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Model for training marathon swimmers in fins accounting for energy supply mechanism of muscle activity

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ABSTRACT

Open-water marathon swimming with fins demands high levels of physical fitness from the athletes. The highest emphasis is placed on improving the general and speed endurance. This can only be achieved through targeted impact on the physiological structures of marathon swimmers, accounting for the individual characteristics of the mechanism behind the energy supply for muscle activity. Analysis of the literature has revealed that most works on training of marathon swimmers in fins do not provide sufficient data accounting for the individual specifics of the mechanism supplying energy for the athlete's muscle activity during training for competitions. This greatly limits the possibilities for differentiating the techniques and methods for improving general and speed endurance. Furthermore, methods for improving general and speed endurance in open-water marathon swimmers with fins, with different types of energy metabolism serving as the differentiation criterion, have not received sufficient attention. The existing system for training marathon swimmers in fins; for competitions does not offer satisfactory options accounting for the energy supply mechanism of muscle activity during practice. The system's main drawback is in the general approach to training of marathon swimmers in fins, which does not allow effectively increasing the general endurance and speeding endurance. Our findings indicate that the techniques and methods for training marathon swimmers in fins accounting for the individual characteristics of the mechanism for energy supply of muscular activity play a prominent role in improving the efficiency of training athletes for competitions. This actually helps athletes to achieve better results in training and in competitions. We have established that properly organized training sessions accounting for the individual characteristics of the energy supply mechanism of muscular activity have a higher efficiency. Studies have shown that the goals of developing general and speed endurance should be achieved in training marathon swimmers in fins in open water. General endurance is necessary for athletes to maintain high speed during the race, and speed endurance is necessary for building up speed at the finish. We have confirmed that special tasks during such training should be solved allowing for the individual characteristics of the mechanism for energy supply of muscular activity in marathon swimmers. The article reports on the results obtained for a training model developed for open-water marathon swimmers in fins, accounting for the individual peculiarities of the mechanism for energy supply to the athletes' muscular activity.

Keywords: Marathon swimmers in fins; Training model; Energy supply mechanism; Muscle activity; Training for competitions.

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INTRODUCTION

Open-water marathon swimming with fins is a strenuous activity demanding high levels of physical fitness. Specialized training for long distance swims in natural water bodies is based on developing special endurance in overcoming long distance with high wave disturbance and unstable temperature conditions. The efficiency of developing special endurance depends on specific training procedures accounting for the type of energy metabolism in marathon swimmers. Multiple studies on this problem only perfunctorily address the issues related to the energy supply of muscular activity in marathon swimmers (Bakayev & Bolotin, 2020; Ferreira et al., 2016; Bolotin & Bakayev, 2017a; Costa et al., 2012; Morales, & Arellano, 2019).

The practice shows that the means and methods of training marathon swimmers with fins, considering peculiarities of the mechanism of energy supply of their muscle activity, is of considerable importance efficiency of preparation for competitions. This actually helps athletes to achieve better results in course of training process and during competitions (Bakayev, Bolotin, & You, 2018; Leko, Siljeg, & Greguranic, 2019). When taking into account peculiarities of the muscular activity energy supply mechanism, trainings prove to be more efficient. They solve tasks related not only to the development of physical abilities of marathon swimmers with fins, but also to a number of positive morphological changes in the structure of their muscles, ligaments and joints, as well as to the improvement of the muscular activity energy supply mechanism (Sousa et al., 2013; Bolotin, & Bakayev, 2017b; Dalamitros, Manou, & Pelarigo, 2014). These changes make it possible for marathon swimmers with fins to achieve better results in course of trainings (Bolotin et al., 2020).

MATERIAL AND METHODS

The study involved 18 marathon swimmers specializing in open water swimming at distances of 6 and 20 km. The participants were aged 17–20 years. The developed training options were tested on 4 groups of athletes, formed depending on the type of energy metabolism: aerobic type, anaerobic type, mixed type, type without account for energy supply. The experiment lasted for 6 weeks of special training. Techniques and methods of specialized training for each group of athletes were developed taking into account the peculiarities of the mechanism for energy supply of muscular activity. The model for training swimmers was substantiated by comparative analysis of functional capabilities in athletes from various groups, differentiated by type of energy metabolism.

A method for rapid diagnostics of the functional state and reserve capacities of the athletes developed by Dushanin (1986), called the D&K-Test, was used for the study. The algorithms determined the athlete's type of energy metabolism based on analysing the behaviour and height of the R- and S-waves of the electrocardiogram, taken in 3 main, 3 augmented and 6 chest leads.

