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Original Article

The impact of the high level of intensity training process on the performance and recovery of young swimmers at the national level

ILYA GUSSAKOV[1], DINARA NURMUKHANBETOVA[2], AIBOL KULBAYEV[3], AMINA YERMAKHANOVA[4], RYSKUL LESBEKOVA[5], VLADIMIR POTOP[6]
[1,2,3,4,5] Kazakh Academy of Sports and Tourism, Almaty, KAZAKHSTAN
[6] Ecological University of Bucharest, ROMANIA

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Abstract
This article describes the effect of the 8-week low-volume training process for high level of performance young swimmers who compete at the national level. *Material.* In the experiment, fourteen swimmers took a part, they were distributed into two groups. The experimental group had a high-intensity training with low training volume, and the control group was training following traditional methods. The experimental group reduced the amount of weekly training in zone 1 (low intensity zone) by 50%, but increased training in 3 zones (zone of high frequency) by 200%. The control group did not make changes in the training process. *Results.* As a result, there was a significant interaction between time and groups in terms of swimming speed at a lactate level of 4 m/mol. Also, the 8-week low-volume training process with a high level of intensity had a significant impact on the performance parameters and psychological state of recovery. *Conclusion.* The main conclusion of the study was that the eight-week HIT experiment led to an increase in the swimming speed at the level of 2 and 4 m / mol of lactate in the blood of the experimental group. In the control group, these indicators remained almost unchanged.
Keywords: Large volume training, high-intensity training process, swimming, building a training process, recovery intervals.

Introduction

Due to the wide variety of competitive distances swimming is a cyclic sport with various physiological and biomechanical features of energy supply. The time of the winners at the 2016 Olympics in Rio de Janeiro ranged from 21.40 sec. at a distance of 50 meters freestyle up to 14 minutes 34,57 seconds. at a distance of 1500 meters freestyle. Nevertheless, twenty-six of the thirty-two (81%) Olympic swimming distances are held at distances of up to 200 meters, the average duration of the distance is about 2 minutes. Despite the short duration of most swimming distances, the traditional practice of the swimmers' training process usually includes large training volumes (i.e. the total training volume and duration). In many cases, training volumes for swimming significantly exceed other cyclic sports, such as running, rowing and cycling. Most often, large training volumes are used at the youth level, where training volumes can vary from 14–26 hours a week for 8–12 training sessions (Nugent, Comyns, & Warrington, 2017; Sein, et al., 2010; Nugent, et. al., 2016).

Swimming efficiency is determined by several different physiological and biomechanical parameters (Faude, et al., 2008; Stott, 2014; Deminice, et al., 2010). Biomechanical parameters such as stroke frequency (number of cycles per minute), stroke length (distance traveled by the swimmer in one cycle) and stroke index (stroke length times the swimming speed) are some of the best defining characteristics of swimming efficiency (Faude, et. al., 2008; Stott, 2014; Deminice, et. al., 2010). This is perhaps one of the incentives for large training sessions, as swimming coaches suggest that for a large number of technical elements, it takes about 20 hours a week to master an effective stroke technique. In recent years, several surveys have studied the effect of swimming programs with a small training volume and a high level of intensity (HIT) in comparison with a large volume of low-intensity training (LVT). A HIT training program is defined as a program with a lower swimming volume that focuses on performing high-intensity intervals. The emphasis is on the 3rd zone, > 4 m / mol of lactate in the blood. The training program for solid domestic waste is defined as a program with a large volume of swimming, which focuses on the implementation of long-term low-intensity training in 1 zone, < 2 m / mol of lactate in the blood (Nugent, Comyns, & Warrington, 2017; Faude, et al., 2008). Some highly qualified swimmers of international level achieved success using HIT programs, which differ from more traditional LVT programs, which led to disputes in the swimming world (Stott, 2014; Deminice, et.al., 2010). Unofficial data suggests that many of the best swimming coaches and athletes are HIT supporters.

Recently, Nugent et al. conducted a systematic review in which they studied the effect of HIT on swimmers' performance (Nugent, Comyns, & Warrington, 2017, p. 3). Seven studies met the same criteria,

Corresponding Author: VLADIMIR POTOP, E-mail: vladimir_potop@yahoo.com

lasting from 4 weeks to 4 years, studies were conducted for school-age children, students, and elite swimmers. Six out of 7 studies showed that HIT programs improved swimming performance indicators, such as maximum oxygen consumption (MOC) and swimming speed at fixed blood lactate values. Four of the 7 studies showed that HIT programs improved performance at distances from 50 to 1,500 m, while none of the 7 studies led to a decrease in performance. The review concluded that the use of HIT may be limited since a number of controlled studies lasted only 4-5 weeks, and therefore more research on this topic is required (Sein, et al., 2010).

