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Original Article

Effects of swimming performance on a change in blood parameters

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Abstract:
The aim of the study was to find out the effect of an applied swimming load in the form of a 200-meter-freestyle swimming test on changes in lactate and haemoglobin levels in young swimmers. Test subjects consisted of 12 swimmers (7 men: age = 17.5±1.1 years, height = 179.5±4.4cm, weight = 80.5±6.8kg; and 5 women: age = 17.1±0.6 years, height = 169.0±3.5cm, weight = 59.6±3.6kg). Swimmers performed a 200-meter-freestyle swimming test and changes in lactate (LA) and haemoglobin (HGB) before a performance (LA^1 a HGB^1), after the performance (LA^2 and HGB^2) and 10 minutes after the swimming test (LA^3 and HGB^3) were monitored. The Friedman Test with an effect size Kendall's Coefficient of Concordance (W) and the Wilcoxon Signed Ranks Test with Bonferroni correction and the effect size (ES) were used to detect significant differences among the observed parameters. The IBM® SPSS® Statistics V19 software was utilised in statistical analysis. The Friedman Test showed significant differences between measured LA levels in men ($\chi^2_{(2)} = 14.000$, $p < 0.05$, Kendall's W = 1.00, the effect size very strong) and in women ($\chi^2_{(2)} = 10.000$, $p < 0.05$, Kendall's W = 1.00, the effect size very strong). The Wilcoxon Signed Ranks Test with Bonferroni correction did not show significant differences among men's LA^1, LA^2 and LA^3, however the effect size was large: $LA^1 – LA^2$ T = 0, n = 7, $p > 0.05$, ES = 0.63 – large effect; $LA^2 – LA^3$: T = 0, n = 7, $p > 0.05$, ES = 0.63 – large effect; $LA^1 – LA^3$: T = 0, n = 7, $p > 0.05$, ES = 0.63 – large effect. Results of women's LA^1, LA^2 and LA^3 were similar to those of men: $LA^1 – LA^{2:}$ T = 0, n = 5, $p > 0.05$, ES = 0.54 – large effect; $LA^2 – LA^3$: T = 0, n = 5, $p > 0.05$, ES = 0.54 – large effect; $LA^1 – LA^3$: T = 0, n = 5, $p > 0.05$, ES = 0.54 – large effect. The Friedman Test applied on the HGB parameter did not show significant differences neither in measured levels in men ($\chi^2_{(2)} = 0.222$, $p > 0.05$, Kendall´s W = 0.02, the effect size very weak) nor in women ($\chi^2_{(2)} = 0$, $p > 0.05$, Kendall´s W = 0, the effect size very weak).
Key words: swimming (sport), performance, lactate, haemoglobin

Introduction

Training stimuli or more precisely an athlete's load initiates changes in the body. The internal environment is being deliberately affected and the impact of autoregulative processes leads to dealing with an entropy of the internal system, and as a result the internal system adapts to relevant stimuli. The body afterwards tries to maintain the internal stability in spite of various training impacts, and as a result to a disruption of definiteness and orderliness of the body, the relevant functional mechanisms are mobilized. These functional mechanisms lead to the stability of the internal environment (Costill et al., 1991; Laczo, 2005).

Possibility of evaluating physiological and biochemical parameters after the load allows us to collect more objective information about the impact of the observed stimulus and also its dynamics of the body's regenerative capabilities. Physiological parameters include observed haemoglobin values and biochemical parameters include lactate values (Laczo, 2011).

Measuring lactate levels in blood is a common practice of the indirect evaluation of training process intensity, the regeneration rate and type of energy metabolism (Janakiraman, Shenoy & Sandhu, 2011). Lactate is not only the waste product of anaerobic glycolysis causing fatigue, but as a metabolic intermediate is an important component of the energy metabolism of the whole body (Bielik, 2006). A high level of lactic acid negatively affects the central nervous system and damages the neurodynamic processes that manifest themselves externally in the aggravated coordination of the neuromuscular apparatus and decrease in the velocity of movement in water. The concentration of lactate in the blood reflects, in a way, the extent of the anaerobic energy metabolism during maximal and submaximal load intensity (Heller, 1996) and provides information on load intensity as well as its process (Ozturk, Ozer & Gocke, 1998).

