of motor actions was carried out the means of the automated software complex «Lumax», quantitative characteristics of rowing locomotive technique were determined for sportsmen of different qualifications in single boats: angles in elbow, knee and shoulder joints (°); linear velocity of the elbow, knee, shoulder joints and the boat (m s^{-1}); horizontal speed of the paddle blade (m s^{-1}); duration of one rowing cycle and rowing phases (c); the boat path in one rowing cycle; trajectory of the handle in the stroke cycle. The above indicators were calculated in automatic mode of APC "Lumax".

In our study, the modeling of motor technique was used to develop statistical models of female athletes of different qualifications in single boats. The methods of creating statistical models contained gathering of information about the technique of competitive action in the form of quantitative biomechanical characteristics, to determine their variability and carrying out a comparative analysis to identify discriminatory features of techniques, as well as the relationship (correlation) between technical characteristics and the speed of the boat. Statistical models of technique of female athletes of different qualifications were laid in the basis of the program of improvement of the technique of rowing locomotion of skilled female athletes in single boats in the yearly circle at the stage of specialized basic training, which was approved in pedagogical experiment.

The study involved 12 skilled female rowers in single boats – members of youth national team of Ukraine, aged 17-18 years. The dividing of female athletes into control and experimental groups was carried out by random selection of six female athletes who at the beginning of the experiment had no statistically significant differences in technical parameters.

Methods of mathematical statistics. The processing of the obtained data was performed in accordance with the recommendations of the specialized literature on mathematical statistics and the experience of previously fulfilled researches. The following statistics were determined: mean, variance, paired Pearson correlation coefficient (r). Because the quantity of samples in the ascending ($n < 12$) and forming experiments ($n < 6$) were small, the significance of differences between the independent samples was determined using the non-parametric Mann Whitney U-criterion, and for the dependent samples using the Wilcoxon criterion at the 95 % ($p = 0.05$). These methods were implemented by computer using standard programs (Excel, Statistica-12).

Results

In the course of studying the peculiarities of the kinematic structure of rowing technique, the following parameters were determined: angular characteristics between the bio-links and the speed of the separate bio-links of the athlete's body at limiting moments of the rowing, the pace and the rhythmic structure of the paddle, the trajectory of the boat in the rowing cycle, as well as the speed of the boat. These characteristics, each of which contributes to the solution of certain tasks, were determined in the limiting moments of the phases: capture, start of posting, middle of posting, end of posting, middle of preparation.

Before making the biomechanical analysis of the technique of competitive actions, we conducted a comparative analysis of the anthropometric body size of female athletes, which affect both the individual characteristics of the technique and the quality of the entire rowing (Gamali, 2013), in particular length of body, torso, upper and lower limbs. No statistically significant differences in these indicators were found between female athletes of different qualifications ($p > 0.05$).

The analysis of the characteristics of rowing technique of female athletes of different qualifications at point 1000 m before the finish showed that, the vast majority of characteristics do not have statistically significant differences except for the integral indicators: the speed of rowing, the path of the boat for paddle and its speed. The information obtained was not enough to identify trends in changes in the female athlete's technique with increasing qualifications that lead to an improvement in the integral indicators. To this end, we analyzed the kinematic structure of the rowing technique in all female athletes at the finish line at point of 1000 m before the finish, when the speed of the boat is maximum, which allowed us to identify differences in the technique of rowing locomotion of different qualifications in women's single skulls boats.

In order to develop a medium-group model of kinematic structure of rowing technique of female athletes of different qualifications in single boats, we performed a correlation analysis, based on which the closest interrelation between the studied indicators of technique and the speed of the boat was established. These include the twelve most informative indicators of technical preparedness, namely: the pace of rowing, the speed of the paddle blade in the "catch", the angle at the elbow at the moment of "catch", the angle of inclination of the torso at the moment of the "end of stroke ", the duration of the phase "catch – start of stroke ", duration of phase "end of stroke – middle of preparation", speed of shoulder joint and centre of mass of wrist at a moment of "end of stroke", velocity of knee joint at a moment of "middle of stroke", duration of one rowing cycle, path of boat for paddle, average speed of boat in the rowing cycle.

All of the above indicators were used by us to construct statistical average group models of kinematic structure of rowing technique of female athletes of different qualifications in women's single skulls boats.

When constructing the models, the values of the technical characteristics of the world leading female athletes were taken as 100%, and the values of the technical characteristics of the other female athletes – in percentage relative to them (Fig. 1).

