RED

SynchroProject II: Alto rendimiento y salud en mujeres de natación artística

Desarrollo del Synchroproject 1

Xavier Iglesias

Jornada Científica

INEFC Barcelona, 20 noviembre 2024

REDES DE INVESTIGACIÓN EN CIENCIAS DEL DEPORTE 2024

¿Cómo nace Synchro Project ?

1) **Profesorado:** Función del profesorado universitario: TRANSMITIR y CREAR conocimiento
2) **Alumnado:** Voluntad de realizar un doctorado
3) **Entrenadoras:** Preocupación → Desconocimiento → El cuerpo bajo el agua
4) **Grupo de Investigación:** Línea de investigación + Equipo de trabajo
5) **Motivación:** Inquietud por conocer más + Temática motivadora

¿Cómo se desarrolla Synchro Project?

1. ANÁLISIS de las potencialidades y las posibilidades

2. CREACIÓN de un proyecto de investigación

3. EJECUCIÓN del Proyecto

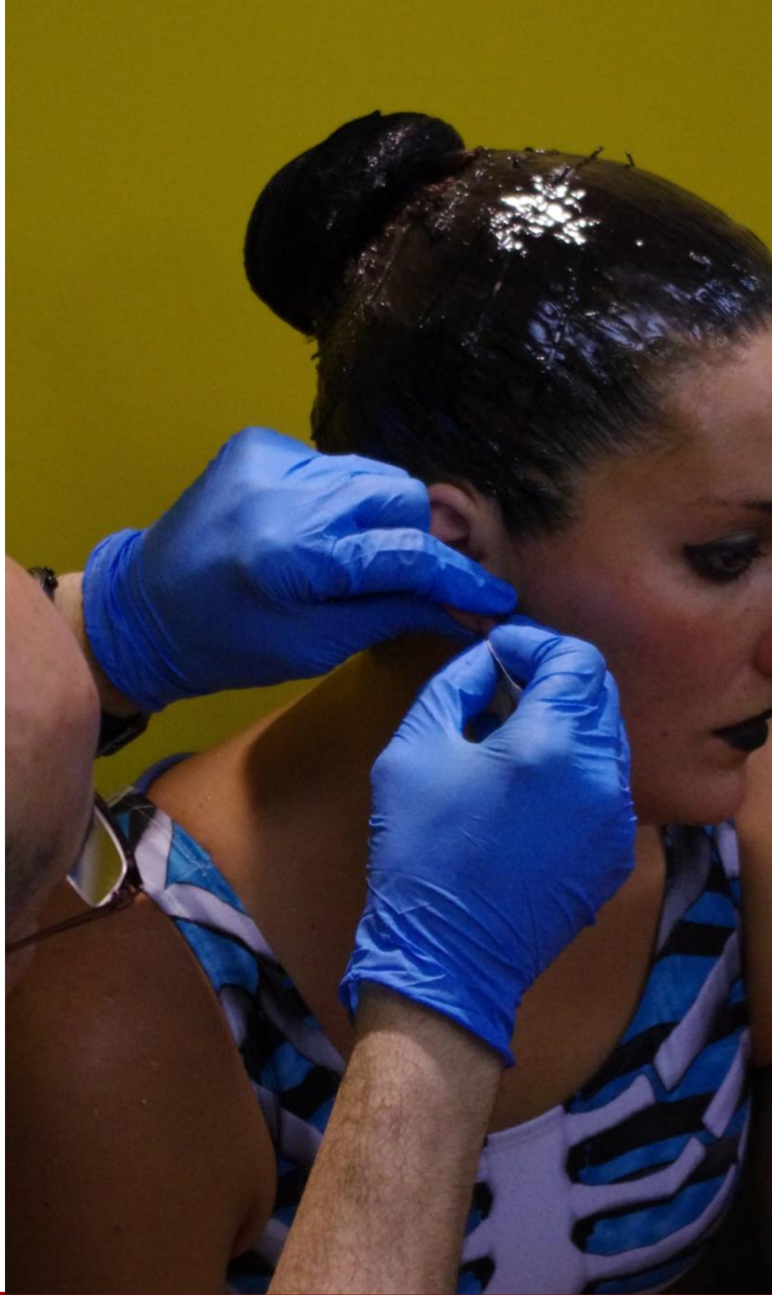
4. TRANSFERENCIA i DIFUSIÓN: Proceso productivo

1. Análisis de las potencialidades y las posibilidades

2. CREACIÓN de un proyecto de investigación

3. EJECUCIÓN del Proyecto

4. TRANSFERENCIA i DIFUSIÓN: Proceso productivo



1. Análisis de las potencialidades y las posibilidades

- Acceso a la muestra (Nadadoras, Madres/padres, entrenadoras)
- Autorizaciones (Federación, Comité arbitraje…)
- Falta de investigaciones sobre la Sincro
- Interés mutuo del proyecto: Universidad/Federación

inefc Institut Nacional d'Educació Física de Catalunya

grceib Grup de Recerca en Ciències de l'Esport INEFC Barcelona

- Grupo de estudiantes PhD con implicación en el proyecto
- 2/3 contratos predoctorales
- Búsqueda de nueva financiación
- Profesorado del INEFC con gran implicación y compromiso
- Materiales del grupo de investigación (INEFC) de otros proyectos

1. Análisis de las potencialidades y las posibilidades

2. CREACIÓN de un proyecto de investigación

3. EJECUCIÓN del Proyecto

4. TRANSFERENCIA i DIFUSIÓN: Proceso productivo

2. CREACIÓN de un proyecto de investigación

Synchro Project: Caracterización estructural y bioenergética de la natación sincronizada

Título del proyecto: *Synchro Project: caracterización estructural y bioenergética de la natación sincronizada*
Referencia: CSD 001/UPB10/11 **Año:** 2011
Importe concedido: 9.841,38 €
Investigador Principal (IP): Dr. Xavier Iglesias Reig

Generalitat de Catalunya
Institut Català de les Dones

Título del proyecto: *Caracterizació estructural i bioenergètica de la natació sincronitzada*
Referencia de la concesión: IC Dones U-34/10 **Año:** 2010
Importe concedido: 11.650,00 €
Investigador Principal (IP): Dr. Xavier Iglesias Reig

Synchro Project 1

Xavier Iglesias
Lara Rodríguez-Zamora
Marta Carrasco
Diego Chaverri
Alfredo Irurtia
Pilar Clapés
Lorena Torres
Anna Barrero
Jorge Castizo
Ferran A. Rodríguez
y otras colaboraciones

OBJETIVOS

3 OBJETOS DE ESTUDIO

- **Análisis bioenergético de las rutinas de competición**

Caracterizar la respuesta bioenergética de las nadadoras en la ejecución de las diferentes rutinas de competición (solo, dúo y equipo)

- **Análisis estructural y temporal de la natación sincronizada**

Analizar la estructura técnica y temporal de las diferentes rutinas competitivas (solo, dúo y equipo)

- **Valoración del estado nutricional de las nadadoras**

Caracterizar las relaciones entre el gasto energético y la adopción de unos hábitos y estilos de vida saludables en deportistas de natación sincronizada

1. Análisis de las potencialidades y las posibilidades

2. CREACIÓN de un proyecto de investigación

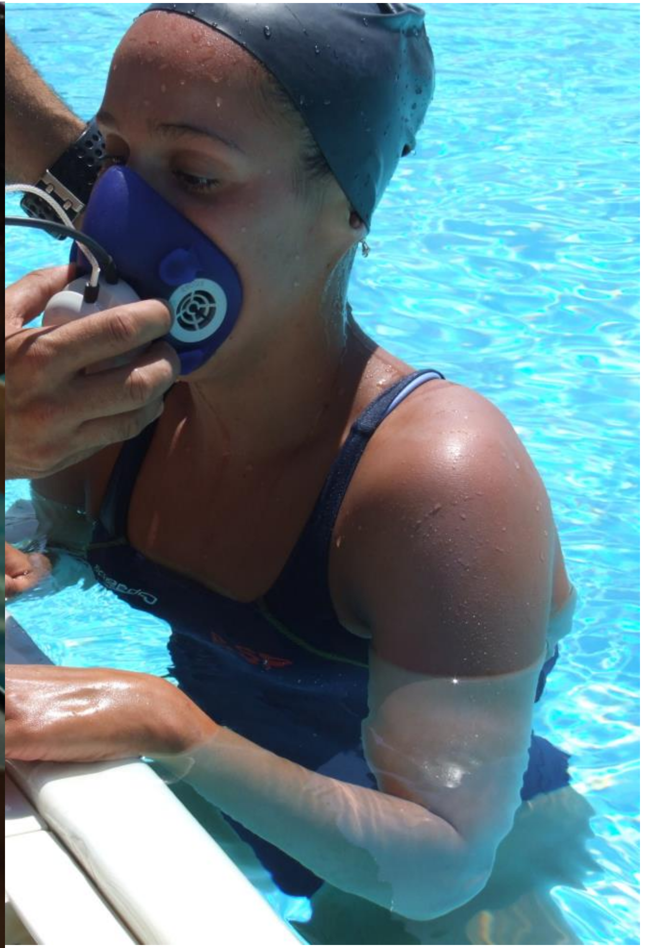
3. EJECUCIÓN del Proyecto

4. TRANSFERENCIA i DIFUSIÓN: Proceso productivo

OBJETIVO 1

Análisis bioenergético de las rutinas de competición

Caracterizar la respuesta bioenergética de las nadadoras en la ejecución de las diferentes rutinas de competición (solo, dúo y equipo)



Fase 1

Monitorización de la frecuencia cardíaca, lactato y RPE durante las rutinas en competición oficial de natación sincronizada

OPEN ACCESS Freely available online

PLOS | ONE

Physiological Responses in Relation to Performance during Competition in Elite Synchronized Swimmers

Lara Rodríguez-Zamora[1], Xavier Iglesias[1]*, Anna Barrero[1], Diego Chaverri[1], Pau Erola[2], Ferran A. Rodríguez[1]

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Abstract

Purpose: We aimed to characterize the cardiovascular, lactate and perceived exertion responses in relation to performance during competition in junior and senior elite synchronized swimmers.

Methods: 34 high level senior (21.4±3.6 years) and junior (15.9±1.0) synchronized swimmers were monitored while performing a total of 96 routines during an official national championship in the technical and free solo, duet and team competitive programs. Heart rate was continuously monitored. Peak blood lactate was obtained from serial capillary samples during recovery. Post-exercise rate of perceived exertion was assessed using the Borg CR-10 scale. Total competition scores were obtained from official records.

Results: Data collection was complete in 54 cases. Pre-exercise mean heart rate (beats·min^{-1}) was 129.1±13.1, and quickly increased during the exercise to attain mean peak values of 191.7±8.7, with interspersed bradycardic events down to 88.8±28.5. Mean peak blood lactate (mmol·L^{-1}) was highest in the free solo (8.5±1.8) and free duet (7.6±1.8) and lowest at the free team (6.2±1.9). Mean RPE (0–10+) was higher in juniors (7.8±0.9) than in seniors (7.1±1.4). Multivariate analysis revealed that heart rate before and minimum heart rate during the routine predicted 26% of variability in final total score.

Conclusions: Cardiovascular responses during competition are characterized by intense anticipatory pre-activation and rapidly developing tachycardia up to maximal levels with interspersed periods of marked bradycardia during the exercise bouts performed in apnea. Moderate blood lactate accumulation suggests an adaptive metabolic response as a result of the specific training adaptations attributed to influence of the diving response in synchronized swimmers. Competitive routines are perceived as very to extremely intense, particularly in the free solo and duets. The magnitude of anticipatory heart rate activation and bradycardic response appear to be related to performance variability.

