

The Effects of Reduced Breathing on Swimming Performance and on Blood Lactate Concentration in 25 and 50 m Breaststroke Swimming at Maximal Intensity.

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ABSTRACT

In Freestyle and the Butterfly stroke, swimmers use the least possible breaths in order to keep their hydrodynamic position and maintain a higher swimming velocity. The purpose of this study was to determine the duration of reduced breathing when swimming Breaststroke affects the hydrodynamic position and preserves the high swimming speed in relation to the production of blood lactate. In this study, 16 swimmers, aged 15.6 ± 3.2 participated. They swam 25 and 50 m Breaststroke, with breathing frequency for both distances, one breath every stroke (1 on 1) and one breath every three strokes (1 on 3) at high intense. Blood lactate concentration, performance, and efficiency parameters were measured. From the results, swimmers' blood lactate concentration and the time in 25 m between the two breathing frequencies 1 on 1 and 1 on 3, showed a statistically significant difference 10.1 ± 1.8 vs 9.3 ± 1.5 mmol/L ($p = 0.02$) and 19.5 ± 1.6 vs 19.3 ± 1.6 sec ($p = 0.03$) respectively. In conclusion, in the 25 m distance at maximum intensity, it is preferable to use the 1 on 1 breathing frequency in order to maximize blood lactate concentration, the 1 on 3 breathing frequency in sets of 25 m is more effective at the rate of distances of 100 and 200 m.

Key words: Swimming, hypoxic, Breaststroke, performance

Introduction

Reduced breathing training is a method that many coaches use in order to improve swimmers' performance. Specifically, hypoxia depends on physiological variables such as the reduced blood acidosis, oxidative stress, basal metabolic rate, increase hematocrit, erythropoietin concentration, hemoglobin mass, and lung volumes (4). The effectiveness of this training method is presented in cardiovascular adaptations such as the reduction of stroke volume and the oxygen consumption through the decrement of the heart rate (2).

[There is another effect on blood lactate concentration too. Olsen's (9) study, showed that blood lactate concentration increased during diving exercises. Similar results were found in Joulia's (3) study, where well-trained athletes can reduce blood lactate concentration during apnea tries, more than less trained athletes. In a study with the participation of 15 healthy persons showed that plasma lactate concentration was increased more with face immersion (20%), instead of air apnea (11%), suggesting an increased anaerobic metabolism during apneas (1).

Besides the use of hypoxia training in interventions, the acute effect in swimmers, presented no significant differences in the blood lactate concentration (3.8 ± 4.2 vs. 13.6 ± 3.1 mmol/L) and in heart rate (180 ± 8 vs 176 ± 13 bpm), between normal breathing and non-breathing patterns, in 8 * 50 m Freestyle, at 90% of their best time (13). In swimming races, in order to achieve high swimming speed is significant to have the best propulsion and the minimum resistance. Thus, the coaches often use reduced breathing frequency tactics for their swimmers, maintaining the high swimmers' velocity while keeping the body in a more efficient streamlined position.

In Freestyle, the maximum swimming speed is achieved with the combination of the effective push and the least frontal resistance, while the head and the body are in a straight horizontal line. In Freestyle, breathing is a parameter that reduces swimmers' velocity by almost 3%, altering swimmers' body position creating resistance when the head moves out of its normal position for the inhalation (8). In short distances such as 25 and 50 m, the breathing frequency must be less than in longer distances (10).

Another hypoxia parameter is the exhalation, where its duration is less in elite swimmers than in beginners, because of the increased pulmonary volume and the stronger breathing muscles (10). Exhalation occurs immediately after inhalation (6). The most experienced swimmers have a greater ability to coordinate hand and breathe, therefore their body maintains a better hydrodynamic position with an increased stroke length.

Backstroke is a peculiar style as far as it concerns breathing. Literature mention that inhalation must be done freely and according to the athlete's will (6). An influencing factor in breathing, is the stroke rate that the swimmers use· a factor that differs among the swimmers and depends on the distance they swim. A study showed that in races, elite swimmers breathe 60 to 70 times per minute (7).

