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# Differences in Physiological Responses of Synchronized Swimming Athletes and Female Swimmers

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**Abstract**

Synchronized and classical swimming are two different sports taking place in the special environment of water. They have main differences but also essential similarities. The purpose of this study was to examine the characteristics of physiological responses of swimmers and synchronized swimming athletes. The sample consisted of 24 national-level female athletes (n = 12 synchronized swimming athletes, aged 16 ± 1.0 years and n = 12 athletes of swimming, age 16 ± 1.0 years). All participants performed 6 attempts of 50 meters with 1min mixed time for each 50m (6x50m freestyle swimming, 25m with maximum intensity without breathing and 25m active recovery). Anova analysis showed that physiological responses of swimmers and synchronized swimming athletes for this sample are not statistically significantly different. Difference was observed in performance time, with female swimmers having significantly lower values of performance time (107.7 ± 9.3sec and 92.5 ± 4.07sec for the synchronized swimming and classical swimming respectively, Sig .000). Further research among the athletes of these sports is needed for the conduction of significant results. Different protocols and different swimming distances could be used in next studies in order to better develop training procedure of both sports.

**Keywords:** synchronized and classical swimming, lactate, heart rate.

## Characteristics of Physiological Responses of Synchronized Swimming Athletes and Female Swimmers

### 1. Introduction

Synchronized swimming is a demanding sport which requires advanced water skills, great strength, aerobic endurance, flexibility as well as exceptional breath control. The athletes, in solos, duets, trios, combos, or teams, must perform a synchronized routine of specific moves in the water, accompanied by music.

On the other hand, classical swimming is a technical sport in which athletes must face time and velocity in several swimming distances. Even though the nature of the two sports is different, the athletes of both sports have to deal with the special conditions of aquatic environment. This means that part of the training procedure is similar and that coaches of the two sports can learn from each other.

In both sports, repeated bouts of freestyle swimming with maximum intensity without

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breathing are part of the training procedure in order to develop speed and better breath control. For synchronized swimming athletes, breath control is essential when performing the demanding routines in upside down position. Swimmers must have exceptional breath control in order to keep a better steady horizontal position in all out bouts, after the starts and turns. Physiological responses of the athletes of the two different sports in this common training part are of great interest.

25m freestyle swimming with maximum intensity without breathing is a type of dynamic apnea. Low intensity swimming after repeated bouts of maximum intensity causes less concentration of blood lactate (Cazorla, Dufort, Cervetti, 1983).

1. Blood lactate concentrations are between 1 - 2 mmol / l at rest and can increase up to 10 - 20 mmol / l at maximum intensity efforts (Maglischo, 2003). The extent of accumulation depends on the intensity of swimming speed, the range of oxygen consumption and the type of muscle fiber (Maglischo, 2003). In previous studies (Ferretti, Costa, Rerrigno, Grassi, Marconi, Lundgren, Cerretelli, 1991; Joulia, Steinberg, Wolff, Gavarry, Jammes, 2002; Joulia, Guillaume, Faucher, Jamin, Ulmer, Kipson, Jammes, 2003; Andersson, Liner, Fredsted, Schagatay, 2004) during apnea an increase in blood lactate concentration has been observed.

A study in synchronized swimming showed that during synchronized swimming figures of apnea lasting 50 sec, the levels of lactate ranged up to 1,5 mmol / l, while heart rate went down up to 70 beats / min. In repeated efforts of apneas in freestyle swimming with moderate intensity of 3min, lactate levels ranged up to 4,3 mmol / l, while heart rate increased during periods of apnea up to 132 beats / min (Figura, Cama, Guidetti, 1993). In another study, levels of lactate in synchronized swimming athletes after a maximal 400m freestyle swimming test were higher than lactate after a 3min synchronized swimming routine (Bante, Bogdanis, Chairopoulou, Maridaki, 2007). A research of Yamamura et al. (1999) showed that lactate of synchronized swimming athletes after maximal effort of 100m freestyle swimming reached 8,5 mmol / l.

In swimming, in a research that was carried out during the European Championship, levels of lactate for women athletes of medium distances, ranged at 10 ± 1,5 mmol / l (Bonifazi, Martelli, Marugo, Sardella, Carli, 1993). In another investigation of Avlonitou (1996), female swimmers showed lactate of 12 ± 1 mmol / l in medium distances after national championship.

