POST - COMPETITION BLOOD LACTATE CONCENTRATION IN SWIMMERS

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ABSTRACT

The aim of this study was to seek a possible significant correlation between post-competition blood lactate concentrations (BLc) and the times achieved in swimming events. The research was done among 71 swimmers (44 men and 27 women) of the Bulgarian national swimming team. The average age of the participants was 17.48 ± 2.50 years (18.02 ± 2.62 for men and 16.59 ± 2.00 for women). Blood lactate concentrations were measured 3 to 6 min after the finals of all individual swimming events in official competitions and the time ranged between 653 and 898 FINA points. The total number of measurements was 280 (175 samples from men and 105 from women) collected during a 3-year period (2016 -2018). The results indicated that the highest mean values of BLc were obtained after sprint distances: men's 100 m freestyle (16.91 ± 4.32 mmol/L) and women's 100 m butterfly (16.89 ± 2.35 mmol/L). The lowest mean values were measured after distance swimming of 1500 m freestyle: 7.14 ± 3.34 mmol/L for the man and 5.10 mmol/L for the women. Statistically significant coefficients of correlation between swimming times and BLc were observed in men's swimming events of 100 m butterfly (r = -0.484); 100 m backstroke (r = -0.721); 100 m freestyle (r = -0.854); 50 m freestyle (r = -0.891) and women's swimming event of 50 m freestyle (r = -0.688). In conclusion, there is no statistically significant difference in the post-competitive BLc levels depending on gender; significant differences in mean values of BLc between breaststroke and all other strokes; in sprint swimming events (especially in 100 m freestyle) statistically significant correlations between BLc and swimming times were observed.

Key words**:** *swimming, blood lactate concentration.*

INTRODUCTION

The blood lactate concentration (BLc) is one of the main indicators of the performance in training and it is widely used for monitoring swimmers at different velocity. Likely it is the most used metrics by researchers and trainers for assessment of the anaerobic capacity of athletes, incl. of swimmers (Rozi et al. 2010). According to Maglischoit high blood lactates following competition efforts indicated high level of blood buffering capacity as well as rapid rate of anaerobic metabolism. In fact, many factors like pre-competition lactate levels, percentage of slow-twitch and fast-twitch muscle fibers, glycogen storage and level of motivation (which is hard to estimate) have an additional influence on post-competition BLc (Maglischo, 2003).

There are several research studies of post-competition BLc in swimmers (M. Sawka et al. 1977; Vescovi et al. 2011; Bonifazi et al. 1993). The reported data showed maximal BLc levels in 3 to 5min (Sawka et al. 1977; Stoddard et al. 1989) or 6 to 7 min (Vescovi et al. 2011) after finishing the swimming event. Usually higher blood lactate levels are measured in sprinters than in distance swimmers (Komi et al. 1977). This is most likely due to the metabolic characteristics of competitive swimming in various distances (Table 1).

Table 1. *Relative contributions of each phase of energy metabolism to various swimming races (%) according to Maglischo (2003)*

	Anaerobic lactate (ATP-CP)	Anaerobic lactate metabolism	Aerobic glucose metabolism	Aerobic fat metabolism
50 m	20%	60%	20%	
100 m	10%	55%	35%	
200 m	5%	40%	55%	
400 m		35%	65%	
800 m		25%	73%	2%
1500 m		15%	78%	7%

As shown in table 1, the anaerobic metabolism contributed greatly to performance in swimming events for distances up to 200 m. Because of longer duration of swimming at 100 and 200 m we could expect higher levels of BLc in comparison to 50 m event. In fact, in the research of Avlonitou (1996) the highest lactate levels were recorded following swimming events of 100 and 200 m. In addition, the rate of lactic acid production in muscle fibers depends on the swimmer's speed (Maglischo 2003). Therefore, some correlation between post-competitive BLc, distance and the time for swimming the event should be expected. Such correlations could become a helpful indicator in the control of the training process.

The aim of this study was to seek a possible significant correlation between post-competition blood lactate concentrations and the times achieved in swimming events.

METHODOLOGY

Statement

The study was performed in accordance with the Declaration of Helsinki for Human Researches (World Medical Association Declaration of Helsinki - Ethical principles for medical research involving human subjects. 59th WMA General Assembly, Seoul, Republic of Korea, 2008).

Participants

The research was done among 71 swimmers (44 men and 27 women) of the Bulgarian national swimming team. The average age was 17.48 ± 2.50 years (18.02 ± 2.62 years for men and 16.59 ± 2.00 years for women). In the beginning of the investigation, all swimmers received detailed information about the study and signed an informed consent form.