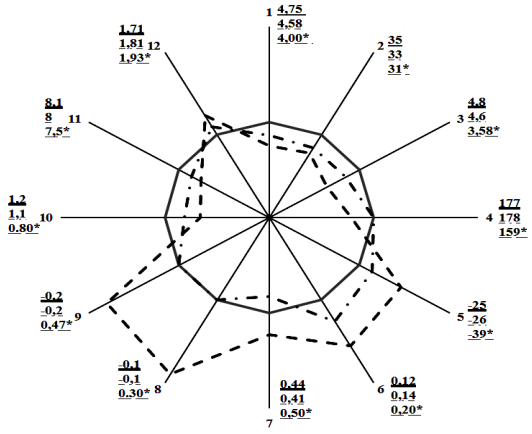


Fig. 1. Average group models of the most significant elements of the kinematic structure of rowing technique of female athletes of different qualification before starting the pedagogical experiment:

1 – average speed of the boat in the cycle of paddling, $m \cdot s^{-1}$; 2 – pace of rowing, $paddle \cdot min^{-1}$; 3 – the speed of the paddle blade at the moment of "catch", $m \cdot s^{-1}$; 4 – angle in elbow joint in the moment of "catch", degrees; 5 – torso angle at "end of stroke", degrees; 6 – duration of the phase "grip – start of stroke", s; 7 – the duration of the "end of stroke – middle of preparation" phase, s; 8 – shoulder joint velocity at the moment "end of stroke", $m \cdot s^{-1}$; 9 – the speed of the centre of the wrist at the moment of the "end of the stroke", $m \cdot s^{-1}$; 10 – knee joint velocity at the moment of "middle of stroke", $m \cdot s^{-1}$; 11 – path of boat for paddle, m; 12 – duration of the single rowing cycle, s;

—— –world's leading female athletes;

– . – – Ukrainian leading female athletes;

– – – qualified female athletes;

*– statistically significant difference between female athletes of different qualifications at $p<0,05$

Models of world and Ukrainian leading female athletes of the are very similar, except for minor differences: average boat speed in the rowing cycle of the leading female athletes of Ukraine is 3.58% lower, the speed of rowing is also 5.7% lower, the speed of the paddle in the phase of "catch" less on 4,17%, angle at elbow joint at the moment of "start of stroke" is for 0,56% more, angle of torso relative to vertical in phase "end of posting" is for 4% more, duration of phase "catch – beginning of posting" is more for 16%, the duration of the "end of stroke – middle of preparation" phase is shorter for 6%, the speed of the knee joint in the "middle of

stroke" is less by 8%, the boat's path for the single rowing cycle is reduced by 8%, the duration of one rowing cycle is 5% more relatively to the world leading female athletes.

Comparing the characteristics of the rowing locomotion of skilled female athletes with the model of kinematic characteristics of the world leading female athletes, we can note the following significant differences ($p < 0.05$): the average speed of the boat in the single rowing cycle is 16% less, the speed of rowing is 11.3% low, the speed of the paddle blade in the "catch" is less for 25%, the angle in the elbow joint at the moment of "catch" is for 10.1% low, the angle of the torso relative to the vertical in the phase "end of stroke" is for 56% more, the duration of the phase of "catch – the beginning of stroke" is 66,6% longer, duration of the phase "end of stroke – middle of preparation" is 13% greater, the speed of the shoulder joint at the "end of stroke" is greater by 200%, the speed of centre of wrist mass at the "end of posting" phase is 135% greater, and the speed of the knee joint at the moment of "stroke" is 33% shorter, boat rowing cycle is 24% shorter, duration of single boat paddle is 13% longer.

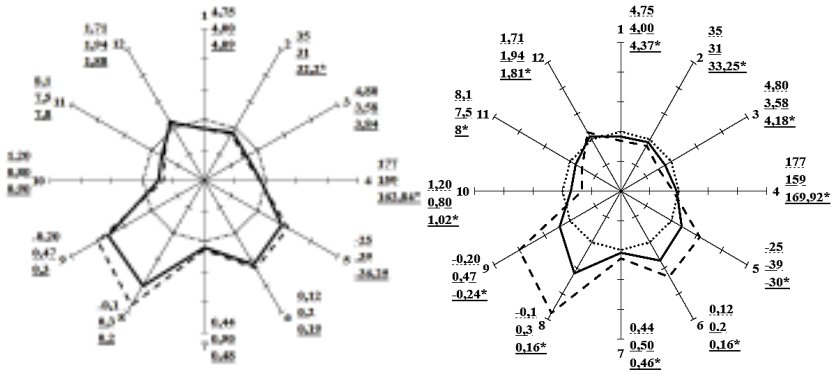
The obtained models of the characteristics of the kinematic structure of the technique of rowing high-qualification female rowers formed the basis for the development of a program for the improvement of the technique of qualified female athletes at the stage of specialized basic training in rowing academic in single boats.

The experimental program was subordinated to the program-purpose principle of organizing the training process (A. Laputin, 1979). The proposed program is aimed to improve the technique of paddling by correcting individual elements of the biomechanical structure of movements of skilled female rowers. The peculiarities of the program are the use in the preparatory and competitive periods of the yearly cycle of training of qualified female athletes developed by us complexes of special physical exercises with motor priorities, aimed to improve the individual elements of the technique of motor athletes' actions; during the carrying out current and stage control over the criteria we have identified for the effectiveness of competitive techniques. One of the components of our program was the experimental redistribution of the number of hours of training aimed at technical improvement in different periods of the yearly cycle.