Citation: Rodríguez-Zamora L, Iglesias X, Barrero A, Chaverri D, Erola P, et al. (2012) Physiological Responses in Relation to Performance during Competition in Elite Synchronized Swimmers. PLoS ONE 7(11): e49098. doi:10.1371/journal.pone.0049098

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Competing Interests: The authors have declared that no competing interests exist.

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Introduction

Synchronized swimming (SS) combines swimming, dancing and gymnastics. Swimmers (in solo, duet or team events) perform synchronized routines of elaborate moves in the water accompanied by music. SS became part of the official Olympic program in 1984, initially in the solo and duet modes, was dropped in 1996 in favor of team competition, and was reintroduced in duet competitions at the 2000 Olympic Games. In each program, swimmers competing above junior level must perform both a technical and a free routine. The technical routine is composed of various required elements that are selected every four years. They are performed in a specific order and last 2 min for the technical solo (TS), 2:20 mins for the technical duet (TD) and 2:50 mins for the technical team (TT). The free routine allows more flexibility to demonstrate grace, artistry and creativity, as there are no figure requirements. Its duration is 3 min for the free solo (FS), 3:30 mins for the free duet (FD), and 4 min for the free team (FT) [1].

In modern SS athletes need to combine technically, physically, and esthetically very demanding exercises, lasting about 2 to 4 minutes, performed at increasingly higher levels of intensity both breathing freely and holding breath. Almost 50% of this time is spent in apnea [2]. Consequently, the sport seems to require high levels of aerobic and anaerobic endurance, as well as exceptional breath control when upside down underwater [3]. Most studies on SS have focused on heart rate (HR) and blood lactate measurements after performing single figures [2,4,5] or a routine training program [6,7]. However, barely any of these assessments have been performed during real competition, making it difficult to derive valid information on the physiological demands of the sport and in different events [3].

Monitoring Internal Load Parameters During Competitive Synchronized Swimming Duet Routines in Elite Athletes

Lara Rodríguez-Zamora, Xavier Iglesias, Anna Barrero, Lorena Torres, Diego Chaverri, and Ferran A. Rodríguez

INEFC-Barcelona Sports Sciences Research Group, Institut Nacional d'Educació Física de Catalunya, Universitat de Barcelona, Barcelona, Spain

Abstract

Rodríguez-Zamora, L, Iglesias, X, Barrero, A, Torres, L, Chaverri, D, and Rodríguez, FA. Monitoring internal load parameters during competitive synchronized swimming duet routines in elite athletes. *J Strength Cond Res* XX(X): 000–000, 2013—The aim of the study is to compare the heart rate (HR) and rate of perceived exertion (RPE) responses as internal load indicators while performing duet routines during training and competition, both in the technical and free programs of synchronized swimming (SS). Participants were 10 SS Olympic medalists (age, 17.4 ± 3.0 years; height, 164.0 ± 6.1 cm; body mass, 52.0 ± 6.4 kg; training, 36.3 ± 6.2 h·wk^{-1}; experience, 9.2 ± 2.6 years). They were monitored while performing the same technical duet or free duet, during a training session (T) and during an official competition (C). Heart rate was continuously monitored. Rate of perceived exertion was assessed using the Borg CR10 scale. Heart rate responses during T and C were almost identical: pre-exercise mean HR (b·min^{-1}) was 130.5 ± 13.9 (T) and 133.6 ± 7.7 (C) and quickly increased yielding mean peak values of 184.8 ± 5.8 (T) and 184.8 ± 6.6 (C), with interspersed bradycardic events down to 86.6 ± 4 (T) and 86.3 ± 5 (C). Routines were perceived as "hard" to "extremely hard" by the swimmers in both conditions, and mean RPE scores (0–10+) were equally high during C (7.9 ± 1.2) and T (7.5 ± 1.2) ($p = 0.223$). Rate of perceived exertion inversely correlated with minimum ($R = -0.545$; $p = 0.008$) and mean HR ($R = -0.452$; $p = 0.026$) and positively correlated with HRrange ($R = 0.520$; $p = 0.011$). The internal load imposed by SS duets performed during training is virtually identical to that elicited in a real competitive situation. Therefore, practicing competitive routines is suitable for developing and maintaining the cardiovascular fitness that is needed for specific conditioning in elite synchronized swimmers, with the added value of favoring exercise automaticity, interindividual coordination, and artistic expression simultaneously.

Key Words synchronized swimming, heart rate, rating of perceived exertion, training, competition

Introduction

Synchronized swimming (SS) has been an event at the Summer Olympics since the 1984 Games. The current Olympic program has competition in duet and team events and includes free and technical routines. Successful performance depends on the swimmers' ability to execute a synchronized routine of elaborate moves in the water accompanied by music. To attain this goal, synchronized swimmers must train for aerobic and anaerobic fitness, strength, power, endurance, flexibility, performance skill, and artistic expression (34). As a result, training demands at an elite absolute level often result in high-volume (averaging about 40 h·wk^{-1}) (35,40), high-intensity training programs (35), including long periods devoted to choreography when much time is spent in the pool to perfect synchronization. The regulation of exercise intensity during SS training is critical to the success of each conditioning program because exercise intensity set too low does not induce the desired physiological adaptations, whereas an exercise intensity set too high may result in overtraining fatigue or injuries from overuse in this kind of athletes (34,35,54). For this reason, balancing the training components listed previously to produce the desired result at the time of competition without producing overuse injuries should be the major task for all National Team coaches (35). In this line, to monitor and control the training process, it is important to have a valid measure of the swimmers' internal training load (12). This is particularly relevant in this kind of esthetic sports, where the planned external load is often different for each team member because of the variety of elements configuring each routine and the order in which they are executed.

The use of telemetric heart rate (HR) monitors provides a simple, noninvasive, and convenient method for a continued

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Journal of Strength and Conditioning Research

Perceived Exertion, Time of Immersion and Physiological Correlates in Synchronized Swimming

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Key words
- synchronized swimming
- RPE
- blood lactate
- heart rate
- apnea
- water immersion

Abstract

This study examined the relationship between ratings of perceived exertion (RPE, CR-10), heart rate (HR), peak blood lactate (La_{peak}), and immersion (IM) parameters in 17 elite synchronized swimmers performing 30 solo and duet routines during competition. All were video recorded (50 Hz) and an observational instrument was used to time the IM phases. Differences in the measured variables were tested using a linear mixed-effects model. RPE was 7.7±1.1 and did not differ among routines, and neither did any of the HR parameters. There were differences among routines in La_{peak} ($F_{3,7}$=16.5; P=0.002), number of IM ($F_{3,15}$=14.0; P<0.001), total time immersed ($F_{3,16}$=26.6; P<0.001), percentage of time immersed ($F_{3,13}$=6.5; P=0.007) and number of IM longer than 10 s ($F_{3,18}$=3.0; P=0.04). RPE correlated positively to HR pre-activation, range of variation and recovery, IM parameters and La_{peak}, and inversely to minimum and mean HR. A hierarchical multiple linear regression (MLR) model (number of IM > 10 s, HR recovery, minimum HR, and La_{peak}) explained 62% RPE variance (adj. R_m^2=0.62; P<0.001). A stepwise MLR model (La_{peak}, mean IM time and pre-exercise HR) explained 46% of performance variance (adj. R_m^2=0.46; P<0.001). Findings highlight the psycho-physical stress imposed by the combination of intense dynamic exercise with repeated and prolonged apnea intervals during SS events.

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July 16, 2013

Bibliography
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Introduction

The ultimate goal of sports is to produce a winning or personal best performance at a specific time during competition. Monitoring the internal load, i.e., the acute physiological response induced by exercise on the athlete, is crucial for understanding the physiological and mental requirements for sporting success. Furthermore, internal load monitoring is a key component of the training process for the purpose of setting the optimal dose-response relationship between training stress and adaptation. In modern synchronized swimming (SS), performances depend on advanced water skills and require great strength, endurance, flexibility, grace, artistry and precise timing, as well as exceptional breath control when upside down underwater [18]. As a result, training requirements at the elite level often result in high-volume (averaging about 40 h per week) and high-intensity training programs [41]. As such, elite synchronized swimmers need to engage in a well-designed and balanced training program, to optimize performance and to reduce the risk of overtraining, burnout and injury [40,41].

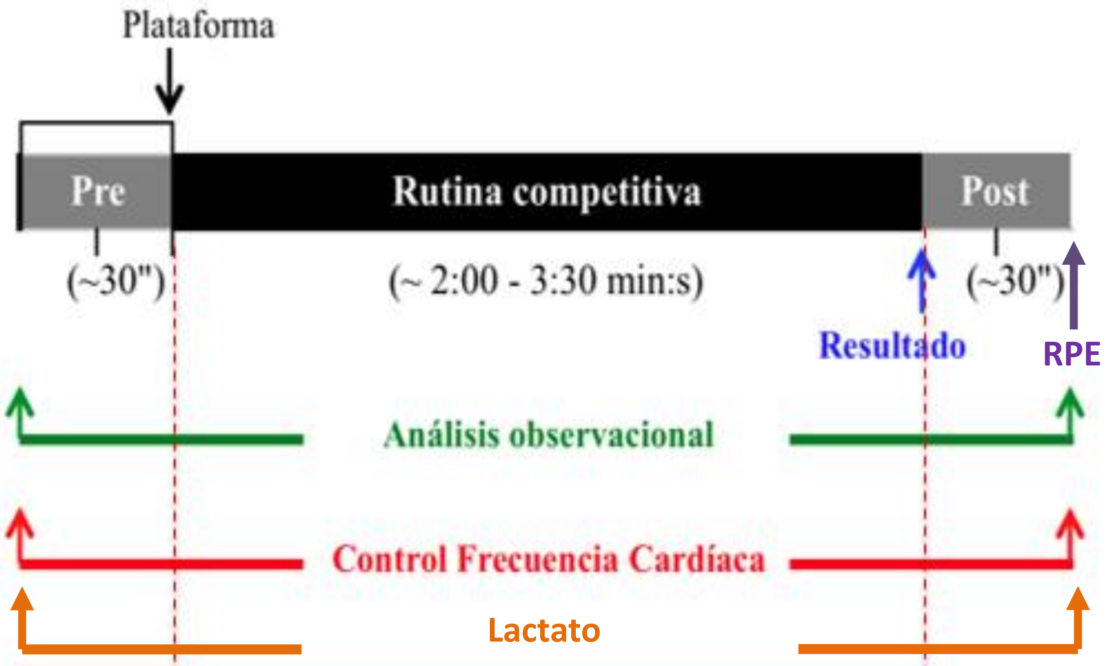
Several studies have addressed the physiological responses during different types of SS training such as figure execution [20,23,24], routine elements [56,60] and simulated competitive routines [5,12,28,44] with the aim of quantifying the internal training load. However, the addition of acrobatic elements, the increase in movements speed, the complexity and difficulty of routines, the synchronization to each other (in duet and team events), as well as the fact that swimmers spend almost 50% of the routine time underwater [23] have made it difficult to monitor swimmers' physiological parameters during competition. Additionally, the use of such physiological measures in training sessions on a daily basis is often limited by the lack of appropriate equipment and the fact that training needs to be interrupted to obtain these measurements [46]. For these reasons, coaches usually monitor the training process based on the administered external load (e.g., number and duration of training sessions, type and number of elements, sets and repetitions) despite the fact that the same external load can elicit different physiological responses and training adaptations, depending on the athlete's age, fitness and skill level [7].