The purpose of this study was to examine the characteristics of physiological responses of synchronized swimming athletes and female swimmers, after a swimming test of 6x50 m freestyle swimming (25m with maximum intensity without breathing and 25m active recovery with one breath every three strokes).

## 2. Methods

*Sample*

The sample consisted of 24 athletes. Of these, n = 12 were synchronized swimming athletes aged 16 ± 1years, with body height 167 ± 5 cm and weight 57 ± 6 kg and n = 12 female swimmers aged 16 ± 1 years, body height 165 ± 5 cm and weight 56 ± 8 kg and competitive experience at least 2 years. The protocol of this measurement has the approval of the ethics committee.

*Procedures*

All athletes, after being informed for the purpose of the research, the potential risks and the measurement procedures, they gave with their parents their written consent. Afterwards, we proceeded with conduction of the measurement. All participants were taking part in a daily training program lasting two hours a day, at least five times a week. Body height and body weight were measured in the afternoon between 15:00 to 17:00 prior to workout in their fitness club (Ilisiakos and N.O.Volou). Firstly, two days before measurements, in a separate session, they swam 25 meters freestyle swimming with maximum intensity in a 50 m pool, in order to calculate the 50% of best performance for each swimmer. The aim of this work was to verify that the speed during the active recovery would be at the level of 50 %.

The protocol of this study is for the development of the ability of breathe holding during swimming (Maglischo, 2003).

In the first session, all participants started with a warm up of 1000 m under the guidance of their coach. After a rest period of 15 minutes, they swam 6x50m freestyle swimming with 1 min mixed time for each 50m (25 meters maximum intensity without breathing and then another 25 meters using freestyle swimming with an intensity of 50 % of the maximum performance of

25 meters with one breathe every three strokes). Also, sings were put in the bottom of the pool so as for the athletes to know when to stop the maximum effort.

Furthermore, during active recovery, hand signals were used from one of the examiners to communicate with the participants beckoning them to maintain an appropriate pace (West, Drummond, Vanness, 2005). The athletes were familiar with the speed of active recovery during training and it was not difficult to follow this pace. The ability of swimming in maximum intensity without breath is essential for both athletes of synchronized and classical swimming, for the first because of the routines in an upside down position with breath control, and for the second, for maximum efforts, in order to reduce the bilateral movements of breathing and to keep the steady, horizontal position.

For the purpose of this study, the following variables were measured. Performance time of 6x50m freestyle swimming was recorded with electronic timer Seiko Water Resistant 10bar S140. In order to determine the maximum concentration of lactate in blood, immediately after the end of the sixth attempt, in a sitting position, capillary blood samples were taken from the fingertip of the participants at $3^{rd}$ , $5^{th}$ , $7^{th}$ min and analyzed by the automatic analyzer Scout Lactate Germany . Also, heart rate was measured manually from the wrist immediately after the swimming of 6x50m in 10 seconds. Heart rate is referred to as beats per minute.

Finally, two indices were calculated from the previous variables: lactate / average speed and heart rate / lactate. The index of lactate production to average speed indicates the average lactate that swimmers would have for a steady swimming speed. The index of the heart rate to the maximum production of lactate represents the relation between the physiological parameter of heart rate and the metabolic parameter of lactate and indicates how many pulses swimmers would have in average for the concentration of 1 mmol/l.

The water temperature was $26^{o} \pm 1^{o}$ C. All measurements were made 10 to 15 days before the main competition of the summer season, in an open swimming pool of 50m and always by the same examiners. They all started swimming from the water taking into account the regulations of swimming.

*Statistical analysis*

Measurement results are expressed as mean values with their standard deviations (M ± SD). For the statistical analysis of data, the analysis of variance ANOVA was used. The level of statistical significance was set at $p < 0.05$. The analysis of data was performed with the statistical program SPSS 20.0.

## 3. Results

The results showed that physiological responses of female swimmers and synchronized swimming athletes for this sample did not differ significantly. Difference was observed in performance time, with female swimmers having significantly lower values of performance time (107.7 ± 9.3sec and 92.5 ± 4.07sec for the synchronized swimming and classical swimming respectively, Sig .000), (Table 1).