The data obtained has allowed us to estimate the following indicators:

1. The anaerobic energy supply capacity index (CANSE) describes the ability to withstand the load in the 3rd, 4th and 5th intensity zones.
2. The aerobic energy supply source capacity index (CASE) describes the ability to withstand the load in the 1st and 2nd intensity zones.
3. The total metabolic capacity index (TMC) describes overall performance ability of the body.
4. The power of creatine phosphate energy supply index (PCPES) describes the swimmers' velocity.
5. The glycolytic energy supply capacity index (GPS) describes the swimmers' speed endurance.
6. The aerobic energy supply capacity index (PAE) describes the ability for general endurance, as well as one for recovering from anaerobic work.

Effective control over the training process was achieved by differentiating the techniques for special training of marathon swimmers depending on the specifics of the energy supply of their muscular activity.

The swimmers' pace endurance, mainly that of aerobic type of energy metabolism, developed by the method of continuous long-term exercise, and speed endurance – by the method of repeated trainings.

Pace endurance of athletes with anaerobic type of energy metabolism developed by the method of interval exercise, and speed endurance – by the method of submaximal load with the fixed number of repetitions of swim segments. For the reference group of marathon swimmers, standard means and methods of pace and speed endurance development were used.

The load for marathon swimmers was selected based on the current result in swimming at 1,500 m. The number of repetitions of the swim segments and the weekly scope of the training load were chosen depending on the level of the athletes' functional state. For managing specific training, the training process control system proposed by Turetsky (Kleshnev & Turetsky, 2000) was applied. It included power bench testing, lactate profile estimation, Skin fold test and blood profile analysis. The system was used for planning swimmers' training program considering their heart rate and energy metabolism type. According to the studies, the success in training athletes for competitions largely depends on marathon swimmers' individual features, their muscular activity energy supply mechanism to be taken into account (Bolotin, & Bakayev, 2017a). This requires revision of attitudes on organization and conduct of the training process for marathon swimmers. It is necessary to select for training such means and methods that should be most consistent with the athletes' peculiarities of the muscular activity energy supply mechanism.

It is typical for marathon swimmers' training to solve specific tasks on pace and speed endurance development. Pace endurance is required for athletes to maintain their high speed during swimming, while speed endurance is responsible for increasing the swimming speed at the finish section of the marathon distance. And the longer this final section of the high speed swim, the better the athlete's end result is. Previous studies proved that special tasks during such training sessions should be solved on the basis of peculiar features of the muscular activity energy supply mechanism (Bolotin et al., 2020).

Table 1. Main parameters of marathon swimmers' load at the specific preparatory stage of practicing for the competition (6 weeks).

Load parameters	**Groups of the tested, by energy metabolism type**		
	Aerobic type	**Anaerobic type**	**Without reference to a particular energy metabolism type**
Daily swimming length, km	18–20	12–16	16–18
Weekly swimming length, km	116–120	72–96	96–116
Number of training sessions per week	12	12	12
Main training task	6 x 800 m; 4 x 2,500 m	4 x (5 x 400 m); 6 x 1,000 m	8 x 1,000 m; 2 x 5,000 m
Training method	Balanced, repetitive	Interval, of submaximal loads	Balanced, repetitive, interval

For solving the problem aimed at improving quality of organization and conduct of the training process in case of marathon swimmers, we have developed the pedagogical model of training athletes. The main approach to building the model of training for marathon swimmers supposes distribution of means and methods of the athletes training for competitions, based on peculiar features of the muscle activity energy supply mechanism. Such distribution should be aimed at developing pace and speed endurance of marathon swimmers in fins (Table 1). In course of development of marathon swimmers' pace and speed endurance, the means and methods of their training was changed too, in accordance with peculiarities of the muscular activity energy supply mechanism. Such training resulted in marathon swimmers' readiness to efficiently solve tasks under any conditions of contests.

RESULTS AND DISCUSSION

As a result of the study, some variation in specialized tests indices has been identified, depending on marathon swimmers' energy metabolism type (Table 2).

Table 2. Changes of results for marathon swimmers with various energy metabolism types for swimming at 6,000 m (min).

Testing period at the special preparatory stage of practicing	Groups of the tested, by energy metabolism type		
	Aerobic type	Anaerobic type	Without reference to a particular energy metabolism type
Stage start	59.2 ± 1.4	59.7 ± 1.3	59.4 ± 1.2
Stage finish	57.9 ± 1.2	58.2 ± 1.2	58.9 ± 1.1

When swimming at 6,000 m, athletes with the aerobic energy metabolism improved average time of passing the distance by 78 s, with the gain of 2.9 % ($p < .05$). The tested athletes with the anaerobic energy metabolism improved average result by 90 s, with the gain of 3.3 % ($p < .05$). In this test, athletes from the group without reference to a particular energy metabolism type demonstrated average time reduction by 30 s, which corresponds to the gain of 1.1 % ($p < .05$).