A level of trainability in individual bio-energetic areas predetermines the quality of the performance in individual disciplines. Differences in assignments are primarily caused by the duration, the inborn abilities and the level of trainability. The evaluation of trainability is mostly based on changes of lactate concentration in blood and the heart rate. The increase of lactate concentration relatively corresponds with the changes of lactate directly in the muscles (Paugschová & Pupiš, 2007). Although the level of lactate in the blood is not a definite

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factor causing the fatigue or activation rate of the energy metabolism, the systematic assessment and the proper use of the lactate level in blood can improve the training process (Bielik, 2006).

Haemoglobin is protein made up of haem subunits and it is an essential part of erythrocyte. It can reversibly bind and release molecular oxygen also partakes in the transport of carbon dioxide and acts as a blood buffering system (Trojan, 1992). At the beginning of the load, the number of red blood cells increases as a result of hormonal stimuli but a long-standing load leads to fluid loss, which causes red blood cells to decrease relatively. During the load, the haematocrit values of long-distance swimmers increase to 50 - 55% (Komadel, 1997). Blood flow conditions deteriorate and blood coagulation increases. The number of white blood cells increases as well as their quantity. After interruption or rather termination of the load, the number of blood elements restore to its initial values in a short time interval. Excessive physical or mental strain, intensive training and racing cause transient changes in the function of white blood cells and the decrease of antibodies (Jančík, Závodná & Novotná, 2007). The number of studies has demonstrated considerable plasma volume changes during and after exposure to different environmental and physiological conditions. These changes are thought to result from transient fluid shifts into (haemodilution) and out of (haemoconcentration) the intravascular space (Kargotich et al., 1998).

The acute reduction of the blood haemoglobin concentration causes lower levels of VO_2max and endurance performance but otherwise, the haemoglobin's increase is similar to the increase in the oxygen carrying capacity of blood and its main effect is monitored on endurance capacity. The haemoglobin's reduction causes a coupling between O_2 demand and delivery during submaximal exercise, but during maximal exercise there is neither peak cardiac output nor peak leg blood flow. In conclusion, there is no effect of the acute increase of haemoglobin on maximal exercise capacity and VO_2 peak during exercise in acute hypoxia (Calbet et al., 2006).

The aim of the study was to find out the effect of a performed swimming load in the form of a 200-meter-freestyle swimming test on changes in lactate and haemoglobin levels in young swimmers.

Materials & methods

Subjects characteristics

The study was realised by assessing subjects consisting of 12 swimmers (7 men: age = 17.5±1.1 years, height = 179.5±4.4cm, weight = 80.5±6.8kg; and 5 women: age = 17.1±0.6 years, height = 169.0±3.5cm, weight = 59.6±3.6kg) chosen intentionally from two Slovak swimming clubs.

Measurement organisation

The study used a 25-meter swimming pool on the premises of Department of Physical Education and Sports, Faculty of Arts, Matej Bel University (DPES FA MBU) in Banská Bystrica. The study took place from 8.00 - 10.00 a.m., Jančoková (2000) stating this time interval as the first daily peak performance. The male and female subjects had not received any specialized preparation before the study.

Measurement

The swimming test and also the blood monitoring were realized in the swimming pool on the premises of the DPES FA MBU in Banská Bystrica as follows:

1. 200-meter-freestyle (ST) – the test was carried out after a general warm up (10min) and freestyle warm-up (400 metres). The swimming test began after the starting signal and finished with the swimmers touching the wall. The times were recorded by 3 examiners. The results are presented at an average value. The 3 examiners recorded times and the results are presented at an average value.
2. Lactate (LA) - the monitoring of lactate levels was carried out immediately before the performance (LA^1), immediately after the swimming test (LA^2) and 10 minutes after (LA^3).
3. Haemoglobin (HGB) - the monitoring of haemoglobin levels was carried out immediately before the performance (HGB^1), immediately after the swimming test (HGB^2) and 10 minutes after (HGB^3).

The LA and HGB values were measured with a CERACHECK 3in1 GHL device, which measures the values of sugar, haemoglobin and lactate in blood. A sufficient blood sample for measurement is 0.5 – 1 µl and values are known after 5 - 10 seconds.