As far as it is known in Kazakhstan, the effect of HIT on biomechanical parameters in young swimmers at the national level has not been studied. Many swimming trainers suggest that HIT programs can be harmful to the construction of the correct swimming technique, since the swimming technique is best practiced at low intensity and in large volume, but this topic requires further study. In addition, none of the previous HIT studies gave an accurate quantitative assessment of the training process carried out by HIT and LVT groups using indicators such as heart rate and blood lactate level (Hydren & Cohen, 2015: Barbosa, et al., 2006; Sperlich, et. al., 2010). The present study was aimed at eliminating this methodological shortcoming by assessing physiological and biomechanical changes when using HIT in young swimmers of a national level. Due to the training schedule for 2019, it was not possible to conduct a longer experiment.

Aim of the study: to assess the impact of an 8-week training process under the HIT program on physiological and biomechanical changes in young swimmers of a national level.

Research Objectives:

- determination of anthropometric data from HIT and LVT groups;
- a description of the training process during the experiment;
- determination of the physiological and biomechanical data of the experimental (HIT) and control LVT group during the training process experiment: as well as their descriptive statistics.

Material and methods.

Anthropometry, analysis of the training process using SPSS 21.0 software (SPSS Inc, Chicago, Illinois, USA), the physiological performance was assessed using a 9 × 100 m step test described by Pyneet al., Tests were used to determine the biomechanical characteristics swimming, and evaluated using the methods described by Smith et al., calculated swimming speed (SP), stroke frequency (CH), stroke length (DG) and stroke index (IG) for 50 and 200 meters freestyle. The study involved 14 highly qualified national swimmers aged 16-18. Swimmers were divided into two groups of 7 people each, the control group did not change the training process. At the same time, an eight-week training macrocycle was compiled for the experimental one with interspersed high-intensity, low-volume training sessions in the generally accepted training process. The experiment was carried out based on the sports complex "Rakhat-fitness" in the city of Almaty, Kazakhstan.

Results

According to the results of the study, there was a significant change in indicators between the control and experimental groups ($P > 0.07$). The average volume floated by the HIT group during the experiment was 17.0 ± 2.2 km per week and 33.4 ± 3.2 km per week for the LVT group. The total training volume during the experiment was 119.2 km for the HIT group and 233.7 km for the LVT group. Significant changes in the physiological and biomechanical indices of both groups are also observed (Table 1).

Table 1. Physiological and biomechanical data of the experimental (HIT) and control LVT group during the training process during the experiment

Variable data	HIT group (n=7)	LVT group (n=7)
Average heart rate (bpm)	182±9	151± 8
Max. heart rate (bpm)	193±6	181± 10
The average lactate level (m/mol)	6.8±2.7	1.8± 0.7
Average speed (m/s)	1.46± 0.12	1.12± 0.04
Maximum speed (m/s)	1.58± 0.12	1.39± 0.07
Average stroke frequency (cycle/min.)	40±7	27±5
Average stroke length (m/cycle)	1.97 ± 0.12	2.15 ± 0.02

Note: HIT - high-intensity training: LVT - large-volume training; heart rate; bpm - the number of beats per minute; m / s - meters per second; m/mol - miles/mol per liter of blood; cycle/min - the number of strokes per minute; m/cycle - meters per stroke

Descriptive statistics of physiological, biomechanical, and training effectiveness tests for both groups are presented in Table 2, which shows a significant two-way interaction between time and groups in terms of swimming speed at a lactate level of 4 m / mol ($P = .03$, $\eta p2 = .45$), biomechanical characteristics (ChG50, DG50, IG50, ChG200, DG200, IG200) and swimming efficiency characteristics (50 meters freestyle, 100 meters freestyle and 200 meters freestyle) ($P > 0.07$ for all indicators; table 4). There was a significant two-way interaction between the velocity at the level of 4 m / mol and the velocity ($F_{1.11} = 7.34$, $P = 0.02$, $\eta p2 = 0.40$), DG50 ($F_{1.10} = 5.99$, $P = 0\ 03$, $\eta p2 = 0.37$) and IG50 ($F_{1.10} = 6.49$, $P = 0.03$, $\eta p2 = 0.39$). All other bilateral interactions were not significant ($P > 0.05$). A significant effect was found for the freestyle swimming speed at a distance of 50 meters ($F_{1.11} = 5.16$, $P = .04$, $\eta p2 = 32$, Table 2), while the swimming speed at a distance of 200 meters freestyle remained unchanged in both groups. All data were analyzed based on 12 random training sessions of both groups and indicated on average ± standard deviation. Heart rate was measured during the second half of the training process. Blood samples were taken to determine the level of lactate in the second half of each control training. Swimming speed was measured during the main part of the training. The stroke frequency and stroke length were measured over the entire training period.

