

# HEART RATE KINETICS DURING SYNCHRONIZED SWIMMING SOLO ROUTINES IN RELATION TO BREATH HOLDING AND BODY POSITION

Iglesias X.<sup>1</sup>, Rodríguez-Zamora L.<sup>1</sup>, Clapés P. <sup>1</sup>, Barrero A. <sup>1</sup>, Chaverri D.<sup>1</sup>, Erola P.<sup>2</sup>, Irurtia A. <sup>1</sup>, Rodríguez F.A.<sup>1</sup>



<sup>1</sup>INEFC-Barcelona Sport Sciences Research Group, Institut Nacional d'Educació Física de Catalunya, Universitat de Barcelona (Barcelona, Spain)  
<sup>2</sup>DEIM, Universitat Rovira i Virgili (Tarragona, Spain)



## Introduction & Aim

Performance times for synchronized swimming (SS) solo routines range from 2 min for the technical solo (TS) to 3min for the free solo (FS) (FINA rules 2009-2013). Homma (1994) found that, on the average, 62.2% of this time is spent underwater, while Alentejano et al. (2008) reported a lower value (46%). It is known that synchronized swimmers experience diving bradycardia during breath holding (BH) bouts underwater (Gemma & Wells 1987, Rodríguez-Zamora et al. 2012).

**This study aims to determine the frequency and duration of face immersion periods in relation with body position, and to characterize heart rate response in technical and free solo routines**