Table 3 presents results of evaluation of functional and reserve capabilities of the athletes' bodies before and after the special preparatory stage of training marathon swimmers with fins.

Thus, as a result of the differentiated training method to be applied to marathon swimmers with fins, the significant gain in the indices of functional and reserve capacities of the body was identified. It should also be mentioned that, with no significant gain in the CANSE and PAE indices in the group of athletes without reference to a particular energy metabolism type, there was a significant gain in these indices in the groups of athletes with aerobic and anaerobic types of energy metabolism. The data obtained allow us to conclude on efficiency of the differentiated method of preparation of marathon swimmers for open water swimming, developed on the basis of energy metabolism types.

In course of the study, it was found out that the content of the pedagogical model of training marathon swimmers, based on peculiarities of their energy metabolism types, should be developed in view of the systemic and program-targeted approaches to selection of training means and methods.

The *systemic approach* to selection of means and methods for training marathon swimmers made it possible to consider the training process as a set of its structural components and their functional relations, in the course of preparation for competitions. These components of the training process and their functional

relations has totally determined a certain integrity and internal organization of the pedagogical model of preparing marathon swimmer for competitions, based on specific features of their energy metabolism types.

Table 3. Changes of indices of functional and reserve capacities of a marathon swimmer's body as a result of the special preparatory stage of practicing

Testing period	Groups of the tested by energy metabolism type			
	Aerobic type	**Mixed type**	**Anaerobic type**	**Without reference to a particular energy metabolism type**
	Anaerobic metabolic capacity (CANSE), c.u.			
Before	45.42±13.68	71.07±6.9	124.65±8.96	76.12±34.63
After	48.96±11.23	76.9±4.89	136.1±11.32	82.52±9.15
t	*0.62*	*2.19**	*2.44**	*0.84*
	Aerobic metabolic capacity (CASE), c.u.			
Before	240.1±21.36	229.5±17.63	204.41±21.69	226.65±29.49
After	260±18.13	249.5±13.68	218.92±18.67	244.85±16.83
t	*2.22**	*2.89**	*1.38*	*2.50**
	Overall metabolic capacity (TMC), c.u.			
Before	285.5±12.3	300.6±21.42	329.06±22.18	302.78±34.07
After	308.52±14.38	326.4±19.22	355±23.01	327.65±18.87
t	*4.10***	*2.98***	*2.34**	*2.98***
	Power of creatine phosphate energy supply (PCPES), c.u.			
Before	31.54±2.35	29.55±1.95	38.75±2.26	32.64±5.93
After	34.79±2.167	32.03±2.19	41.93±2.12	35.57±2.16
t	*3.23***	*2.96***	*2.86**	*2.17**
	Glycolytic power supply (GPS), c.u.			
Before	31.60±2.65	29.52±2.47	33.5±2.03	31.28±3.19
After	34.35±2.76	31.94±2.03	35.77±1.58	33.75±2.12
t	*2.35**	*2.47**	*2.35**	*3.00***
	Power of the aerobic energy supply source (PAE, c.u.			
Before	57.48±4.43	52.12±5.80	46.39±4.03	51.62±10.60
After	62.25±3.22	56.03±6.13	51.63±4.34	56.28±8.96
t	*2.63**	*1.60*	*2.57**	*1.56*

*Note: ** – p < .01; * – p < .05*

When substantiating the model of preparing marathon swimmers for competitions, based on specific features of their energy metabolism types, the *program-targeted approach* to selection of means and methods of training was applied. Application of the program-targeted approach to selection of means and methods for training marathon swimmers, based on specific features of their energy metabolism types was determined by provisions that the core of the model for training marathon swimmers for competitions should include: the goal of the training session, conditions for its achievement, control of the training process, results and their correction. In this case, the training process should be considered as the unity of the athletes' and the coach's activities in course of preparation for competitions. Such the athletes' and the coach's united activities in the course of preparation for competitions constituted the stable interrelation of the target, content and evaluation and result components of the pedagogical model of training athletes, considering peculiarities of their energy metabolism types. The results of the pedagogical experiment demonstrate high efficiency of the developed pedagogical model of preparing marathon swimmers for competitions, taking into consideration peculiarities of their energy metabolism types.

In the experimental group, marathon swimmers' readiness for competitions was significantly higher than that of the tested in the reference group. The performance results of the tested from the experimental group at competitions objectively demonstrated high efficiency of the pedagogical model of training marathon swimmers, developed on the basis of specific features of their energy metabolism types. At competitions, their performance results were on average better by 2.5–3 minutes than those of the tested athletes from the reference group.