Sujetos

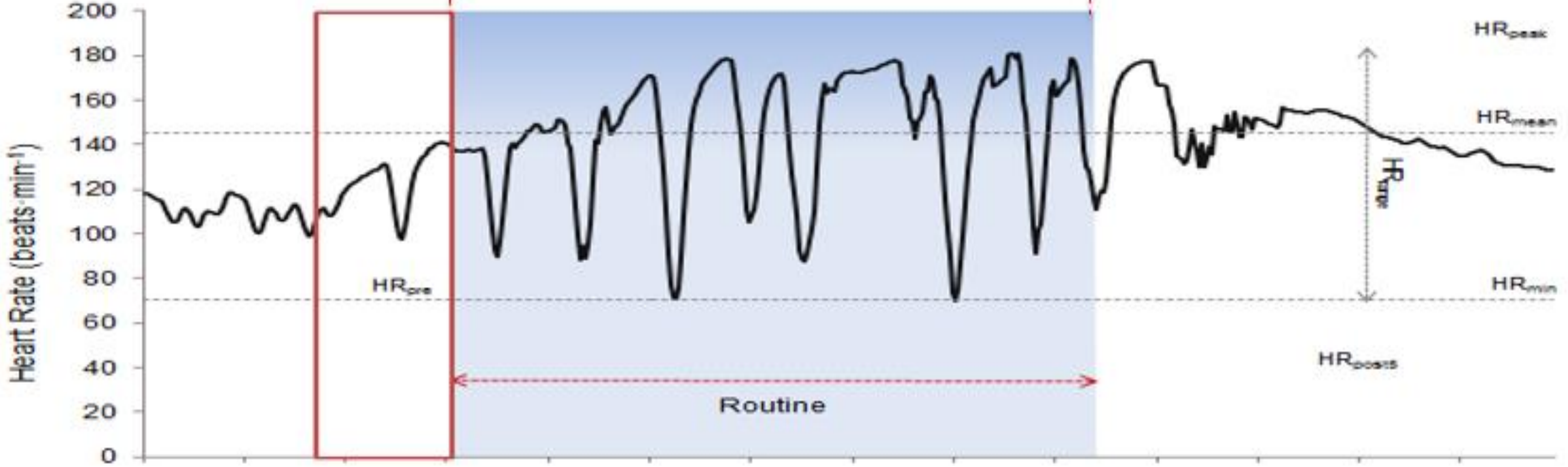
	Todas (n=34)	Junior (n=24)	Senior (n=10)
Talla (cm)	165.2 ± 6.5	163.7 ± 5.1	168.9 ± 8.0
Peso (kg)	53.6 ± 5.6	53.2 ± 5.3	54.6 ± 6.3
Edad (años)	17.5 ± 3.3	15.9 ± 1.0	21.4 ± 3.6
Entrenamiento ($h \cdot semana^{-1}$)	33.1 ± 10.0	29.9 ± 8.2	40.7 ± 10.1
Años de práctica (años)	9.6 ± 2.5	8.7 ± 1.5	11.7 ± 3.3

Valores = media ± SD

Método



Plataforma
Pre
Rutina competitiva
Post
(~30")
(~ 2:00 - 3:30 min:s)
(~30")
Resultado
RPE
Análisis observacional
Control Frecuencia Cardíaca
Lactato



Heart Rate (beats·min-1)
200
180
160
140
120
100
80
60
40
20
0
HRpeak
HRmean
HRmin
HRpre
HRposts
HRrange
Routine

P/N/M

Resultados

Natación Sincronizada:
ENTRENAMIENTO vs COMPETICIÓN

SYNCHRO
project

Figure 1. The National Spanish duet wearing the waterproof cardiotacometer while executing the free program during the competition

Figure 2. The National Spanish duet wearing the waterproof cardiotacometer while executing the free program during a training session

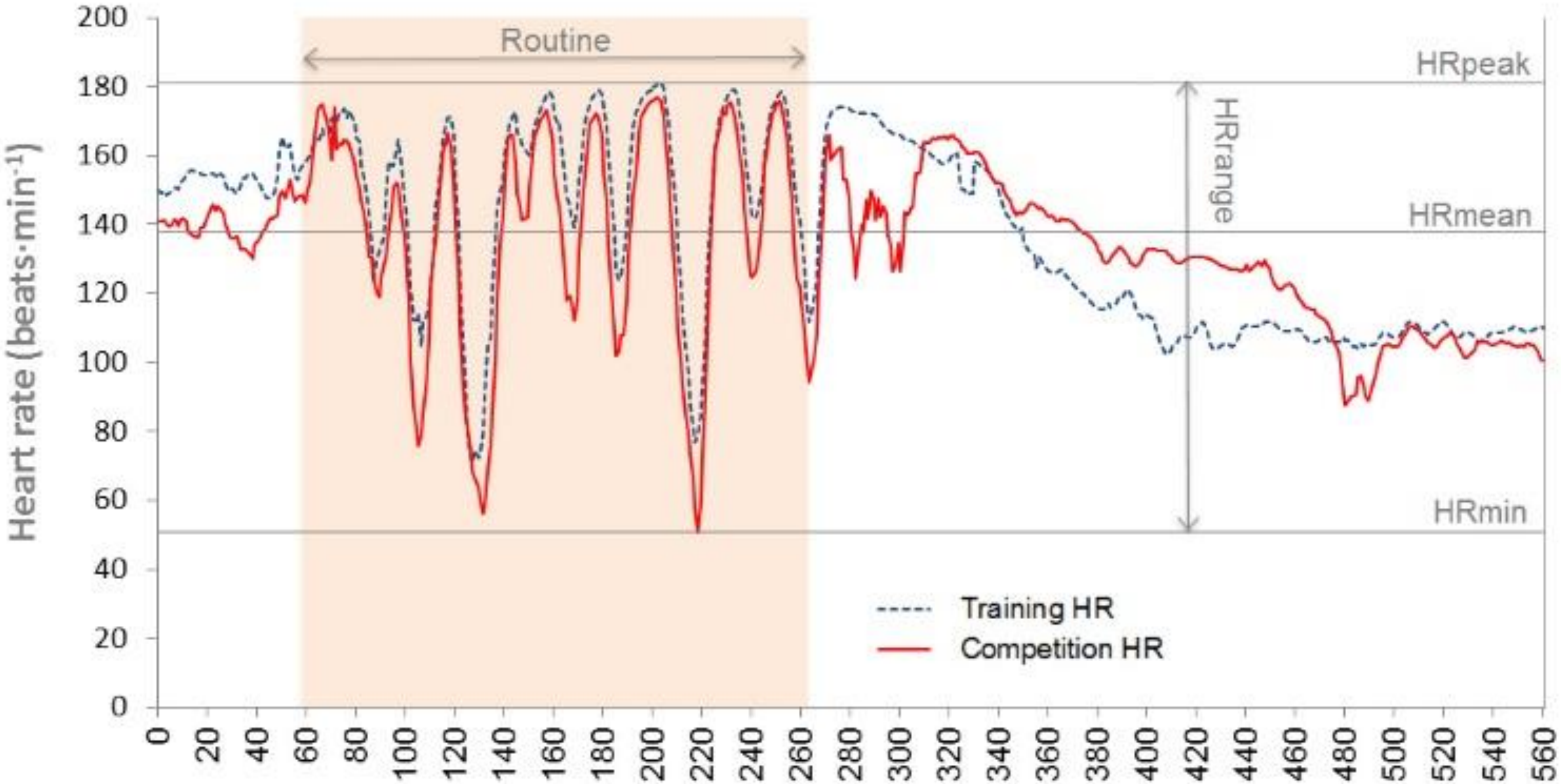


Figure 3. Heart rate profiles before, during (shadowed), and after a free duet routine performed during training (blue line) and competition (red line) in one of the swimmers.

Rodríguez-Zamora, L., Iglesias, X., Barrero, A., Torres, L., Chaverri, D., & Rodríguez, F. A. (2014). Monitoring internal load parameters during competitive synchronized swimming duet routines in elite athletes. *The Journal of Strength & Conditioning Research, 28*(3), 742-751.


src 17:21:57:22
16:08:26:12

Table 2. Heart rate (HR) parameters before (Pre), during (Routine), and after (Post) the competitive routines for the entire group of swimmers.

		TS (n = 5)	FS (n = 6)	TD (n = 10)	FD (n = 9)	TT (n = 5)	FT (n = 24)	All Routines (n = 59)
Pre	HR_{pre}	122.3±10.8	130.5±15.9	124.6±12.5	130.7±9.6	125.9±10.1	132.0±14.7	129.1±13.1
Routine	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	191.7±8.7
	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	159.6±14.4
	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	88.8±28.5
	HR_{range}	102.4±17.8	118±34	97.2±25.2	107.1±32.6	101.2±18.8	101.9±31.9	103.5±28.7
Post	HR_{post1}	146.6±21.9	146.5±24.1	157.6±12.5	155.3±21.5	155.6±17.0	152.0±35.9	152.7±26.7
	HR_{post3}	108.0±12.8	117.8±11.5	113.0±13.7	130.4±7.1	123.1±12.9	128.8±11.0[a,b]	122.9±13.4
	HR_{post5}	88.3±18.1	105.1±4.9	103.2±8.3	111.0±15.5	110.5±9.0	113.6±12.2[a]	108.1±13.6

Data are mean ± SD (beats·min^{-1}). TS, Technical Solo; FS, Free Solo; TD, Technical Duet; FD, Free Duet; TT, Technical Team; FT, Free Team. HR_{pre}, last minute before routine; HR_{peak}, HR_{mean}, HR_{min}, HR_{range}: peak, mean, minimum, and range values during routine; HR_{post1}, HR_{post3}, HR_{post5}: first, third and fifth minutes during recovery. Significant differences ($P<0.05$) among routine programs were noted only during recovery: [a]FT vs. TS; [b]FT vs. TD.

doi:10.1371/journal.pone.0049098.t002

Table 5. Peak blood lactate (La_{peak}), and rates of perceived exertion (RPE) of the routines.

Category	Variable	TS (n = 9)	FS (n = 11)	TD (n = 16)	FD (n = 16)	TT (n = 14)	FT (n = 30)	All Routines (n = 96)
All swimmers	La_{peak} ($mmol \cdot L^{-1}$)	6.9±1.4	8.5±1.8[b]	6.8±1.8	7.6±1.8	7.1±2.4	6.2±1.9[a]	7.3±2.0
	RPE (a.u.)	7.1±1.7	8.0±0.9	7.6±0.9	8.1±0.9	6.6±1.2[d]	7.5±1.1[c,e]	7.0±1.4
Junior	La_{peak} ($mmol \cdot L^{-1}$)	6.1±1.1	8.1±3.3	6.5±1.5	6.9±1.7	7.0±2.7	6.5±1.9	6.7±2.0
	RPE (a.u.)	6.7±1.2	7.4±0.9	8.1±0.6	8.2±0.9	7.4±1.1	7.9±0.8	7.8±0.9*
Senior	La_{peak} ($mmol \cdot L^{-1}$)	7.4±1.5	8.8±1.7	7.0±2.2	8.8±1.4	7.2±2.2	5.3±1.7	7.4±2.1
	RPE (a.u.)	7.3±2.0	8.5±0.5[h]	7.0±0.8	7.8±1.0[i]	5.7±0.5[f]	6.1±1.1[g]	7.1±1.4

Values are mean ± SD. TS, Technical Solo; FS, Free Solo; TD, Technical Duet; FD, Free Duet; TT, Technical Team; FT, Free Team; a.u., arbitrary units (0–10+).
*Significant differences between junior and senior swimmers for all routines. Significant differences among routines in:
La_{peak} ($P<0.05$) for all swimmers are: [a]FT vs. FD and FS; [b]FS vs. TD.
RPE for all swimmers are: [c]FT vs. FS; [d]TT vs. FS, TD and FD; [e]FT vs. FD.
RPE ($P<0.05$) for the senior group are: [f]TT vs. TS, FS and FD; [g]FT vs. FS and FD; [h]FS vs. TD; [i]TD vs. TT.
doi:10.1371/journal.pone.0049098.t005