Considering the opinion of the coaches and specialists in rowing, we considered it advisable to reduce the number of hours allocated for technical training in the preparatory period, and the freed-up time was used for training to improve technique during the competitive period.

The reliability of the differences between the kinematic characteristics of the independent samples was determined using the non-parametric Mann-Whitney criterion, and at the end of the forming experiment, the non-parametric Wilcoxon criterion was used at level of liability 95% ($p = 0.05$).

At the end of the experiment, statistically significant improvements in the values of the characteristics ($p < 0.05$) included in the model of the kinematic structure of the technique of paddling were observed in the skilled female athletes of the experimental group (Fig. 2).



a **b**

Fig. 2. Dynamics of changes in the characteristics of the kinematic structure of technique of qualified athletes of the control and experimental groups in women's single skulls boats during the pedagogical experiment:

a – control group; b – experimental group;

the name of characteristics of the technique 1 – 12 are the same as on the Fig. 1.

····· – the world's leading female athletes;

– – – qualified female athletes (at the start of experiment);

——— – qualified female athletes (at the start of experiment);

* – statistically significant difference between characteristics at the start and at the start of experiment at $p<0,05$

The pace of rowing was increased by 7.2%, the speed of the paddle blade at the moment of "catch" increased by 19.4%, the angle at the elbow joint at the moment of "catch" grew by 6.8%, the speed of the knee joint at the moment of "middle of the stroke" grew by 27 %, the path of the boat in the rowing cycle increased for 13.1%, the velocity of the centre of mass of the wrist at the moment of the "end of the stroke" increased at 60%, average boat speed grew at 7.7%. There was also a decrease in the angle of the torso relative to the vertical at the moment of the "end of stroke" by 7.6%, the duration of the phase "catch - the beginning of stroke" decreased by 20%, the duration of the phase "end of stroke - the middle of preparation" decreased at 8%, the duration of the whole rowing cycle decreased at 7%.

During the experiment, female athletes of the control group also experienced positive changes in rowing technique, but no statistically significant differences with the initial data were detected ($p > 0.05$).

Based on the above, we can conclude that the experimental program for improving the technique of competitive rowing at the stage of specialized basic training has proved its effectiveness and can be successfully used to improve the sports and technical skills of qualified female athletes in single boats in rowing.

Discussion

The confirmation and further development of fundamental statement of the authors P. F. Pelz, & A Vergé, (2014), A.N. Columbet, (2018), A. Baudouin, (2002), on the efficiency of using the method of biomechanical analysis, synthesis, and modelling in improving the sports technique of skilled athletes have been obtained. The statement of Gamali (2013), Černe, T. (2013), that a comparative analysis of the performance characteristics of athletes of different qualifications can be used to identify discriminatory attributes of athletes in one qualification group has also been confirmated. Also confirmed the data of V. Kleshnev, (2005), N. Fleming, (2007) about the rhythmic structure of the rowing and the dynamics of the speed of women's single skulls boats during the rowing cycle athletes of high qualification.

The results obtained in our study complement the data of E. Buckeridge, (2012), L. Ng, (2013), PF Pelz, & A. Vergé, (2014) on the objective criteria for evaluating the technical skills of female athletes of different qualifications in rowing and peculiarities of the kinematic structure of the rowing locomotive technique of high-class female athletes, namely: angular characteristics of the positions of the bio-links of the body, their speed and velocity of the paddle blade at the certain moments of the phases of the rowing cycle, peculiarities of the trajectory of the handle of the oar, the rhythmic structure and boat speed in the rowing cycle.

Statistical average group models of technical qualification of high-skilled female athletes and skilled female athletes in single boats made it possible to identify deficiencies in the technical training of rowers at the stage of specialized basic training and to substantiate the orientation of the training program for their technical improvement. The data obtained as a result of the pedagogical experiment confirmed the effectiveness of our proposed program of improving the kinematic structure of rowing technique of female athletes in women's single skulls boats of the experimental group. During the implementation of the program there were positive changes in the characteristics of the kinematic structure of rowing movements: the speed of rowing increased by 2 rows$\cdot$min^{-1}; the speed of the paddle blade in the catch increased by 0.5 m$\cdot$s^{-1}; the angle at the elbow joint at the moment of "catch" became more for 11 °; the torso angle at the end of the stroke has decreased for 10 °; the duration of the "catch - start of stroke" phase decreased by 0.03 s and the "end of stroke - mid - stage" phases by 0.04 s; at the moment of the "end of stroke" the speed of the shoulder joint increased at 0.64 m$\cdot$s^{-1} and the centre of mass of the wrist raised for 0.26 m$\cdot$s^{-1}; the knee joint velocity increased by 0.22 m$\cdot$s^{-1} at the moment of "middle of stroke"; the duration of one rowing cycle decreased for 0.12 s; the boat's path increased for 1.24 m in one row; the average speed of the boat in the rowing cycle increased by 0.37 m$\cdot$s^{-1}. Female athletes in the control group also noted positive dynamics of individual indicators, but statistically significant differences with the original data occurred in isolated cases.

Conflict of interest. The authors state that there are no conflicts of interest.

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