HEART RATE, BLOOD LACTATE AND PERCEIVED EXERTION IN SYNCHRONIZED SWIMMING ROUTINES DURING COMPETITION

Rodríguez-Zamora L.[1], Iglesias X.[1], Barrero A. [1], Chaverri D.[1], Erola P.[2], Rodríguez FA.[1]

[1]INEFC-Barcelona Sport Sciences Research Group, Institut Nacional d'Educació Física de Catalunya, Universitat de Barcelona (Barcelona, Spain)

[2]DEIM, Universitat Rovira i Virgili (Tarragona, Spain)

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Introduction & Aim

In modern synchronized swimming (SS) athletes need to combine sets of technically, physically, and esthetically very demanding exercises, lasting about 2 to 5 minutes, both breathing freely and holding breath (BH) for almost 50% of the time (Homma, 1994). In each program, swimmers competing above junior level must perform both a technical and a free routine. No research has been found that characterized the physiological responses during competition.

This study aims to examine the cardiovascular, blood lactate and perceived exertion responses to competitive routines in synchronized swimming.

Materials & Methods

34 high-level senior (21.4 ± 3.6 y) and junior (15.9 ± 1.0 y) synchronized swimmers were monitored while performing a total of 96 routines during an official national championship in the technical solo (TS), free solo (FS), technical duet (TD), free duet (FD), technical team (TT), and free team (FT) programs.

- Heart rate (HR) was monitored using a waterproof monitor (Cardio Swim, Freelap, Fleurier, Switzerland).
- Peak blood lactate (La_{peak}) was obtained from earlobe capillary samples before the routine and during recovery (minutes 3, 5, 7, and 10).
- Post-exercise rate of perceived exertion (RPE) was assessed using the Category-Ratio (CR-10) Scale (Borg, 1998).

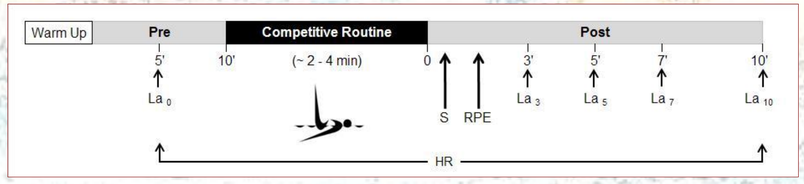

Figure 1. Study protocol

Results

Pre-exercise mean HR (beats·min^{-1}) was 129.1 ± 13.2, and quickly increased during the exercise to attain mean peak values of 192.0 ± 8.6, with frequent interspersed bradycardic events down to 88.8 ± 28.3 (Figure 2). Mean La_{peak} (mmol·L^{-1}) was 7.3 ± 2.0. On average RPE was 7.0 ± 1.4 ranged from 6.6 (TT) to 8.1 (FD) and was higher in juniors.

Table 1. Heart rate parameters during the routines and peak blood lactate and RPE after exercise

	Technical Solo	Free Solo	Technical Duet	Free Duet	Technical Team	Free Team
HR_{peak}	195.5 ± 8.3	189.3 ± 7.6	191.8 ± 10.9	192.5 ± 14.4	192.4 ± 7.3	191.2 ± 5.6
HR_{mean}	156.9 ± 9.1	150.1 ± 21.1	161.2 ± 13.1	153.1 ± 20.2	167.2 ± 7.4	162.5 ± 11.6
HR_{min}	93.1 ± 21.7	71.4 ± 35.4	94.5 ± 28.1	85.4 ± 27.7	91.2 ± 13.8	89.3 ± 31.3
HR_{range}	102.4 ± 17.8	118 ± 34	97.2 ± 25.2	107.1 ± 32.6	101.2 ± 18.8	101.9 ± 31.9
HR_{post}	88.3 ± 18.1	105.1 ± 4.9	103.2 ± 8.3	111.0 ± 15.5	110.5 ± 9.0	113.6 ± 12.2‡
La_{peak}	6.9 ± 1.4	8.5 ± 1.8**	6.8 ± 1.8	7.6 ± 1.8	7.1 ± 2.4	6.2 ± 1.9*
RPE	7.1 ± 1.7	8.0 ± 0.9	7.6 ± 0.9	8.1 ± 0.9	6.6 ± 1.2¶	7.5 ± 1.1†§

Significant differences (p<0.05) are: *FT vs. FD and FS; **FS vs. TD; ‡FT vs. TS; †FT vs. FS; ¶TT vs. FS, TD, and FD; §FT vs. FD. Tested using mixed model MANOVA and Bonferroni post-hoc pairwise comparisons

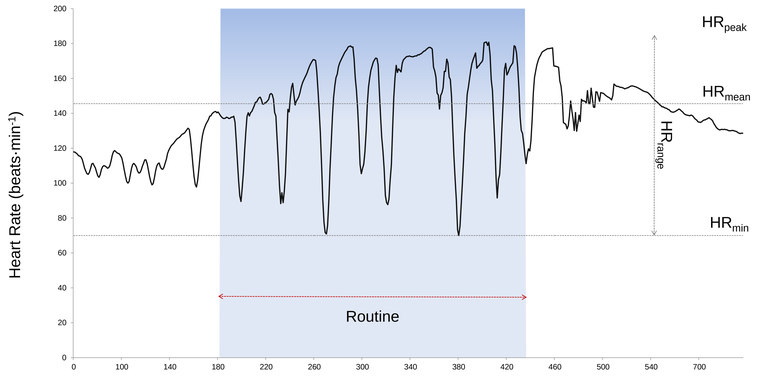

Figure 2. Heart rate profile before, during, and after a competitive free duet routine on an Olympic medalist. Line depicts smoothed 5-s averaged values for clarity

Discussion

- The **diving response** appears to be powerful enough to **override the HR response to exercise during apnea**. Cardiac output is expected to be reduced throughout dynamic apneas, largely due to bradycardia, whereas the systemic vascular resistance would increase (Andersson 2002).
- When the swimmer starts holding breath both inputs (tachycardia and bradycardia) compete with each other for control of HR (Wein, 2007) and oxygen flow to the exercising muscles, though the **oxygen conservation diving response** would finally prevail until the swimmer is able to breathe again.
- SS competitive routines appear to elicit a **moderately intense activation of glycolytic muscle metabolism** as a consequence of the high energy turnover and both low central and peripheral oxygen availability as suggested by Poole et al. (1980).
- The fact that mean RPE values were significantly higher in juniors than in seniors, could be explained by the greater number of years in training and competitive experience (Borg, 1998).

Conclusions

- **Cardiovascular demands of competitive routines are remarkably high and are characterized by intense anticipatory pre-activation and rapidly developing exercise tachycardia, with interspersed periods of marked bradycardia**
- **Moderate blood lactate accumulation suggests a non predominant role of the glycolytic anaerobic metabolism**
- **Competitive routines are perceived as "very strong" to "extremely strong" particularly in the free solo and duets**

References

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