Data Analyses

In the presented study we used within the periphrastic characteristics of descriptive statistics an arithmetic average (x) from position measures and standard deviation (SD) from variability measures. We also used the minimal (min) and maximal (max) value of an individual's parameters. We used The Friedman Test (Friedman's ANOVA) for dependent selections and wanted to find out if there are any significant differences between the performances of the group during the examined period. The Kendall's Coefficient of Concordance (W) was used for the evaluation of the effect size (Green & Salkind, 2008). The coefficient was interpreted as follows: 0 – 0.20 = very weak effect, 0.20 – 0.40 = weak effect, 0.40 – 0.60 = moderate effect, 0.60 – 0.80 = strong effect, 0.80 – 1.00 = very strong effect (Rovai, Baker & Ponton, 2014).

The Wilcoxon Signed Ranks Test with Bonferroni correction was used to detect significant differences between each measurement ($LA^1 – LA^2$, $LA^2 – LA^3$, $LA^1 – LA^3$). The coefficient effect size (r) was computed according to the relation ES = □z□/√n (Corder & Foreman, 2009) and it was interpreted as: small effect = 0.10, medium effect = 0.30, and large effect = 0.50 (Cohen, 1988). The probability of a Type I error (alpha) was set at 0.05 in all statistical analyses. The statistical analysis was performed using IBM® SPSS® Statistics V19 software (Statistical Package for Social Sciences).

Results and discussion

During the observation period significant differences were detected in lactate (LA) and haemoglobin (HGB) levels in men (Table 1) and women (Table 2) immediately before the swimming test (200m freestyle) - (LA^1 a HGB^1), immediately after the test (LA^2 a HGB^2) and 10 minutes after the test (LA^3 a HGB^3).

Table 1 Measured values of blood parameters and results of the swimming performance of male subjects

Subject	LA^1	LA^2	LA^3	HGB^1	HGB^2	HGB^3	ST
1.	1.20	8.50	6.70	17.40	17.30	18.20	128.1
2.	1.50	7.20	6.90	15.60	15.60	17.00	145.9
3.	3.10	8.00	7.30	15.80	17.00	16.50	159.3
4.	1.00	6.90	6.10	15.20	15.80	15.50	162.8
5.	2.60	13.80	10.80	17.30	17.50	16.90	190.9
6.	1.20	6.30	3.80	17.60	16.30	16.70	240.4
7.	1.20	9.10	7.60	15.00	14.50	14.80	269.0
x	1.69	8.54	7.03	16.27	16.64	16.51	185.2
SD	0.82	2.51	2.08	1.12	1.75	1.10	51.8
min	1.00	6.30	3.80	15.00	14.50	14.80	128.1
max	3.10	13.80	10.80	17.60	20.00	18.20	269.0

LA^1, LA^2, LA^3 = lactate levels (mmol/l); HGB^1, HGB^2, HGB^3 = haemoglobin levels (mmol/l); ST = swimming test performance (s)

Table 2 Measured values of blood parameters and results of the swimming performance of female subjects

Subject	LA^1	LA^2	LA^3	HGB^1	HGB^2	HGB^3	ST
1.	1.50	8.60	7.40	13.10	13.60	13.30	162.6
2.	0.70	3.50	2.10	15.40	15.10	17.00	191.6
3.	1.30	7.10	5.60	15.10	14.60	13.50	214.7
4.	4.80	8.30	6.60	15.00	15.60	15.40	237.5
5.	1.20	7.50	5.80	15.00	13.60	14.10	245.1
x	1.90	7.00	5.50	14.72	14.50	14.66	210.3
SD	1.64	2.05	2.03	0.92	0.89	1.54	33.9
min	0.70	3.50	2.10	13.10	13.60	13.30	162.6
max	4.80	8.60	7.40	15.40	15.60	17.00	245.1

LA^1, LA^2, LA^3 = lactate values (mmol/l); HGB^1, HGB^2, HGB^3 = haemoglobin levels (mmol/l); ST = swimming test performance (s)