Table 2 - Descriptive statistics of physiological and biomechanical data of experimental HIT and control LVT groups

Variable data	HIT experimental group		LVT control group	
	Before the experiment	After the experiment	Before the experiment	After the experiment
Speed at 2.5 m/mol (m/s) lactate level	1.23 ± 0.04	1.27 ± 0.08	1.26 ± 0.02	1.26±0.05
Speed at 4 m/mol (m/s) lactate level	1.30 ± 0.02	1.32 ± 0.08	1.32 ± 0.04	1.32±0.13
The maximum lactate level (m/mol)	9.2 ± 3.4	9.1 ± 3.0	9.4 ± 1.6	9.2±2.2
50 m SF (cycle/min)	49.9 ± 1	49.1 ± 8.1	49.1 ± 2.3	49.6±2.8
50 m SL (m/ cycle)	2.02 ± 0.12	2.07 ± 0.25	2.02 ± 0.15	2.01± 0.27
50 m SI	3.32 ± 0.65	3.37 ± 0.69	3.34 ± 0.49	3.32± 0.70
100 m SF (cycle/min)	48.4 ± 2.6	50.2 ± 2.6	47.7 ± 3.2	49.5 ±2.7
100 m SL (m/cycle)	2.10 ± 0.15	2.20 ± 0.26	2.12 ± 0.31	2.16± 0.20
100 m SI	2.82 ± 0.40	2.97 ± 0.23	2.90 ± 0.46	2.91± 0.20
50 m speed (m/s)	1.74 ± 0.18	1.79 ± 0.16	1.72 ± 0.42	1.72± 0.21
100 m speed (m/s)	1.56 ± 0.04	1.59 ± 0.19	1.54 ± 0.27	1.55± 0.02
200 m speed (m/s)	1.38 ± 0.29	1.38 ± 0.32	1.38 ± 0.38	1.38± 0.07
Note: All the data are indicated on average ± standard deviation; HIT - high intensity training; LVT - large volume training; SF– frequency of strokes; SL - stroke length; SI - stroke index; m/s - meters per second; m/mol - miles / mol per liter of blood; cycle/min - the number of strokes per minute; m/cycle - meters per stroke				

Discussion and conclusion

The main conclusion of the study was that the eight-week HIT experiment led to an increase in the swimming speed at the level of 2 and 4 m / mol of lactate in the blood of the experimental group. In the control group, these indicators remained almost unchanged. Also, indicators of SL and SI at 50 m freestyle decreased in the control group of solid waste. The only indicator of decrease that was found in the experimental HIT group was the maximum level of lactate in the blood, while all other physiological and biomechanical parameters remained unchanged. This suggests that the eight-week experiment on the high-intensity training methodology was useful for most performance parameters of young swimmers at the national level. Also, the HIT experimental group completed, on average, only 6 hours (17.0 km) of swimming per week, compared with 12 hours (33.4 km) per week in the LVT control group. Thus, the HIT program was more effective in time, since it took on average 55% less time for the training process. According to the results of the experiment, biomechanical and physiological indicators indicate that the use of the high-intensity training method is effective in comparison with the large-volume training method (Sperlich, et. al., 2010).

In the course of the study on this topic, it is necessary to note several limitations that arose during the experiment. Firstly, an accurate quantitative assessment of the distribution of the training volume in different training zones is a difficult task, especially in swimming, because of the difficulties associated with the determination of heart rate under water during a distance, heart rate was measured only after the interval. To reduce the error associated with the determination of the load intensity zone during training, the author was present at all training sessions. Secondly, there may be a chance of parallax error due to the use of a single camera to analyze biomechanical data during the experiment. A multi-chamber analytical system was not available during the experiment, but it was shown that the more widely used single-chamber analytical system is accurate in this experiment. Thirdly, the short duration of this study was limited due to the annual training plan for young swimmers at the national level. A systematic review of this topic by Nugent and colleagues (Nugent, et. al., 2016) conducted two studies lasting 1 year and 4 years, which showed that the use of high-intensity training methods improves performance indicators for athletes specializing in sprint distances. Nevertheless, there are numerous methodological shortcomings associated with research, based on which more research on this topic is necessary.

Also, the results of this study can be useful for swimming coaches who work with youth composition, as the results of the study showed a positive effect when using high-intensity training for eight weeks. It will also be useful for those who have a limited training time due to the school schedule. Besides, a smaller training volume using the high-intensity training methodology can potentially reduce the risk of an athlete overtraining. The results show that the eight-week experiment allowed us to reduce the training volume by 50 percent in the first intensity zone and increase by 200 percent the training in the third intensity zone. These changes have had a positive effect on most performance parameters compared to the traditional program aimed at using large training volumes and low intensity levels. The HIT program was also more effective in terms of the average distribution of the training process time: the experimental group trained 6 hours (17.0 km) per week, while the control group had an average training volume of 12 hours (33.4 km) per week.

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