CONCLUSION

The preparatory stage of training marathon swimmers with different types of energy metabolism for competitions revealed different body reactions to the training load. Athletes with anaerobic and mixed types of energy metabolism are quicker to adapt to speed and endurance training, while swimmers with the aerobic type of energy metabolism are quicker to adapt to long-term endurance training. This indicates that accounting for the type of energy metabolism in marathon swimmers may serve to determine the techniques and methods for training athletes in open-water swimming.

We have found that pace endurance in athletes with the aerobic type should be developed through standard continuous practice, and speed endurance through repeated practice. Pace endurance in athletes with the anaerobic type of energy metabolism should be developed by the method of interval practice, and speed endurance by the method of off-peak practice with a normalized number of repetitions of distance segments. Pace endurance in swimmers with mixed type of energy metabolism should be developed by a variable method of practice, and speed endurance by a combination of repeated practice with the method of off-peak practice with a fixed number of repetitions of distance segments.

REFERENCES

Bakayev, V., & Bolotin, A. (2020). Differentiated Training Model for Marathon Runners on Building Tempo and Speed Endurance Based On the Types of Energy Metabolism. Sport Mont, 18(3), 31-34. https://doi.org/10.26773/smj.201011

Bakayev, V., Bolotin, A., & You, C. (2018). Reaction of vegetative nervous system to loads in female long-distance runners with different fitness level. Journal of Human Sport and Exercise, 13(2proc), S245-S252. https://doi.org/10.14198/jhse.2018.13.Proc2.09

Bolotin A., Bakayev V. (2017a). Method for Training of Long Distance Runners Taking into Account Bioenergetic Types of Energy Provision for Muscular Activity. In Proceedings of the 5th International Congress on Sport Sciences Research and Technology Support, pp. 126-131.

Bolotin A., Bakayev V. (2017b). The differences in response of the respiratory system of long and middle-distance runners and their influence on recovery rate. Journal of Physical Education and Sport, 17(4), pp.2443-2446. https://doi.org/10.7752/jpes.2017.04272

Bolotin, A.E., Bakaev, V.V., K.J.van Zwieten, Ponimasov, O.E., Motovichev, K.V. (2020). Differentiated sports training of marathon swimmers for open water competitions based on types of energy metabolism. Teoriya i Praktika Fizicheskoy Kultury, (10), pp. 37-39.

Costa, M.J., Bragada, J.A., Mejias, J.E., Louro, H., Marinho, D.A., Silva, A.J., and Barbosa, T.M. (2012). Tracking the performance, energetics and biomechanics of international versus national level swimmers during a competitive season. European Journal of Applied Physiology, 112, 811-820. https://doi.org/10.1007/s00421-011-2037-6

Dalamitros, A.A., Manou, V., & Pelarigo, J.G. (2014). Laboratory-based tests for swimmers: methodology, reliability, considerations and relationship with front-crawl performance. J. Hum. Sport Exerc., 9(1), pp.172- 187. https://doi.org/10.4100/jhse.2014.91.17

Dushanin, S. A. (1986). System of multi-factor Express diagnostics of functional readiness of athletes at current and operational medical and pedagogical control: Physical Culture and sport.

Ferreira, M.I., Barbosa, T.M., Costa, M.J., Neiva, H.P., Vilaça, J., & Marinho, D.A. (2016). Effects of swim training on energetic and performance in women masters' swimmers. J. Hum. Sport Exerc., 11(1), 99-106. https://doi.org/10.14198/jhse.2016.111.08

Kleshnev, V.V., Turetsky G.G. (2000). Comparison of the systems of organization of applied sports science in Russia and Australia. Teoriya i praktika fizicheskoy kul'turi, 11, pp. 59-63.

Leko, G., Siljeg, K., & Greguranic, T. (2019). Effects of the basic period in swimming training with the age group. Sport Mont, 17(2), 99-102. https://doi.org/10.26773/smj.190617

Morales, E., & Arellano, R. (2019). Regression analysis model applied to age-group swimmers: 50m race component times analysis. Journal of Human Sport and Exercise, 14(2), 315-324. https://doi.org/10.14198/jhse.2019.142.05

Sousa, A., Figueiredo, P., Zamparo, P., Vilas-Boas, J.P., & Fernandes, R.J. (2013). Anaerobic alactic energy assessment in middle distance swimming. European Journal of Applied Physiology, 113(8), 2153-2158. https://doi.org/10.1007/s00421-013-2646-3