No significant changes in haemoglobin levels were detected neither in men ($\chi^2_{(2)} = 0.222$, $p > 0.05$, Kendall's W = 0.02, the effect size very weak) nor in women ($\chi^2_{(2)} = 0$, $p > 0.05$, Kendall's W = 0, effect size very weak). However, the Friedman Test showed significant differences between measured lactate levels in men ($\chi^2_{(2)} = 14.000$, $p < 0.05$, Kendall's W = 1.00, the effect size very strong) and in women ($\chi^2_{(2)} = 10.000$, $p < 0.05$, Kendall's W = 1.00, the effect size very strong). The Wilcoxon Signed Ranks Test with Bonferroni correction was then used to detect any significant differences among LA measurements, but there were no significant differences ($p > 0.05$) among men's LA^1, LA^2 and LA^3. However, the coefficient effect size showed significant differences (large effect) among all measurements (Table 3).

Table 3 Statistical evaluation of differences among men's LA parameters

Parameter	Wilcoxon Signed Ranks Test with Bonferroni correction	Effect size (ES)	
		ES value	ES level
$LA^1 – LA^2$	T = 0, n = 7, p > 0.05	0.63	large
$LA^2 – LA^3$	T = 0, n = 7, p > 0.05	0.63	large
$LA^1 – LA^3$	T = 0, n = 7, p > 0.05	0.63	large

LA^1, LA^2, LA^3 = lactate levels (mmol/l)

We used the Wilcoxon Signed Ranks Test with Bonferroni correction in the same way as before, to detect significant differences among women's LA measurements. The results were similar to those of men, there were no significant differences ($p > 0.05$) among LA^1, LA^2 and LA^3 though the coefficient effect size showed significant differences (large effect) among all measurements (Table 4).

Table 4 Statistical evaluation of differences among women's LA parameters

Parameter	Wilcoxon Signed Ranks Test with Bonferroni correction	Effect size (ES)	
		ES value	ES level
$LA^1 – LA^2$	$T = 0, n = 5, p > 0.05$	0.54	large
$LA^2 – LA^3$	$T = 0, n = 5, p > 0.05$	0.54	large
$LA^1 – LA^3$	$T = 0, n = 5, p > 0.05$	0.54	large

LA^1, LA^2, LA^3 = lactate levels (mmol/l)

Considering facts we can conclude that increasing the anaerobic performance caused significant increase (men: the effect size = 0.63 – large effect; women: the effect size = 0.54 – large effect) of the lactate level after termination of the load. This corresponds with statements that a two-minute anaerobic load is sufficient for the accumulation of lactate. Ten minutes after the termination of the load we recorded significant decrease in the lactate level (the effect size -large effect for men and women). Furthermore, we cannot ignore the empirical aspect of this decrease as it did not reach the resting level. In case of haemoglobin we do not detect a definite trend. We know that myogenic leucocytosis and also hemodilution are often associated with a strain. In some of our results we detect hemodilution but also in some cases the opposite trend occurs.

The study is limited by a low number of male (n = 7) and female (n = 5) swimmers. The various results of the Wilcoxon Signed Ranks Test with Bonferroni correction (in all cases, $p > 0.05$) and the effect size (on all cases - large effect) during the statistical analysis - comparing lactate level changes before and after the swimming test and 10 minutes after the test - were probably created by the low number of swimmers.

Conclusion

Being aware of changes in the levels of blood parameters can be an important indicator of the actual state of the swimmers' bodies, not only for races but also for the planning and conducting of the training process and complex sports training. The aim of the study was to find out the effect of a performed swimming load in the form of a 200-meter-freestyle swimming test on changes in the lactate and haemoglobin levels in young swimmers. The lactate and haemoglobin levels were measured before the swimming test, immediately after the test and 10 minutes after the test. Results did not show significant changes ($p > 0.05$) in haemoglobin levels neither in men nor in women, however the Friedman Test showed significant changes in the lactate level in both men and women. Although in the following statistical analysis the Wilcoxon Signed Ranks Test with Bonferroni correction did not prove significant differences between each lactate measurement ($p > 0.05$), the effect size showed a large effect among every measurement. We can therefore consider changes of lactate level in both men and women before the swimming test, after the test and 10 minutes after the termination of the test.

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