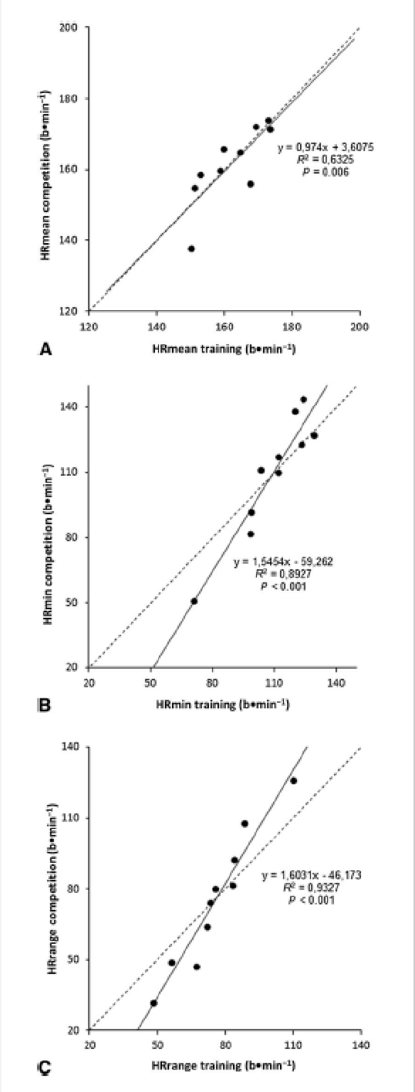


Figure 4. Correlation between heart rate (HR) parameters during duet routines performed during training and competition in elite synchronized swimmers ($n = 10$): (A) mean (HRmean), (B) minimum (HRmin), and (C) range (HRrange) HR. Regression (solid) and identity (dotted) lines are depicted, and regression equations and determination coefficients (R^2) are shown.

- **Equivalencia entre entrenamiento y competición**: Las demandas fisiológicas de las rutinas en entrenamiento y competición son similares, tanto en indicadores objetivos (frecuencia cardíaca) como subjetivos (percepción del esfuerzo, RPE).

- **Altas demandas cardiovasculares**: Las rutinas alcanzan frecuencias cardíacas máximas elevadas con episodios de bradicardia intercalada debido a las apneas.

- **Relación RPE - bradicardia**: La percepción de esfuerzo (RPE) se correlaciona inversamente con los niveles mínimos y medios de frecuencia cardíaca y positivamente con la amplitud de la variación de la frecuencia cardíaca. Esto sugiere que la intensidad percibida está vinculada a la duración y frecuencia de los eventos de bradicardia durante las rutinas.

- **RPE como herramienta práctica**: La percepción del esfuerzo (RPE) es una alternativa viable para monitorear la carga interna de forma no invasiva y económica

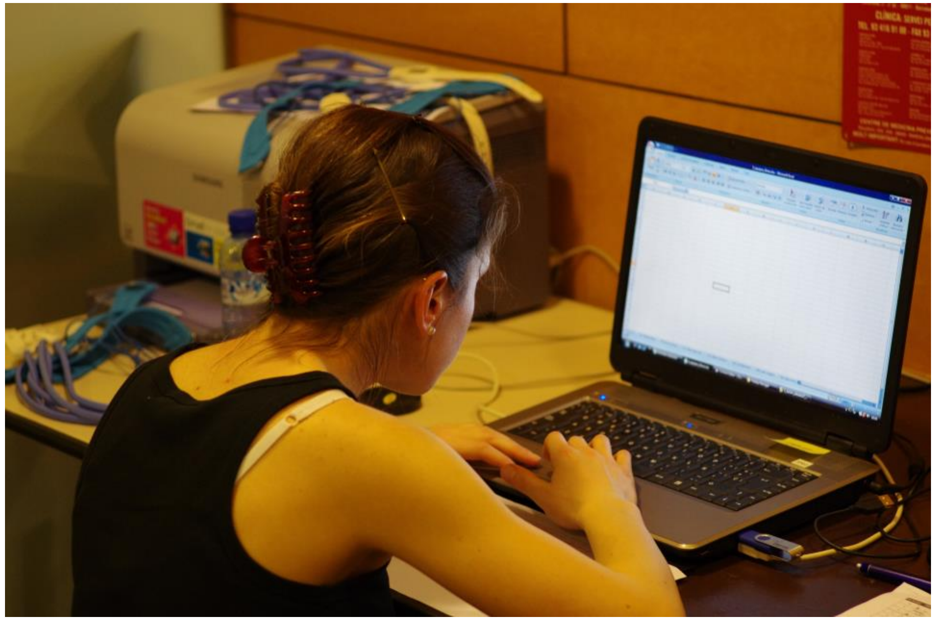
Limitaciones

Mortalidad experimental por los instrumentos = 37 rutinas

ıtines.

TT	FT	All Routines
(n = 14)	(n = 30)	(n = 96)
7.1±2.4	6.2±1.9[a]	7.3±2.0

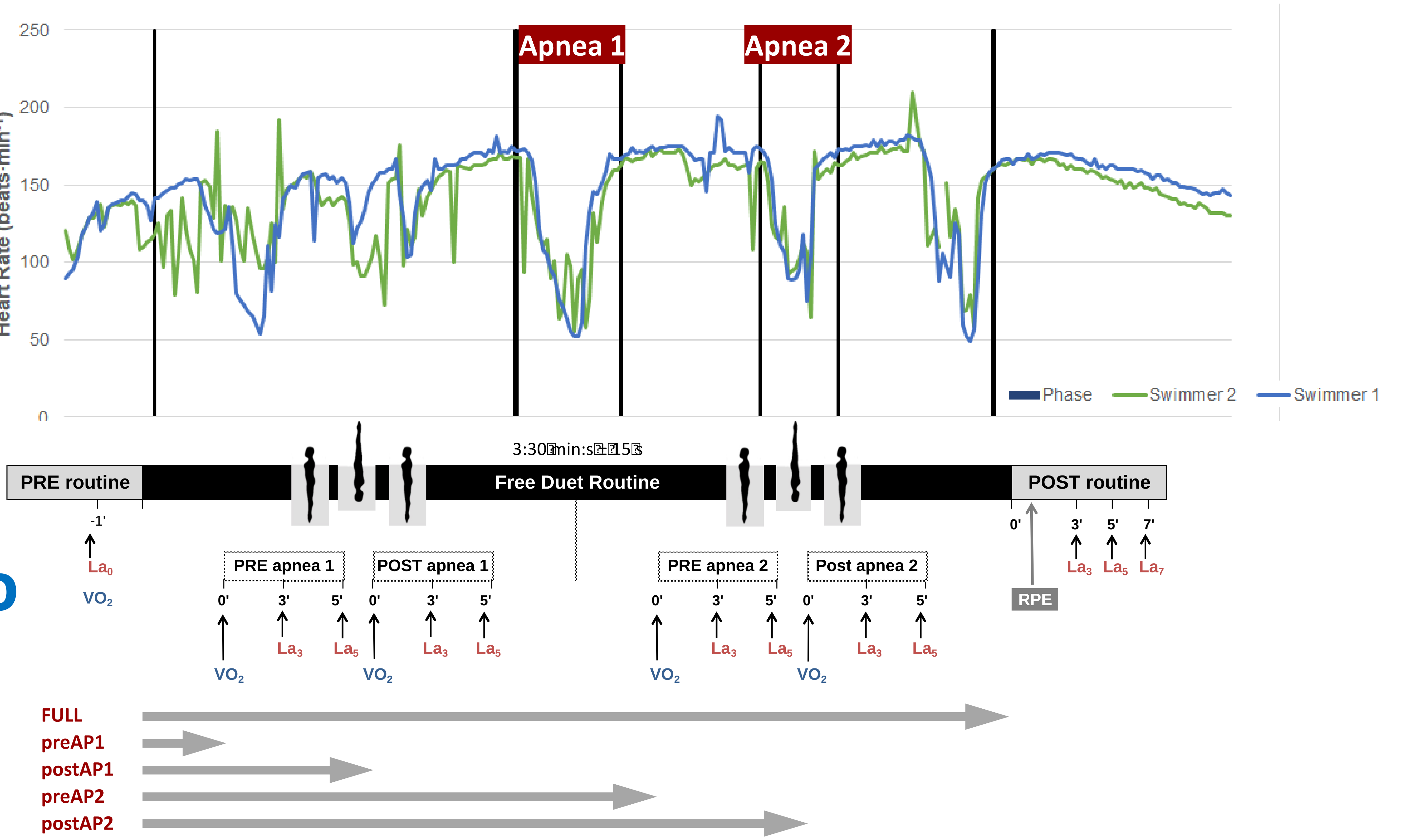
TT	FT	All Routines
(n = 5)	(n = 24)	(n = 59)
125.9±10.1	132.0±14.7	129.1±13.1



Fase 2

Analizar el consumo de oxígeno, frecuencia cardíaca y lactato en rutinas completas y fraccionadas de dúo en natación sincronizada de élite

Método



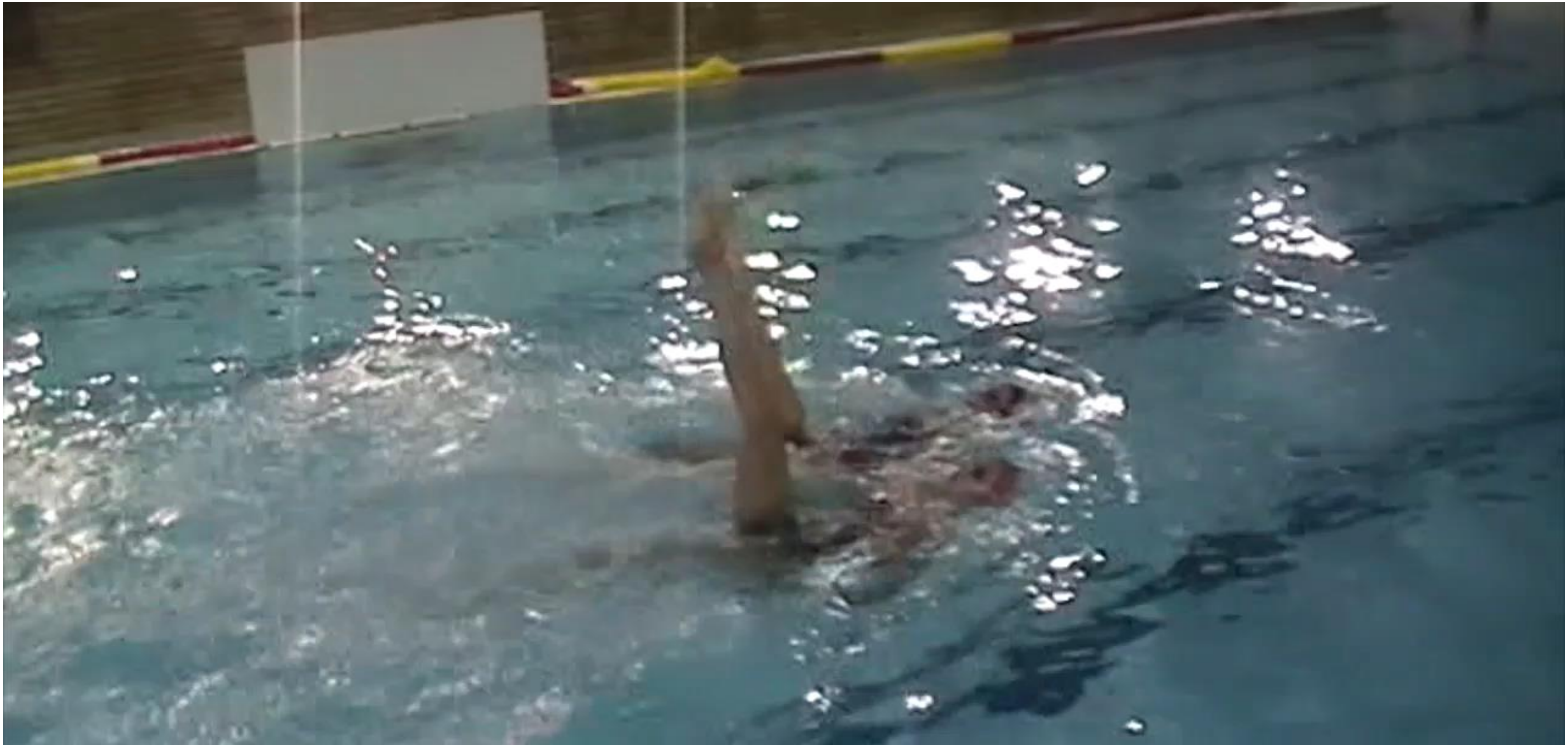
Apnea 1
Apnea 2
Heart Rate (beats·min-1)
250
200
150
100
50
0
Phase
Swimmer 2
Swimmer 1
3:30min:s±15s
PRE routine
Free Duet Routine
POST routine
-1'
La0
VO2
PRE apnea 1
POST apnea 1
PRE apnea 2
Post apnea 2
0'
3'
5'
La3
La5
La7
RPE
FULL
preAP1
postAP1
preAP2
postAP2