In Butterfly style, breathing occurs forward and the arm-leg coordination is possibly blocked because of the increased frontal resistance. Thus, the control of the breathing frequency could possibly help and ensure the right and hydrodynamic position of the body (12). The increased water resistance occurs while breathing and affected by the frontal resistance because of the breast exposures the moment when swimmers take the head out to inhale with the feet going deeper in water. So, the total time gap is bigger in breathing than in non-breathing conditions (23.3% vs 19%). This shows less propulsive continuity between arm and leg actions (5).

So, when the swimmers' frontal resistance is increased, in short distances such as 25 and 50 m in the Butterfly style, a decrease breathing frequency is necessary (5). In longer distances such as 100 and 200 m, high-level swimmers increase breathing frequency because Butterfly is a high energy cost style and requires greater amounts of oxygen. Usually, breathing frequencies at 100 and 200 m Butterfly, is an inhale after one to two strokes (6).

Similar frontal resistance in water, such as in the Butterfly style, has been also observed in Breaststroke style because of frontal breathing. The body receives similar resistances. In literature it has not been observed if the tactic of reduced breathing in high-level races is used. It has been observed only at national level swimming races

and it is naturally used in the swimmers training within the context of hypoxic training. Although sometimes this technique is used in swimming training, it is unknown if it helps the technique of the style and the achievement of the maximum swimming velocity.

So, the aim of this study was to examine whether breathing frequency in Breaststroke style, effects swimmers' performance, blood lactate concentration, and the different swimming efficiency parameters in the 25 and 50 m distances.

Methods

Participants

In this research, 16 swimmers (8 boys and 8 girls) aged 15.6 ± 3.2 participated voluntarily. The project was planned according to the Aristotle University of Thessaloniki code of conduct. They were all members of a swimming team, with at least 6 times a week participation and one of their styles was Breaststroke. Height, weight, and individual record in 25 and 50m Breaststroke, were recorded (Table 1).

Table 1. Age, anthropometric features and records in 25 and 50m of participants' breaststroke.

Parameters	Age (y)	Height (m)	Weight (kg)	Record 25m (s)	Record 50m (s)
Mean (\pm)	15.6 ± 3.2	1.74 ± 9.6	68.5 ± 12.0	18.7 ± 2.7	40.1 ± 3.9

Study design

Tests were performed within 2 days, with a day of resting in between, at a 50 m pool (26°C). The distances of the swimming tests in Breaststroke at high intensity were 25 and 50 m without block starting and first big stroke, while the proportion of breaths per stroke in both efforts was 1 on 1 or 1 on 3.

The participants were divided in Team 1(TM 1), who accomplished the 25 and 50m distances with a breath frequency 1 on 1, and in Team 2 (TM 2) who did the same distances on the first day with 1 on 3 breath frequency. Between the 2 distances (25

and 50 m) there was a 30 min passive rest (PR). On the second day of measurements, the same groups executed the same distances exchanging the breathing frequency.

5 minutes after each distance on both days, blood samples were taken from the finger rail to measure blood lactate concentration (5' BL). The time of the 5 minutes after the effort was chosen because it is known that blood lactate is found in almost maximum concentration (13) (Figure 1).