The values of the total sample in lactate and heart rate show that they have the same physiological responses after freestyle swimming of maximum intensity, while the differences observed in time performance suggest that female swimmers do a targeted training that aims to the reduction of time performance.

For the two indices, values do not differ between the sample of synchronized swimming athletes and female swimmers, meaning that physiological responses of the athletes of these two sports are manifested in a same way after this maximal effort.

**Table 1.** Means, standard deviation and statistical significant differences between the two sports

| | Lactate (mmol/l) | Heart rate (beats/min) | Total performance time (sec) | Lactate / mean velocity (mmol/l) | Heart rate / Lactate (beats/min) |
|---|---|---|---|---|---|
| **Synchronized swimming** | 6.9±2.6 | 171.6±9.8 | 107.7±9.3 | 4.9±1.7 | 27.1±11.1 |
| **Swimming** | 6.4±2.1 | 175.0±12.1 | 92.5±4.07 | 3.9±1.2 | 29.1±8.3 |
| **Sig.** | N.S. | N.S. | .000 | N.S. | N.S. |

## 4. Discussion

In the present study differences in physiological responses were examined between synchronized swimming athletes and female swimmers, after 6x50 m freestyle swimming (25m with maximum intensity without breathing and 25m active recovery with one breath every three strokes).

There is no similar research in literature comparing athletes of synchronized and classical swimming, so the following articles refer to findings concerning physiological responses of each sport separately.

Comparing the results with previous study, the lactate after 400m with maximum intensity in synchronized swimming athletes aged 13.8 ± 0.2 years (Bante, Bogdanis, Chairopoulou, Maridaki, 2007), was at the same level with the present investigation.

In another study of Figura et al. (1993), after 3΄ of freestyle swimming in moderate intensity and repeated apneas, lactate levels ranged up to 4.3 mmol / l, while the heart rate increased during periods of apnea up to 132 beats / min (Figura, Cama, Guidetti, 1993), unlike the present research that lactate arrived at higher levels probably because of the higher intensity and the heart rate reached 173 beats on average for the whole sample.

Yamamura et al. (1999) in their research found higher lactate values in synchronized swimming athletes after maximum intensity test of 100m freestyle swimming compared with the values found in this study (8.5 ± 1.6 and 6.9 ± 2.5 mmol / l, respectively).

In a research involving swimmers (Avlonitou, 1996), the values of lactate were higher at medium distances with respect to those of the present study (12 ± 1 and 6.9 ± 2.5 mmol/l respectively). Also, in a research conducted during the European Championship, the levels of lactate for women athletes in medium distances averaged 10 ± 1,5 mmol/l (Bonifazi, Martelli, Marugo, Sardella, Carli, 1993). One possible explanation for the lower lactate values in swimmers of this research may be that among 25m freestyle of maximum intensity the athletes also performed 25m freestyle swimming for active recovery with one breath every 3 strokes. The active recovery perhaps kept lactate at lower levels than the lactate observed in other swimmers of the same age.

## 5. Conclusion

In conclusion, the results of this study indicate that physiological responses of synchronized swimming athletes and female swimmers in this sample after the test that was applied, was not statistically significantly different. The statistically significant difference in the time performance of swimming athletes was probably due to the fact that their training is focused on reducing performance time. Athletes of synchronized swimming on the other hand, are focused in demanding upright figures than in swimming speed. On a general level, the repeated efforts of 25m maximum intensity with 25m active recovery between sets may have kept lactate at a lower level in the whole sample.

This research leads us to the fact that coaches of both sports can use or follow parts of the training procedure of the other sport that can help the completion of training programming for the improvement of abilities that are important for optimal performance. Consequently, further research among synchronized swimming athletes and female swimmers must be done, in different distances, with different stops and in different age groups in order to give us more information about the physiological responses of athletes of these sports and so to be able to make safer conclusions in this field.

Training of aquatic sports has differences and similarities. The investigation and evaluation of physiological responses of swimmers and synchronized swimming athletes could give helpful information to coaches and athletes to improve programming training procedure and aiming to better performance.

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