Experimental Design

During a 3-year period (from 2016 to 2018) 280 measurements (175 from men and 105 from women) of post-competitive BLc after the finals of all individual swimming events were made. The data were collected during various official competitions such as National swimming championships, Balkan junior swimming games and Multinational junior swimming meets. The achieved swimming times were also recorded ranging between 653 and 898 FINA points[1].

BLc analysis

Measuring BLc was performed with the use of "Lactate Pro 2" device 3 to 6 min after competitive swimming following the standard procedure.

1 The FINA points table allows comparisons of results among different events. The base times are defined every year, based on the latest world records (each of which equals 1000 points) that were approved by FINA.

Statistical analysis included descriptive statistics where the results were expressed as the mean ± standard deviation (± SD). The significance of differences between the means was tested by t-test for independent samples. One-way ANOVA followed by Bonferroni post hoc test for multiple comparisons were performed and adjusted p-values (P) were calculated. Pearson correlation coefficient (PCC) was used to analyze the relation between the post-competitive BLc and the achieved swimming times. For data analysis SPSS 19 statistical package was used.

RESULTS

The individual maximum BLc for men was 25 mmol/L (which was the maximum value that device can measure) after 100 m freestyle and the minimum registered value was 2.5 mmol/L after 1500 m freestyle. The individual women's maximum BLc value was 20.9 mmol/L after 200 m butterfly and the minimum - 4.9 mmol/L after 800 m freestyle.

Descriptive statistics for all swimmers and both for women and for men separately is presented in table 2.

Table 2. *Swimming distances and styles, mean values ± SD for all, women and men*

Distance (m)	Style	BLc - all (mmol/L)	N	BLc – women (mmol/L)	N	BLc - men (mmol/L)	N	P
50	Butterfly	13.60 ± 3.90	13	9.30 ± 3.25	2	14.38 ± 3.59	11	0.09
	Backstroke	13.05 ± 1.07	8	13.04 ± 1.09	5	13.07 ± 1.27	3	0.98
	Breaststroke	10.21 ± 2.42	10	10.82 ± 2.38	5	9.60 ± 2.55	5	0.46
	Freestyle	12.32 ± 4.07	10	11.18 ± 3.03	5	13.46 ± 4.98	5	0.41
100	Butterfly	15.68 ± 2.26	26	16.89 ± 2.35	7	15.24 ± 2.12	19	0.10
	Backstroke	15.57 ± 2.66	18	15.63 ± 2.91	8	15.52 ± 2.59	10	0.94
	Breaststroke	13.89 ± 2.79	18	13.87 ± 3.99	6	13.90 ± 2.20	12	0.98
	Freestyle	16.39 ± 3.86	27	15.64 ± 3.11	11	16.91 ± 4.32	16	0.41
200	Butterfly	15.96 ± 2.41	17	16.69 ± 3.04	7	15.45 ± 1.85	10	0.31
	Backstroke	14.98 ± 2.30	20	14.01 ± 1.83	9	15.77 ± 2.42	11	0.09
	Breaststroke	13.25 ± 2.21	23	12.89 ± 2.29	9	13.48 ± 2.21	14	0.54
	Freestyle	14.78 ± 2.99	20	13.98 ± 2.09	6	15.12 ± 3.31	14	0.45
	IM	15.44 ± 2.73	18	15.48 ± 2.28	5	15.43 ± 2.97	13	0.97
400	Freestyle	12.87 ± 3.34	21	12.13 ± 3.46	6	13.17 ± 3.37	15	0.54
	IM	15.88 ± 2.59	12	12.20 ± 1.70	2	16.61 ± 2.06	10	0.02
800	Freestyle	10.95 ± 4.01	12	9.75 ± 3.06	10	16.95 ± 2.47	2	0.01
1500	Freestyle	6.80 ± 3.10	6	5.10	1	7.14 ± 3.34	5	0.61

IM - Individual medley, N - number of participants, P - significance of differences

In general, the highest mean values of BLc were obtained after 100 m distances: men's 100 m freestyle (16.91 ± 4.32mmol/L) and women's 100 m butterfly (16.89± 2.35 mmol/L). The lowest mean values were measured after 1500 m freestyle for men (7.14± 3.34mmol/L) and after 1500 freestyle for women (5.10 mmol/L). In men's event 400 IM a high mean value of BLc (16.61 ± 2.06mmol/L) was observed. It was found that the differences between men's and women's mean values were statistically significant for 400 m IM (P = 0.02) and 800 m freestyle (P =0.01).

Table 3 presents the statistically significant differences in mean values of post-competitive BLc (mmol/L) in different swimming distances of every style separately for men and women.