Subjects

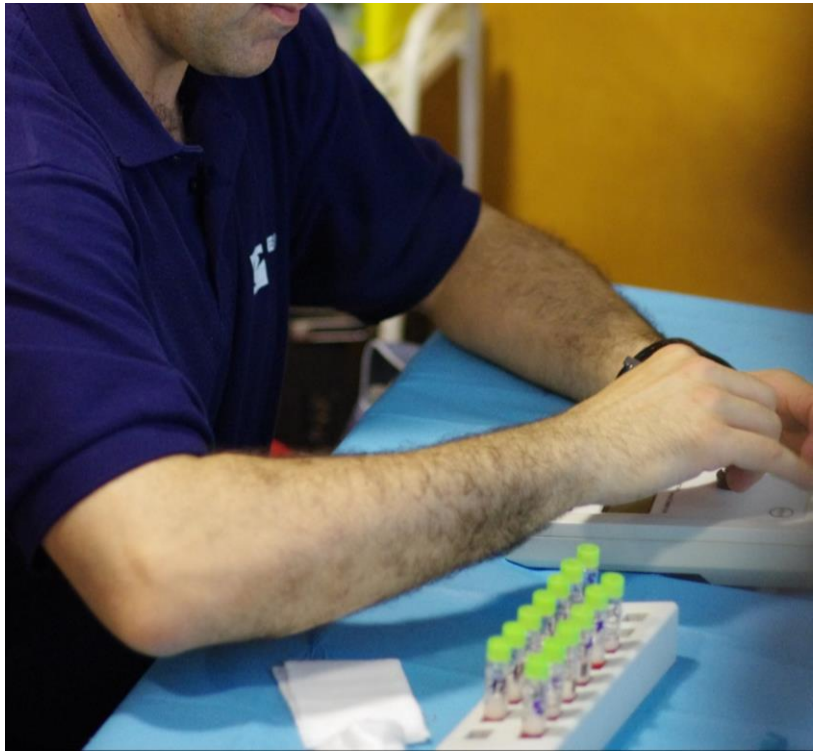
- 16 elite senior & junior swimmers
- Age 16.5 ± 2.5 yrs
- Height 165 ± 7 cm
- Body mass 53 ± 8 kg

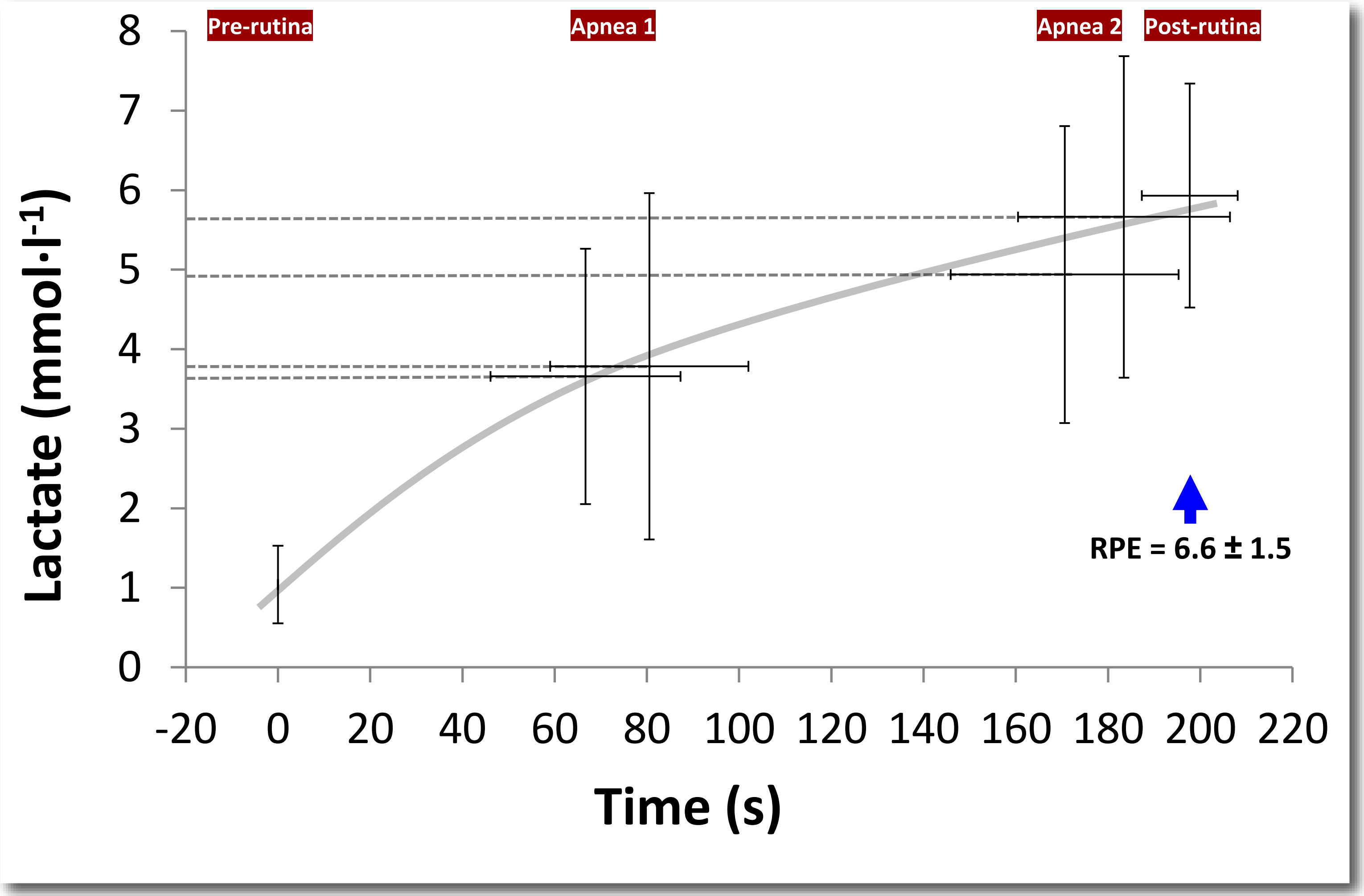
Testing

- Peak VO_2 by backward extrapolation of first 30 s postexercise (Cosmed K4 b^2)
- Serial (min 3, 5, 7) capillary blood samples for La_b (DiaglobalDP100)
- RPE (Borg CR-10 scale)