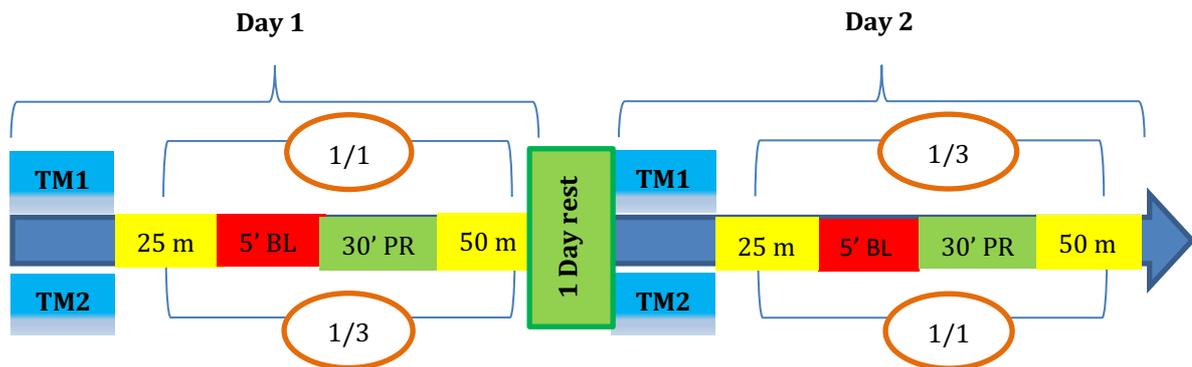


Figure 1. Measurements schedule.

TM 1 = Team 1, TM 2 = Team 2, 5' BL = Blood lactate 5 min after try, PR = Passive rest

In the 25 and 50 m distances in both breathing frequencies it was also examined the stroke efficiency parameters of stroke number (SN), stroke length (SL), stroke rate (SR), swimming velocity (V) and stroke index (SI). The parameter record started after the first 5 m to reinsure that the stroke efficiency parameters will not be affected by the block start factor. All swimming tries were recorded by a video camera. The equalizations used were:

$$\text{Stroke length (m/stroke)} = \text{Distance (m)}/\text{Stroke number (n)}$$

$$\text{Stroke rate (s/cycle)} = \text{Stroke number}/\text{Performance (sec)}$$

$$\text{Velocity (m/s)} = \text{Distance (m)}/\text{Performance (sec)}$$

$$\text{Stroke index (m}^2 \text{*(s/cycle)} = \text{Stroke length (m/stroke)*Velocity (m/s)}$$

Statistical analysis

For the statistical analysis the descriptive statistic and Shapiro – Wilk test of normality were used. From the analysis it was found normality ($p > 0.05$). To compare the

swimmers' performance, the blood lactate concentration and the stroke efficiency parameters was used the paired sample student's *t* test. The analysis was performed using the SPSS Version 25.0 for Windows (SPSS Inc., Chicago, IL, USA). The level of statistical significance was set at $\alpha = 0.05$.

Results

From the Shapiro-Wilk analysis it was found that there was normality in the parameters studied ($p > 0.05$). In paired sample student's *t* test analysis, significant differences in BL and in 25 m performance between the two breath protocols (1 on 1 vs 1 on 3) was found. Figures 2 and 3, show the differences between measurements. In Table 2, SN, SL, SR, SI and V in the 25 and 50 m Breaststroke distances, between two breath protocols are presented.

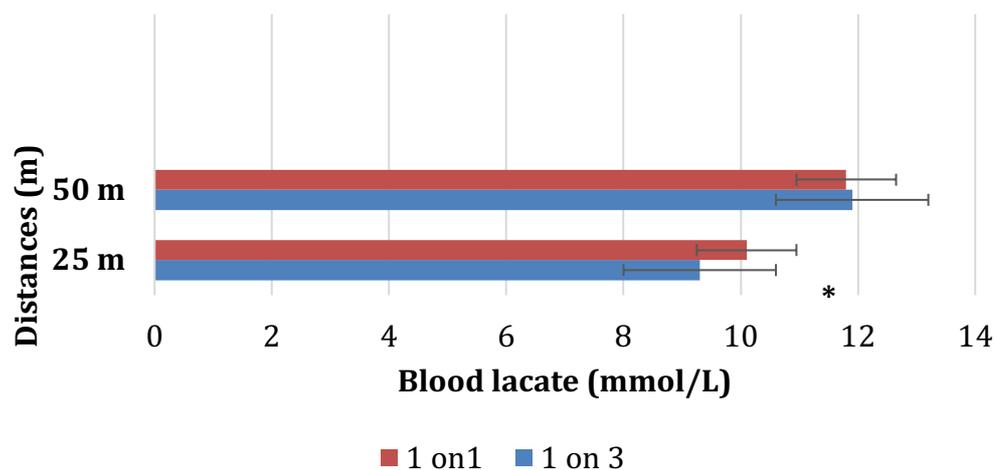


Figure 2. Blood lactate concentration (mmol/L) in 25 and 50 m between two breath ways (1 on 1 vs 1 on 3). * = Statistical significant difference.