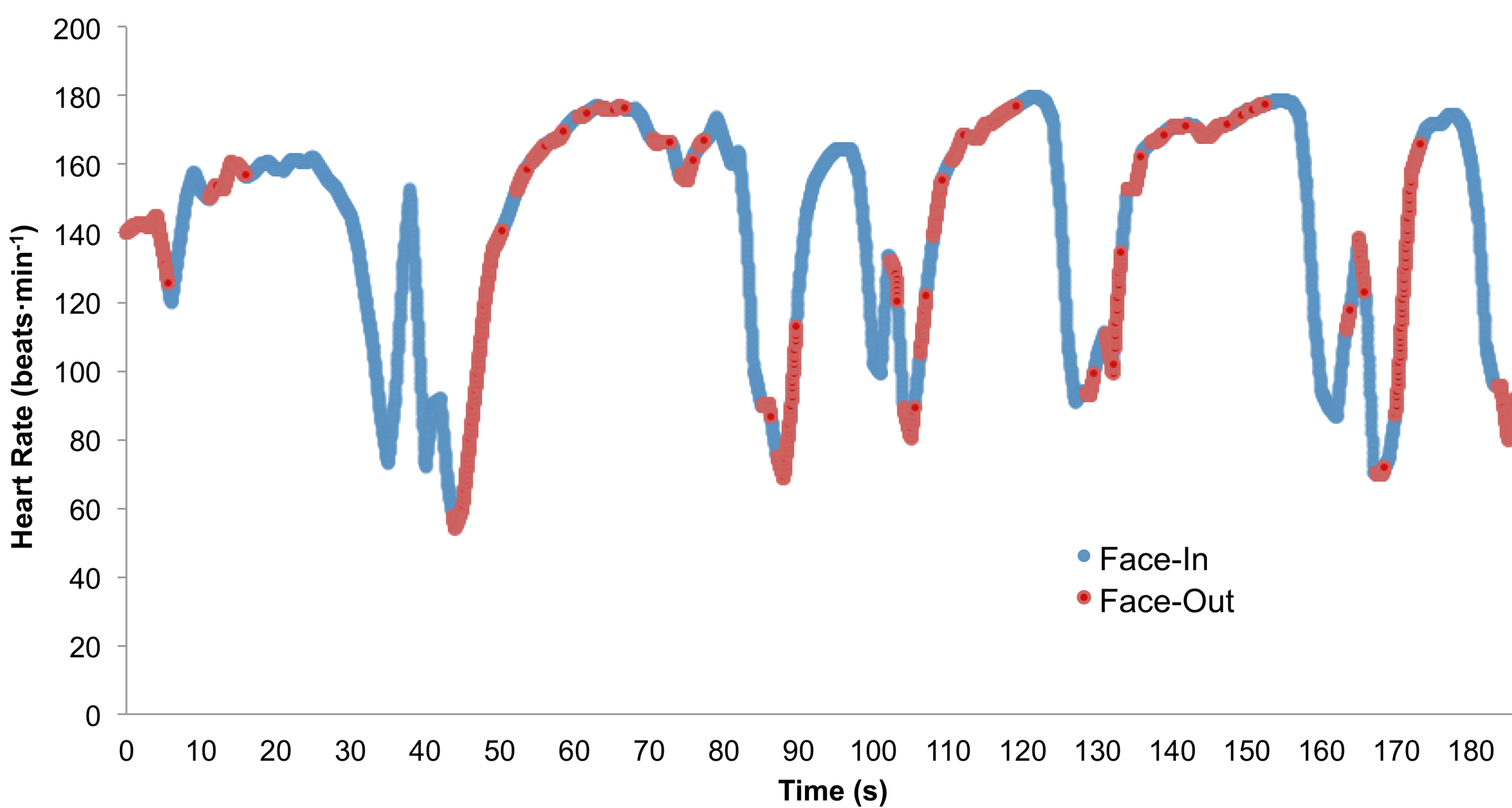
## Materials & Methods

Eight elite synchronized swimmers (20.8 ± 4.9 years, 3 Olympic medalists) were monitored while performing a total of 11 routines during an official national championship in the technical solo (TS, n=5) and free solo (FS, n=6) programs. Heart rate (HR) was continuously monitored using a waterproof beat-by-beat monitor (Cardio Swim, Freelap, Switzerland). All routines were recorded using a digital video camera (Panasonic 3-CCD Mini-DV Camcorder) at 50 Hz and 50 frames·s<sup>-1</sup> with an interlaced resolution of 720x576, allowing a time resolution of 0.102 s. By frame-by-frame video analysis, two face immersion conditions (face-in and face-out; or FI, FO), and three body positions (horizontal, upright, and inverted position; or HP, UP, IP) were identified and timed.

## Results

Mean HR during the 11 solos was 152.3 ± 30.6 beats·min<sup>-1</sup>. HR peak was 190.0 ± 13.2 beats·min<sup>-1</sup> with frequent interspersed bradycardic events down to 80.7 ± 31.3 beats·min<sup>-1</sup>. Swimmers were FI 62.1 ± 3.6% of total time, and FO for the rest (37.9 ±3.6%). Mean HR values during FI was lower (150.1 ± 31.7) than during FO (156.1 ± 28.0) (p<0.0001). HR range during the whole routine was 109.4 ± 27.3. Mean HR at HP (156.0± 27.6) was higher (p<.0001) than at UP (155.2 ± 28.1) and IP (147.4 ± 33.6). **Figure 1** shows the HR profile during a solo routine on a swimmer. **Table 1** presents descriptive values of FI (breath holding) period during solos.

**Figure 1.** Heart rate response during a solo routine related to breath holding (i.e. face-in vs. face-out) in an Olympic medalist



**Table 1.** Heart rate parameters during solo routines in relation to breath holding and body position

|               | HR <sub>mean</sub> | HR <sub>sd</sub> | HR <sub>max</sub> | HR <sub>min</sub> | %    |
|---------------|--------------------|------------------|-------------------|-------------------|------|
| Whole routine | 152,3              | 30,6             | 205               | 20                | 100  |
| Face-In       | 150,1*             | 31,7             | 205               | 20                | 62,1 |
| Face-Out      | 156,1              | 28,0             | 201               | 25                | 37,9 |
| Horizontal    | 156,0‡             | 27,6             | 205               | 23                | 27,9 |
| Inverted      | 147,4              | 33,6             | 200               | 20                | 40,5 |
| Upright       | 155,2              | 28,1             | 201               | 25                | 31,5 |

Values are beats·min<sup>-1</sup> and %. Significant differences (p<0.05) are: \*Face-In vs. Face-Out (Wilcoxon two-sample test); ‡Horizontal vs. Inverted and Upright position (Kruskal Wallis test).

**Table 2.** Frequency and duration of face-in immersions during free and technical solo routines

|                          | Mean | SD  | Maximum | Minimum |
|--------------------------|------|-----|---------|---------|
| Number of immersions (n) | 24,5 | 8,9 | 41,0    | 13,0    |
| Time immersed (s)        | 4,3  | 1,2 | 6,2     | 2,6     |
| Longest immersion (s)    | 21,7 | 4,4 | 27,8    | 16,0    |

## Discussion

This is the first study in which the cardiovascular response related to breath holding and body position has been examined during a SS competition. We found that:

- Bradycardic events occur while swimmer is holding breath (FI) or breathing (FO), in line with results by Gemma et al. (1987) who observed bradycardic episodes in ten synchronized swimmers while performing six SS figures during training
- The diving response appears to be powerful enough to override the chronotropic HR response to intense exercise during dynamic apnea
- Time spent FI was 3% higher in TS than in FS. This could be explained by the higher number of figures performed during free, since FS routines allow more variety of movements to demonstrate grace, artistry and creativity, as there are no figure requirements
- Average immersion time (62.1%) are in full agreement with results reported by Homma et al. (1994) who observed that top international swimmers during solo routines spent 62.2% of the time immersed, clearly higher than 46% reported by Alentejano et al. (2008).

## Conclusions

**The autonomous nervous system plays a fine tuned regulation of HR in this unique type of exercise in which sympathetic and parasympathetic activation and inhibition are continuously interplaying according to the swimmer's body position, breath holding condition, and intense exercise**

**Our main finding is that the main cardiovascular response to face immersion (i.e. bradycardia) is powerful enough to counteract exercise tachycardia during the breath holding phases of intense exercise**

## References

Homma M. (1994). Med Sport Sci 39, 149-154  
Alentejano TC et al. (2010). Res Sports Med 18(2), 97-114  
Gemma KE et al. (1987). Phys Sportsmed 15(10), 99-106  
Gabín B et al. (in press). Procedia Computer Science Technology  
Rodríguez-Zamora et al. (2012) ECSS Annual Congress, Brugges, Belgium