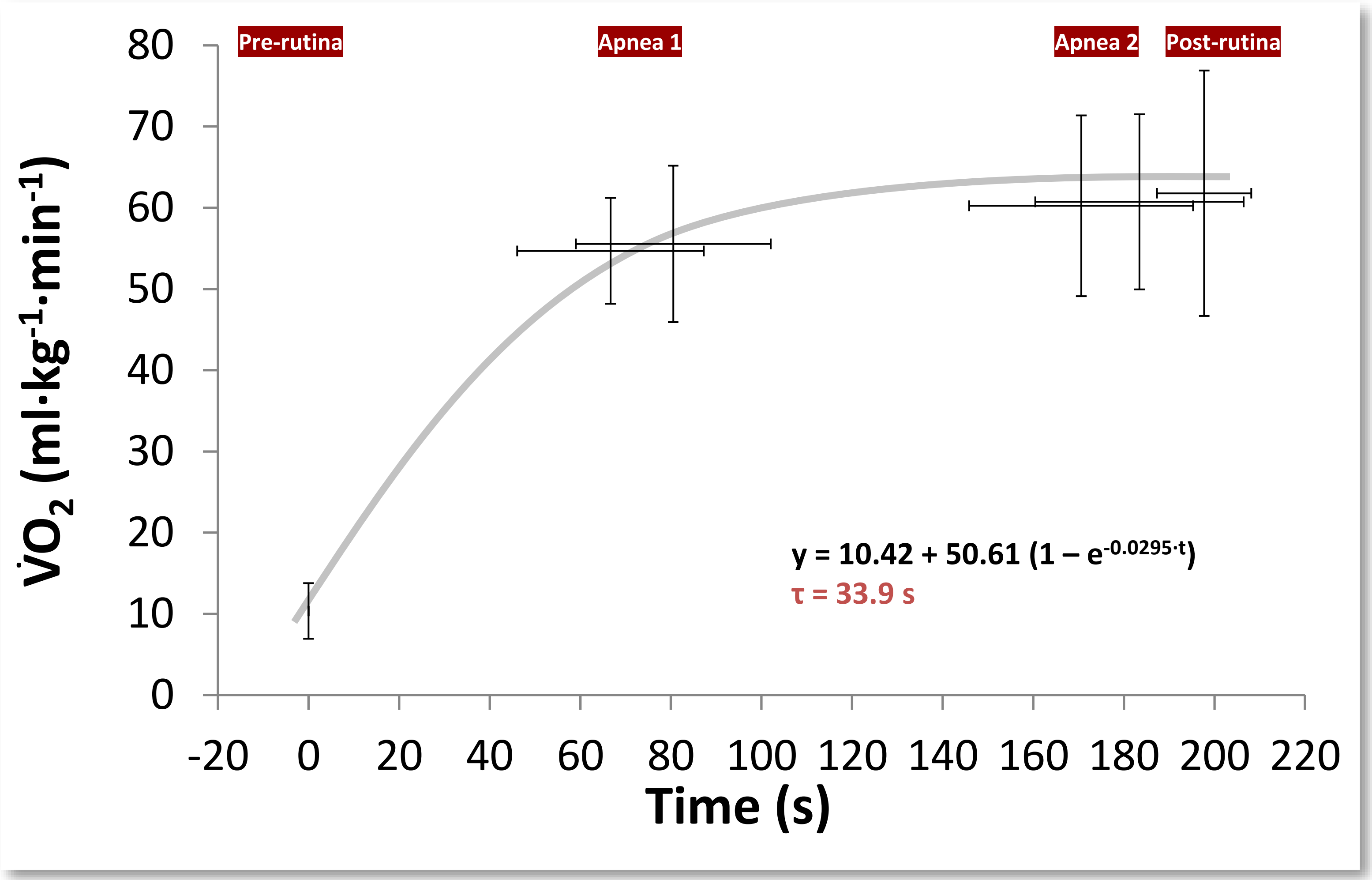


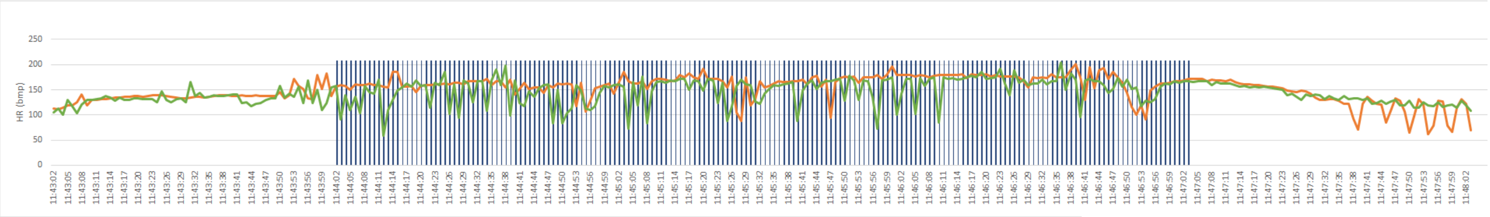
Resultados



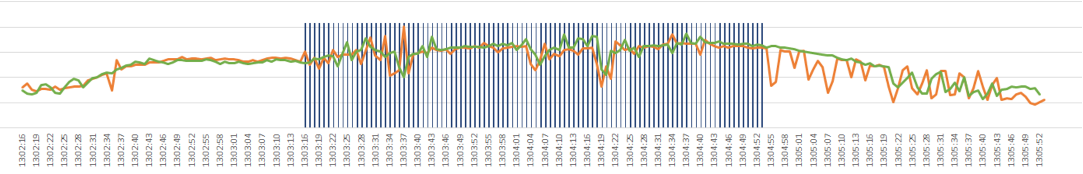


Pre-rutina
Apnea 1
Apnea 2
Post-rutina
Lactate (mmol·l-1)
Time (s)
RPE = 6.6 ± 1.5
0
1
2
3
4
5
6
7
8
-20
0
20
40
60
80
100
120
140
160
180
200
220

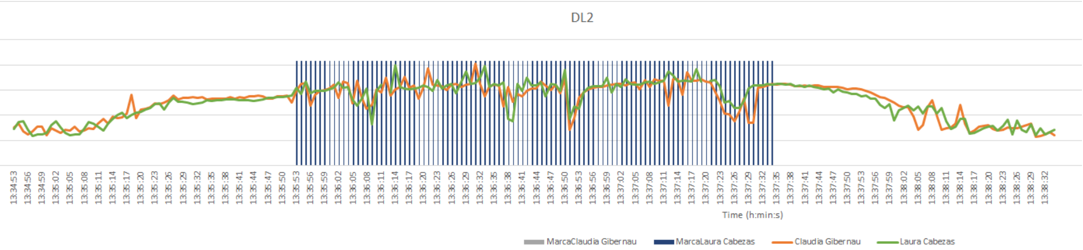

Pre-rutina
Apnea 1
Apnea 2
Post-rutina
V̇O2 (ml·kg-1·min-1)
80
70
60
50
40
30
20
10
0
-20 0 20 40 60 80 100 120 140 160 180 200 220
Time (s)
y = 10.42 + 50.61 (1 – e-0.0295·t)
τ = 33.9 s



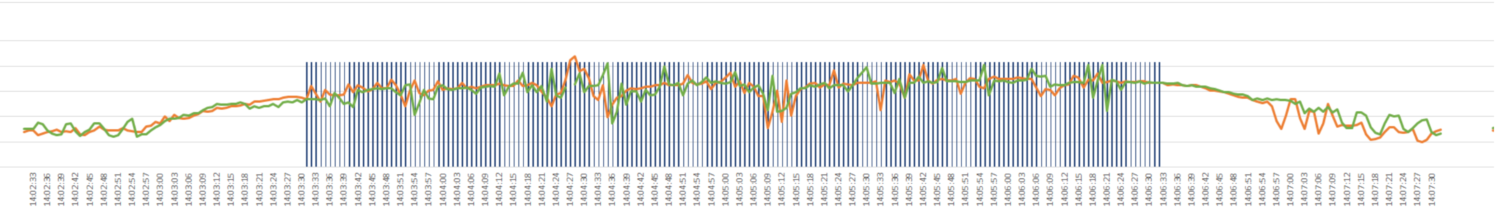
Routine



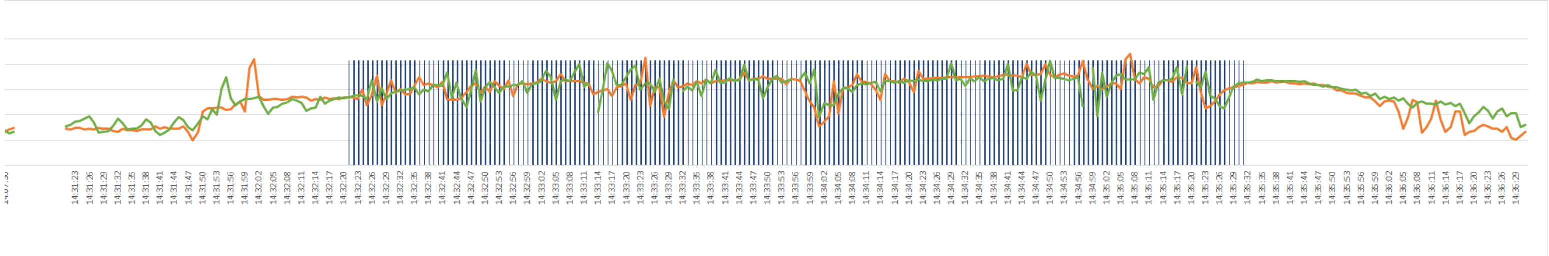
Phase A



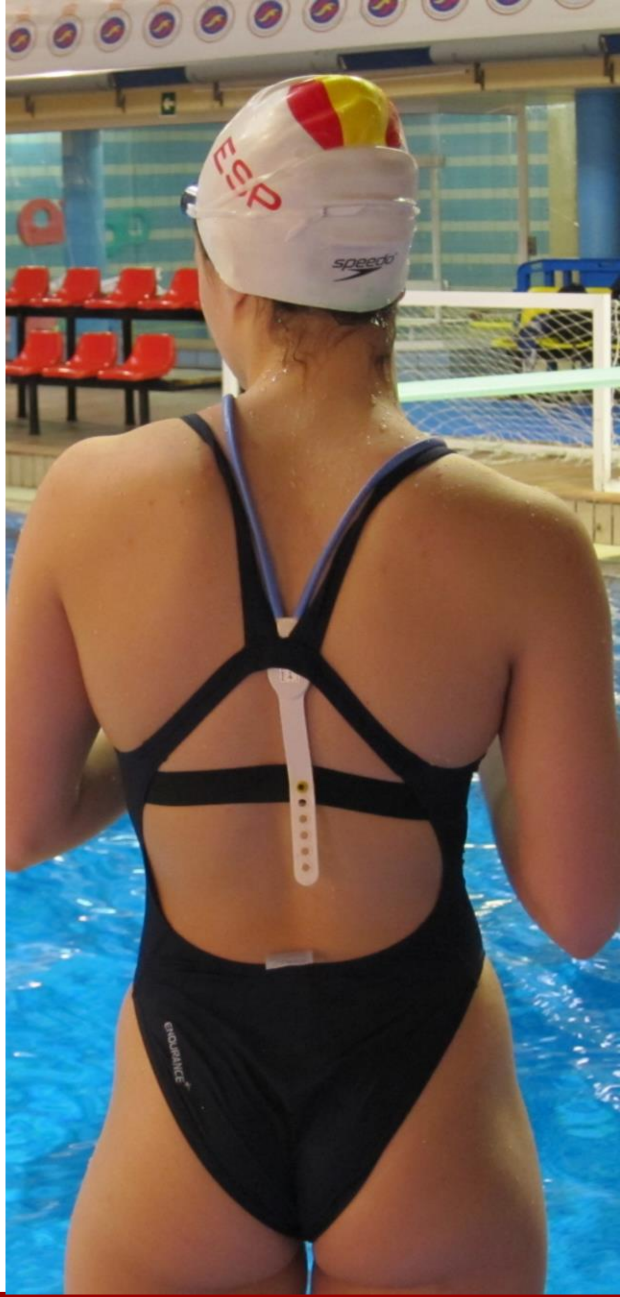
Phase B



Phase C



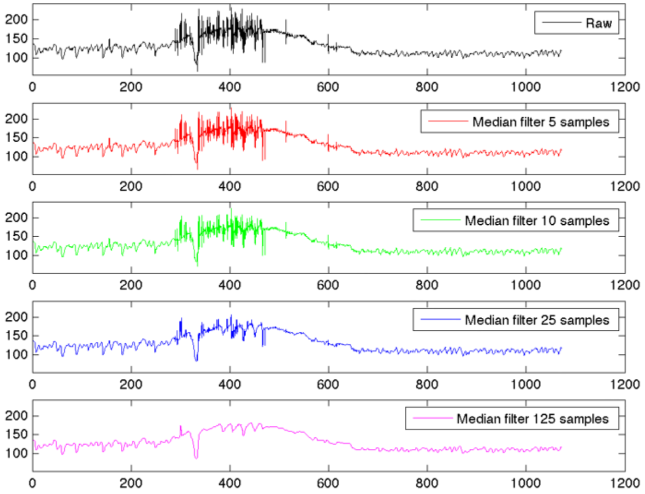
Phase D



Limitaciones

- **Análisis de 22 deportistas (11 rutinas de dúo):**
  - 2 registros de FC perdidos totalmente por errores de Freelap
  - 2 registros de FC con una de las fases perdida por errores de Freelap
  - 6 registros (3 dúos) desestimados por desarrollo de rutinas no completas – Criterio deportivo

- **Dificultad en la sincronía de alta precisión entre FC y Comportamientos observacionales: efecto "acordeón" por limitaciones/errores de Freelap en el registro de FC**

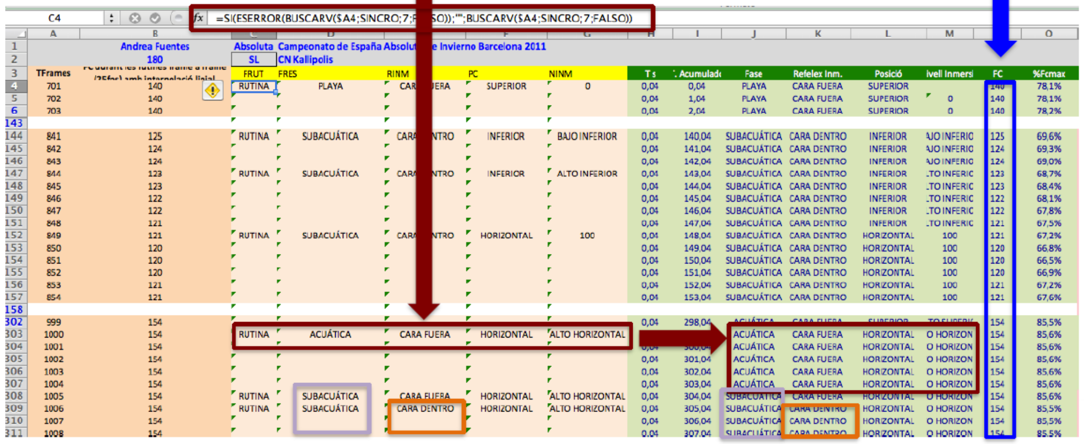


Datos cualitativos

Los registros observados se ajustan (fórmulas condicionales de Excel) a cada uno de los frames (25 fps) de la filmación en video.