From the results it was found a statistically significant difference between the coverage time and the blood lactate concentration in the 25 m distance related to the hand-breathing frequencies 1 on 1 and 1 on 3. One breath per stroke had a statistically significant higher blood lactate concentration 10.1 ± 1.8 mmol/L compared to one breath per three strokes with blood lactate concentration 9.3 ± 1.5 mmol/L ($p = 0.02$). On the contrary, no statistically significant difference was found in the

distance of 50 m in both breath frequencies 1 on 1 vs 1 on 3, with the values be 11.8 ± 2.8 and 11.9 ± 2.4 mmol/L respectively ($p = 0.80$) (Figure 2).

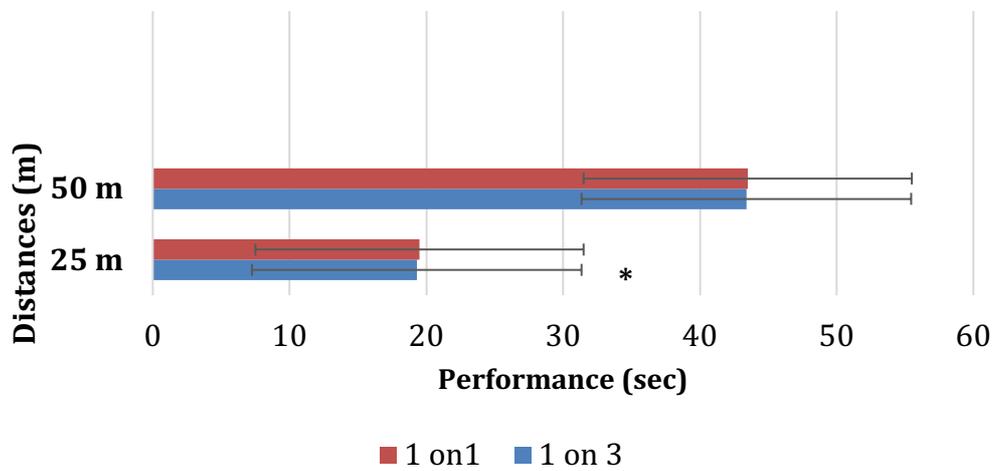


Figure 3. Performance (sec) in 25 and 50 m between two breath ways (1 on 1 & 1 on 3). * = Statistical significant difference.

Statistically significant difference was observed in the coverage time in the 25 m between the two breath protocols too. The protocol of one breath per 3 strokes covered the distance in less time 19.3 ± 1.6 sec in addition to the one breath per stroke 19.5 ± 1.6 sec ($p = 0.03$). On the contrary, was not observed any other statistically significant difference in the 50m

distance and the two-breath frequencies 1 on 1 vs 1 on 3, with rates 43.5 ± 3.7 and 43.4 ± 3.5 sec respectively ($p = 0.80$) (Figure 3).

Table 2. Stroke number (SN), stroke length (SL), stroke rate (SR), stroke index (SI) and velocity (V) in 25 and 50 m Breaststroke, between two breath protocols.