Table 3. *Differences in mean values of BLc (mmol/L) depending on the distance in different swimming styles for men and women*

Style/gender	Distance (meter)	Mean difference (mmol/L)	Significance
Butterfly women	50 vs. 100	-7.59	0.014
Butterfly women	50 vs. 200	-7.39	0.016
Breaststroke men	50 vs. 100	-4.30	0.004
Breaststroke men	50 vs. 200	-3.88	0.008
Freestyle men	1500 vs.100	9.77	0.0001
Freestyle men	1500 vs. 200	7.98	0.003
Freestyle men	1500 vs. 400	6.03	0.050
Freestyle men	1500 vs. 800	9.81	0.048

In women's swimming events significant differences were found in butterfly between 50 m and 100 m (P=0.014) and 50 m and 200 m (P= 0.016). In men's swimming events statistically, significant mean differences were found in breaststroke between 50 m and 100 m (P =0.004) and 50 m and 200m (P=0.008). In men's Freestyle events there were significant differences between 1500 m and 100 m; 200 m; 400 m; 800 m (P=0.0001; P=0.003; P=0.050 and P=0.048, respectively).

The most notable result, when comparing the mean values of BLc and swimming style for distances up to 200 m, was that breaststroke exhibited statistically significant differences with butterfly (P = 0.001), backstroke (P = 0.014), freestyle (P = 0.002) and IM (P = 0.023). No statistically significant differences between mean values of BLc and other swimming styles (butterfly, backstroke, freestyle and IM) were found.

The relation between BLc and swimming times is shown in table 4.

Table 4. *Coefficient of correlations between swimming times and BLc (mmol/L) and the corresponding p-values*

Distance (meter)	Style/gender	PCC	Significance	N
50	Freestyle women	-0.688	0.019	11
50	Freestyle man	-0.891	0.043	5
100	Butterfly man	-0.484	0.036	19
100	Backstroke man	-0.721	0.019	10
100	Freestyle man	-0.854	0.000	16

Statistically significant coefficients of correlation were observed in men's swimming events of 100 m butterfly (r = -0.484); 100 m backstroke (r = -0.721); 100 m freestyle (r = -0.854); 50 m freestyle (r = -0.891) and women's swimming event of 50 m freestyle (r = -0.688).

DISCUSSION

The post-competitive BLc (Table 2) measured in this study reaches the highest levels (absolute and mean) in sprint distances (100 m and 200 m) and the lowest levels (absolute and mean) in longer distances (800, 1500 m) and short sprint (50 m). This corresponds with the metabolic characteristics of the swimming distances (Table 1) and is in accordance with the results of previous studies (Komi et al. 1977; Avlonitou 1996; Vescovi et al. 2011). Very high mean values of BLc are observed in men's 800 m freestyle (16.95 ± 2.47 mmol/L) as opposed to women's values (9.75 ± 3.06mmol/L). These differences may be due to a more economical technique (Barbosa et al. 2008) and a better developed aerobic metabolism (Stanula et al. 2012) in women. The reason for men's values may be a consequence of the fact that some of the participants performed a final sprint, whereas other finished with their average speed but these statements have no scientific evidence.

Comparisons of the results for men and women in all swimming events (Table 2) suggest that the mean values are relatively close to each other and do not depend on the swimmer's gender with some exceptions (50 m butterfly and 800 m freestyle).

Statistically significant differences in mean values of post-competitive BLc depending on the distance in every swimming style are observed in women's butterfly and men's breaststroke for 50 m vs. 100 m and 50 m vs. 200 m. In man's freestyle we found statistically significant differences between 1500 m and every other distance except 50 m.

By observing the differences in BLc depending on the swimming style we could conclude that breaststroke is the only style in which a significantly lower BLc was detected in comparison to all other styles. Other studies show no such differences (M. Sawka et al. 1977). The lower stroke rate and different muscle groups engaged in breaststroke as well as the underwater swim with lower amount of movement compared to the other styles can also be relevant, but this needs to be further

investigated.

Significant correlations are observed between BLc and swimming velocity in some swimming events. These are men's 50 m freestyle, backstroke and butterfly and women's 50 m freestyle (as shown in Table 4). In 100 m freestyle the correlation between the BLc and the swimming times is the highest. In this event the sample is also the largest, which supports the hypothesis that the BLc can serve as indicator for this level of swimming performance. These data can be useful for monitoring of the training process and competitions. It is not surprising that there is no significant correlation between BLc and the swimming velocity in the longer duration swimming events. The reason for that is the higher rate of aerobic metabolism in distance swimming. However, additional research is needed to make more precise conclusions for the sprint events.

CONCLUSIONS

The highest BLc values were observed in the sprint distances, whereas lower values were observed in the longer distances.

No statistically significant difference was found in the post-competitive BLc levels of men and women.

Statistically significant differences in mean values of BLc between breaststroke and all other styles were observed.

In the distance swimming better performance is not related to the increase of the post-competition BLc levels.

Statistically significant correlations between BLc and swimming times in some swimming events were found, especially in 100 m freestyle.

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