Datos cuantitativos

Registros latido a latido interpolados (Matlab, Mathworks Inc., USA) a intervalos de 0.04s, ajustándolos a cada uno de los frames (25 fps) de la filmación en video.



OBJETIVO 2

Análisis estructural y temporal de la natación sincronizada

Analizar la estructura técnica y temporal de las diferentes rutinas competitivas (solo, dúo y equipo)

Participantes

- **25 nadadoras de élite**

- **42 rutinas**
  - 22 de Campeonato del Mundo
  - 20 de Campeonato de España

  - 19 solo técnico
  - 23 solo libre

Instrumento observacional

Criterio	Categorias	Descripción
FASE DE RUTINA	PLAYA	La nadadora está en contacto con el suelo.
	AÉREA	Momentos de salto o suspensión fuera del agua. Ninguna parte del cuerpo está en contacto con el suelo o el agua.
	ACUÁTICA	Desde el momento en que la boca de la nadadora sale del agua, hasta que la vuelve a introducir completamente dentro del agua.
	SUBACUÁTICA	Desde el momento en que la boca se introduce en el agua, hasta el momento en que vuelve a salir.
FASE DE INMERSIÓN	CARA FUERA	Cara parcial o completamente fuera del agua.
	CARA DENTRO	Inmersión completa de la cara (Barbilla y Frente).
POSICIÓN CORPORAL	SUPERIOR	La cabeza permanece por encima de la cadera en relación al suelo.
	INFERIOR	La cabeza permanece por debajo de la cadera en relación al suelo.
	HORIZONTAL	La cabeza permanece a la altura de las caderas o muslos, con su límite máximo a la altura de las rodillas. El tronco permanece en todo momento en posición horizontal.
NIVEL DE INMERSIÓN	0% DE INMERSIÓN	No hay inmersión. Todo el cuerpo de la nadadora está fuera del agua.
	BAJO NIVEL DE INMERSIÓN	Posición superior. La parte del cuerpo INMERSA empieza desde la línea del pubis, hasta el último contacto de la nadadora con el agua. Posición inferior. La parte del cuerpo inmersa empieza en la línea del pubis y finaliza con el último contacto de la nadadora con el agua. Las dos piernas están elevadas sobre la superficie o paralelas a ella, pero siempre con su nivel máximo de inmersión en la línea de pubis o glútea. Posición horizontal. Si es lateral no hay bajo nivel de inmersión. Si es supina habrá nivel bajo de inmersión cuando con las dos extremidades inferiores fuera del agua, la línea de la superficie del agua quede por debajo de la línea del pubis/línea del glúteo. Si es prono habrá nivel bajo de inmersión cuando con las dos extremidades inferiores fuera del agua, la línea del pubis/línea glútea quede en la superficie del agua o por encima.
	ALTO NIVEL DE INMERSIÓN	Posición superior. Todo lo que no es bajo superior y tiene una inmersión parcial. Posición inferior. Todo lo que no es bajo inferior y tiene una inmersión parcial. Posición horizontal. Todo lo que no es bajo horizontal y tiene una inmersión parcial.
	100% DE INMERSIÓN	Todo el cuerpo está dentro del agua.

Instrumento de registro

LINCE


src 17:22:28:12
X = 161.5
min=79
CF-SUP-ALTO

	Solo Técnico		Solo Libre	
	Campeonato España (n = 9)	Campeonato Mundo (n = 10)	Campeonato España (n = 11)	Campeonato Mundo (n = 12)
Puntuación (puntos)	83,6 ± 7,2& #	91,1 ± 3,9*	82,8 ± 7,5* ¶	90,9 ± 4,1&
Rutina (s)	124,6 ± 8,4&	130,5 ± 3,0 ¶	178,0 ± 6,5* ¶	184,4 ± 5,7# &
Fase playa (%)	2,8 ± 1,0	2,9 ± 1,3	2,8 ± 0,9	2,4 ± 0,5
Fase aérea (%)	0,2 ± 0,0& #	0,3 ± 0,1 ¶ *	0,2 ± 0,0* ¶	0,2 ± 0,0# &
Fase acuática (%)	24,1 ± 5,0&	24,3 ± 5,3 ¶	29,5 ± 4,9*	31,6 ± 4,9#
Fase subacuática (%)	72,9 ± 4,3&	72,4 ± 5,9 ¶	67,5 ± 4,8*	65,7 ± 4,8#
Cara dentro (s)	85,1 ± 7,6&	89,8 ± 7,0 ¶	111,1 ± 10,1*	110,8 ± 9,0#
Cara dentro (%)	68,3 ± 4,7&	68,8 ± 5,8 ¶	62,3 ± 4,4*	60,1 ± 5,1#
Tiempo máximo cara dentro (s)	20,7 ± 4,2	19,0 ± 2,9	23,4 ± 3,3	22,3 ± 4,5
Elementos cara dentro> 10'' (n)	2,9 ± 0,6	3,6 ± 0,8	3,9 ± 0,9	4,1 ± 1,0
Elementos cara dentro > 10'' (s)	47,5 ± 10,6	54,2 ± 9,9	62,3 ± 15,7	65,2 ± 14,2

Valores son media ± SD

* = Diferencias con solo técnico en campeonato de España; & = diferencias con solo libre en campeonato de España;
\# = diferencias con solo técnico en campeonato del Mundo; ¶ = diferencias con solo libre en campeonato del Mundo (P<0,05)

Análisis estructural

FASE DE RUTINA	Solo Técnico (n = 9)	Solo Libre (n = 11)	Dúo Técnico (n = 10)	Dúo Libre (n = 9)
Puntuación (puntos)	83.6 ± 7.2	82.8 ± 7.5	83.8 ± 6.3	78.6 ± 3.2
Rutina (s)	124.6 ± 8.4 &#¶	178.0 ± 6.5 *#¶	148.6 ± 6.2 *&¶	207.7 ± 9.6 *&#
Fase playa (%)	2.8 ± 1.0	2.8 ± .9	2.4 ± 1.1	2.1 ± .6
Fase aérea (%)	.2 ± .0 &¶	.2 ± .0 *#	.2 ± .1 &	.1 ± .0 *
Fase acuática (%)	24.1 ± 5.0 &#¶	29.5 ± 4.9 *	34.3 ± 5.2 *	34.1 ± 5.4 *
Fase subacuática (%)	72.9 ± 4.3 &#¶	67.5 ± 4.8 *	63.0 ± 4.9 *	63.6 ± 5.3 *
Cara dentro (s)	85.1 ± 7.6 &¶	111.1 ± 10.1 *#	85.0 ± 8.6 &¶	121.4 ± 8.2 *#
Cara dentro (%)	68.3 ± 4.7 &#¶	62.3 ± 4.4 *	57.2 ± 5.9 *	58.6 ± 5.0 *
Tiempo máximo cara dentro (s)	20.7 ± 4.2	23.4 ± 3.3 #	18.8 ± 3.6 &	21.4 ± 4.1
Elementos cara dentro > 10" (*n*)	2.9 ± .6 ¶	3.9 ± .9	3.8 ± .8	5.2 ± 1.3 *
Elementos cara dentro > 10" (s)	47.5 ± 10.6 ¶	62.3 ± 15.7	53.5 ± 8.0	77.2 ± 18.8 *

Valores: media ± SD

* = Diferencias con Solo Técnico; & = diferencias con Solo Libre; # = diferencias con Dúo Técnico; ¶ = diferencias Dúo Libre (P<.05)

OBJETIVO 3

Valoración del estado nutricional de las nadadoras

Caracterizar las relaciones entre el gasto energético y la adopción de unos hábitos y estilos de vida saludables en deportistas de natación sincronizada

INEFC

BODY COMPOSITION AND NUTRITIONAL STATUS IN ELITE SYNCHRONIZED SWIMMERS

Carrasco M.1,2,3, Irurtia A.2, Rodríguez-Zamora L.2, Iglesias X.2, Brotons D.3, Vidal E.1, Rodríguez, F.A.2

1: FCS Blanquerna, Universitat Ramon Llull (Barcelona, Spain); 2: GRCE, INEFC, Universitat de Barcelona (Barcelona, Spain); 3: SGE, Área de Medicina de L'Esport (Esplugues de Llobregat, Spain).

Universitat de Barcelona

Introduction and aim

Information about the nutritional status and dietary practices and requirements of synchronized swimming (SS) athletes is very scarce (Lundy, 2011).

The body composition and somatic profile of current top young elite SS athletes need to be updated (Bante et al., 2007).

This study examines the body composition and nutritional status of young elite synchronized swimmers aiming to ascertain whether there are risks associated to their health and performance.

Materials and methods

15 swimmers of the junior Spanish national team (15,8±1,0 y; 54,9±4,3 kg; 168,4±5.0 cm; BMI 19,4±2,0 kg/m2) completed anthropometric assessment (ISAK), seven-day food intake record, and haematology and blood biochemistry analysis during a pre-competition period.

Food intake was quantified using PCN-GRAMS 1.1 CESNID® software and compared with the European Food Safety Authority (EFSA) recommendations to assess nutritional status.

Energy requirements were estimated using the Harris-Benedict formula and Ainsworth's compendium of physical activities.

Results

Anthropometry (mean±SD): Σ6 skinfolds 70,6±10,5 mm; body fat mass 17,7±2,1%; skeletal muscle mass 43,1±2,2%; somatotype 2,8±0,5 / 3,5±0.9 / 3,7±1,1 for endo-, meso- and ectomorph components, respectively.

Nutrition: energy intake 2184±406 kcal/d; CHO consumed 4,6±1,1 g/kg; protein consumed 2,1±0,4 g/kg; energy intake from fat 32,8±5,3%.

Haematology and biochemistry: haematocrit 37,±1,8%; haemoglobin 12,4±0,5 g/dl; transferrin 261±36 mg/dl; ferritin 24,7±16,4 ng/ml.

Estimated energy requirements were 2871±358 kcal/d (12,02±1,5 MJ/d). All the swimmers were not in intake/expenditure energy balance. A high percentage of swimmers failed to meet macro- (CHO: 85,7%; Protein: 64,3%; Fat: 78,6%) and/or micronutrient (Fe, Mg: 92,9%; Zn: 100,0%) recommendations for the general population of their age.

Discussion and conclusions

SS is characterized by high and complex physiological demands (Rodríguez-Zamora et al., 2012).

Young synchronized swimmers must be properly conditioned and properly nourished to perform optimally and to meet developmental requirements. A high proportion of the young elite swimmers studied were not in energy balance and/or failed to meet macro- and/or micronutrient recommendations, which may negatively impact performance and physiological development.

More research is needed to understand the unique nutrition needs of this population and to propose general guidelines or recommendations for this high-risk athletic population.