Distances	Breath	SN (n)	SL (m)	SR (s/cycle)	SI (m ² *(s/cycle))	V (m/s)
25 m	1 on 1	15 ± 2	1.35 ± 0.21	1.28 ± 0.15	1.4 ± 0.2	1.03 ± 0.09
	1 on 3	15 ± 2	1.34 ± 0.21	1.27 ± 0.16	1.4 ± 0.2	1.04 ± 0.09
50 m	1 on 1	33 ± 6	1.32 ± 0.17	1.33 ± 0.25	1.4 ± 0.2	1.04 ± 0.09

1 on 3	32 ± 5	1.38 ± 0.19	1.37 ± 0.21	1.5 ± 0.3	1.05 ± 0.10
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No, statistically significant difference was observed between the two breath protocols (1 on 1 vs 1 on 3) in the stroke efficiency parameters of stroke number (SN), stroke length (SL), stroke rate (SR), stroke index (SI) and velocity (V) studied at the 25 and 50m Breaststroke ($p > 0.05$) (Table 2).

Discussion

In the research, the swimmers swam at a high intensity competitive pace. Comparing recorded times to their personal records, times were quite close. The tests were completed during the racing period when, all swimmers were in an excellent physical condition.

Differences were found in the blood lactate concentration and the performance in 25 m between 1 on 1 and 1 on 3 breathing frequency. In the 1 on 1 breathing frequency, there is higher blood lactate concentration.

Possibly, higher body activity and bigger frontal resistances justify it. On the contrary, lower blood lactate concentration, in the breathing frequency, 1 on 3, indicates that when swimmers keep the horizontal body position, lower energy demands are used because of limited body movement as their head and the body position are kept in the water.

On the other hand, no difference was observed in the blood lactate concentration in 50 m, between the two breathing frequencies. Although there was not any statistical difference, probably, in the 1 on 3 breathing frequency blood lactate concentration rate might be lower, because of less muscle activity. There is also a hypothesis that blood lactate concentration in 25 and 50 m at 1 on 3 breathing frequency might be higher because of the lack of oxygen.

In our study and in literature with similar researches for Freestyle, the hypothesis above is not supported (13), although the intense was less than maximum and the energy demands were not similar, probably because of minor frontal resistance.

Interpreting the performance, which in the breathing frequency 1 on 3 was faster than in 1 on 1, it was found that one significant difference between the two-breath frequencies, is also the coordination of movements which is remarkably differentiated. According to literature, two types of Breaststroke were observed, the high and the flat Breaststroke (6).

The main difference between these two breathe coordinations refers to the breast position which lies above the water surface (high Breaststroke) or just on the surface of the water (flat Breaststroke). The high Breaststroke requires more energy for the body movement but less resistance. On the contrary, flat Breaststroke needs less movement energy but more frontal resistance (6).

Consequently, the 1 on 1 breathing frequency matches to the high Breaststroke because of the shoulder and breast lift, out of water in every stroke. On the contrary, the 1 on 3 breath frequency, refers to the flat Breaststroke because, for every 3 strokes, head, shoulders, and breast should stay underwater. It is probable that maintaining the horizontal position, a better hydrodynamic position is achieved.

At the efficiency parameters, no difference was observed in 25 and 50 m between the two breathing protocols. Probably, the 1 on 3 breathing frequency requires more time for swimmers to learn it to achieve the best technique. A few week interventions in that kind of Breaststroke, could probably give different results.

The coordination type chosen may be related to the somatometric characteristics and the age of swimmers. So, the breathing frequency 1 on 3 suits better for swimmers with less muscle mass, since they are not forced to take the head out of the water repeatedly, to breathe, which means, less muscle activation and as a consequence, lower energy demands.

Because of decreased energy demands, it would be also useful to examine if breath frequency 1 on 3 is more appropriate for distances longer than 50 m, as in 100 and 200 m. Further, studies at swimmers who have been trained several times with the 1

on 3 breathing frequency, so that swimmers' performance in Breaststroke may improve.

Practical Applications

It is better, swimming coaches, in the 25 m distances of maximum effort, to use the 1 on 1 breathing frequency in order to maximize the blood lactate concentration. The use of 1 on 3 breathing frequency can be also used in Ultra Short Race Pace Training (USRPT) sets of 25 m, which are more oriented to 100 and 200 m race distances.

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