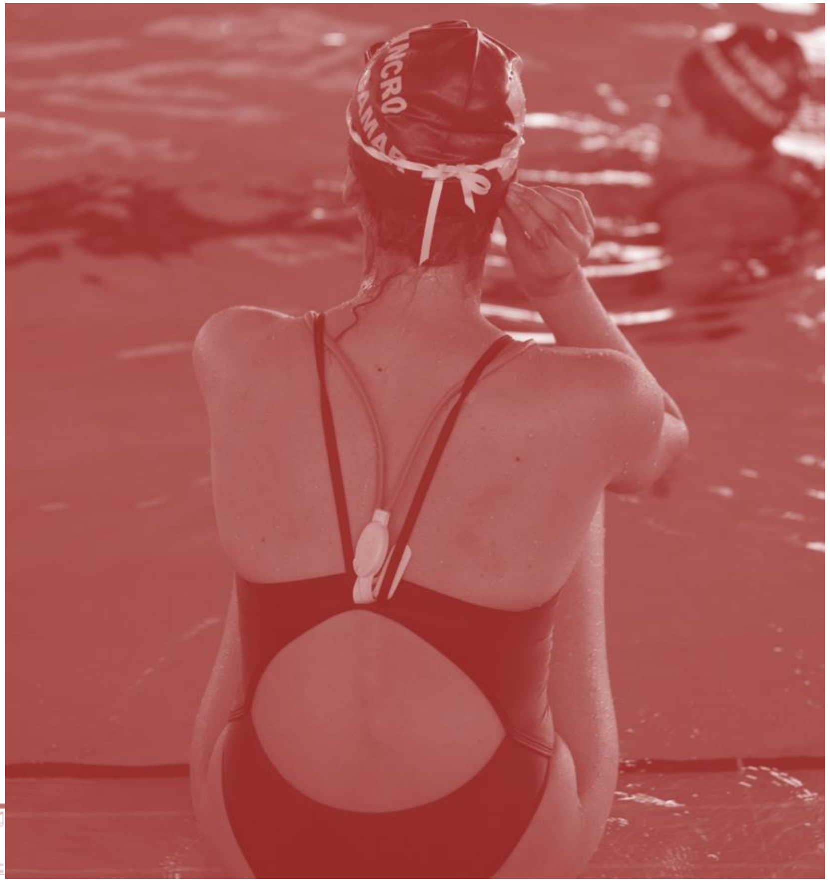
Sport Sciences Research Group INEFC Barcelona

SYNCHRO

Bante S, Bogdanis GC, Chairopoulou C, Maridaki M (2007). ... Phys Fitness 47, 291-299.
Lundy B (2011). Int J Sport Nutr Exerc Metab 21, 436-445.
Rodríguez-Zamora L, Iglesias X, Barrero A, Chaverri D, Erola P, Rodríguez, FA. (2012). PLoS One 7(11), e49098.

ECSS 26-29 JUNE 2013 INEFC BARCELONA

Author's e-mail: MartaCM8@blanquerna.url.edu



Bioelectrical impedance vector analysis (BIVA) for monitoring hydration status in young competitive synchronized swimmers

INEFC
Escola Catalana de Cineantropometria
Generalitat de Catalunya

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Introduction

A synchronized swimming (SS) training session typically includes specific drills, choreographies, and physical conditioning exercises, imposing complex physiological demands[1]. Training volume and intensity differs depending on the age and competitive level of the swimmers. Bioelectrical impedance vector analysis (BIVA) is a non-invasive and safe technique for assessing hydration and body composition changes[2].

Aim

This study applied BIVA to the assessment of hydration changes evoked by SS during a typical training session in swimmers of different age and competitive level.

Methods and Procedures

59 swimmers were divided into 1) pre-juniors (pre-JR) and juniors (JR) (Table 1). Height and body mass (BM) were assessed following the norms and procedures of the ISAK. BIVA was conducted PRE and POST a typical training session as shown in Figure 1. A multi-frequency wrist-to-ankle BIA meter device (Z-Metrix®, Bioparhom, France) was used and 50 kHz whole-body BIA vectors were analysed by the resistance (R) – reactance (Xc) graphic method, and Z mean values plotted[3] (Figure 2).

Statistical analysis

Pre-post differences were tested by paired t-test (Table 1). Hotelling's T^2 test determined differences in the complex localized vector through the 95% confidence and tolerance intervals (Figure 2).

Results

Compared to the reference population[4], significant differences were found in whole-body BIA vector in both pre-JR (T^2=25.6, p=0.003) and JR (T^2=25.8, p=0.001). Changes were observed between PRE and POST in BM (pre-JR: 47.0±7.2 kg vs. 46.7±7.3 kg, P<0.001; JR: 53.7±4.9 kg vs. 53.4±4.9 kg, P<0.001), R (pre-JR: 530±46 Ω vs. 548±45 Ω, P<0.001; JR: 503±33 Ω vs. 524 ±45 Ω, P=0.004), and Xc (pre-JR: 64.4±5.4 Ω vs. 66.6±4.8 Ω, P=0.002; JR: 66.0±2.9 Ω vs. 70.3±4.3 Ω, P<0.001). BIVA showed significant vector migration from PRE to POST (T^2=8.99; p<0.05) in JR, whereas no changes were noted (T^2=1.92; P>0.05) in pre-JR (Fig. 2).

Table 1. Characteristics of participants.

	Pre-junior (n=44)	Junior (n=15)	t-test (*t*)	*p*-value (*p*)
General				
Age (years)	13.9 ± 0.9	16.7 ± 0.9	-10.851	0.0001*
TV (h·week⁻¹)	15.6 ± 3.1	30.0 ± 3.8	-15.911	0.0001*
SSP (years)	6.0 ± 2.1	9.1 ± 1.0	-9.980	0.0001*
Anthropometric				
Height (cm)	161.9 ± 8.2	166.3 ± 4.8	-1.943	0.058
Body mass (kg)	47.2 ± 7.2	53.7 ± 4.9	-3.103	0.003*
Bioelectrical				
R (Ω)	530.0 ± 46.0	503.0 ± 33.0	3.286	0.002*
Xc (Ω)	64.4 ± 5.4	66.0 ± 2.9	0.395	0.695

Values are mean ± standard deviation; TV, training volume; SSP, synchronized swimming practice; R, resistance; Xc, reactance; * significant differences between Pre-junior and Junior swimmers (unpaired t-test, p<0.05).

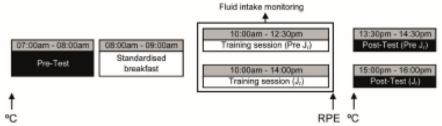

Figure 1. Study protocol. ºC, body and skin temperatures; RPE, rating of perceived exertion; Pre Jr: pre-junior; Jr: junior.

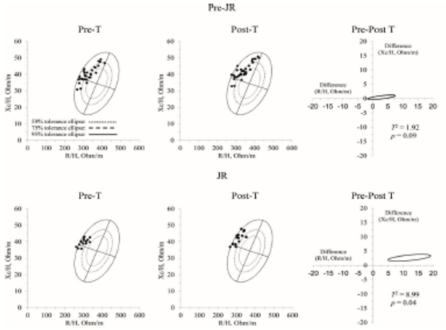

Figure 2. On the left side, scattergram of the 44 Pre-JR and 15 JR individual impedance vectors, plotted on the 50%, 75%, and 95% tolerance ellipses of the corresponding healthy female reference population[4]. Hotelling's T^2 test significance at p < 0.05.

Discussion & Conclusions

Both JR and pre-JR swimmers showed a migration of the BIA vector characterized by an increase in length (R) and height (Xc), likely as a result of moderate dehydration. Regardless of age and competitive level, a typical SS training session affects the homeostatic hydration level of the swimmers. BIVA analysis appears to be sensitive enough to detect these changes (mean diff.: 0.5–0.8 %BM).

References

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World Conference on Kinanthropometry and Body Composition

Changes in the whole-body bioelectrical impedance vector induced by training in young elite synchronized swimmers: preliminary results

Carrasco M.1,2,3, Irurtia A.2, Rodríguez-Zamora L.2, Iglesias X.2, Brotons D.3, Vidal E.1, Rodríguez, F.A.2

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Introduction and aim

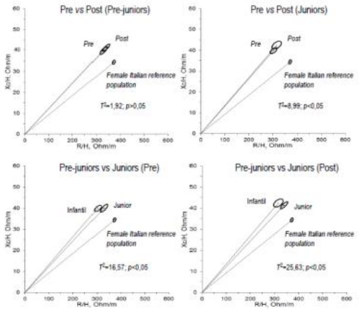
Synchronized swimming (SS) requires high-volume and high-intensity training that is assumed by young swimmers from an early age. A typical training session may include specific drills, choreography, and physical conditioning exercises, imposing complex physiological demands (Rodríguez-Zamora et al., 2012). Bioelectrical impedance vector analysis (BIVA) is a non-invasive and safe technique for assessing hydration and body composition changes (Lukaski & Piccoli, 2012). This study applied BIVA to the assessment of hydration changes evoked by training sessions in swimmers of different age and competitive level.

Materials and methods

59 swimmers were divided into 1) pre-juniors (pre-JR): mean age 13.9 (SD 0.9) y, body mass (BM) 47.0 (7.2) kg, height 161.8 (8.2) cm, fat mass 15.1 (4.8 %BM, muscle mass 37.6 (5.0 %BM); and 2) juniors (JR): 16.7 (0.9) y, BM 53.7 (4.9) kg, height 165.8 (5.2) cm, fat mass 18.6 (2.6 %BM), muscle mass 38.8 (3.7 %BM). Anthropometric assessment (ISAK) and BIVA analysis were conducted PRE and POST a typical training session (p-JR 2.5 (0.1) h, JR 4.0 (0.2) h). A multi-frequency wrist-to-ankle BIA meter device (Z-Metrix®, BioparHom Co, France) was used and 50 kHz whole-body BIA vectors were analyzed by the resistance-reactance (R/Xc) graphic method, and Z mean values plotted (Piccoli et al., 1994). Hotelling's T2 test determined differences in the complex localized vector through the 95% confidence and tolerance intervals.

Results

Changes (p<0.005) were observed between PRE and POST in BM (pre-JR: 47.0 (7.2) kg vs. 46.7 (7.3) kg; JR: 53.7 (4.9) kg vs. 53.4 (4.9) kg), R (pre-JR: 530 (46) Ω vs. 548 (45) Ω; JR: 503 (33) Ω vs. 524 (45) Ω), and Xc (pre-JR: 64.4 (5.4) Ω vs. 66.6 (4.8) Ω; JR: 66.0 (2.9) Ω vs. 70.3 (4.3) Ω). BIVA showed vector migration from PRE to POST (T^2=8.99; p<0.05) in JR, whereas no changes were found in pre-JR (T^2=1.92; p>0.05).



Discussion and conclusions

Junior swimmers showed a migration of the BIA vector characterized by an increase in length (R) and a decrease in the dielectric mass of soft tissues (Xc), likely as a result of moderate dehydration.

In turn, pre-JR showed the maintenance of a good hydration status without significant bioelectrical changes.

These preliminary results should be considered by coaches, nutritionists and physicians in order to ensure adequate fluid intake during training in these young athletes.

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Body composition and nutritional status in elite synchronized swimmers

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Introduction and aim

Information about the nutritional status and dietary practices and requirements of synchronized swimming (SS) athletes is very scarce (Lundy, 2011).

The body composition and somatic profile of current top young elite SS athletes need to be updated (Bante et al., 2007).

This study examines the body composition and nutritional status of young elite synchronized swimmers aiming to ascertain whether there are risks associated to their health and performance.

Materials and methods

15 swimmers of the junior Spanish national team (15,8±1,0 y; 54,9±4,3 kg; 168,4±5.0 cm; BMI 19,4±2,0 kg/m2) completed anthropometric assessment (ISAK), seven-day food intake record, and haematology and blood biochemistry analysis during a pre-competition period.

Food intake was quantified using PCN-GRAMS 1.1 CESNID® software and compared with the European Food Safety Authority (EFSA) recommendations to assess nutritional status.

Energy requirements were estimated using the Harris-Benedict formula and Ainsworth's compendium of physical activities.

Results

Anthropometry (mean±SD): Σ6 skinfolds 70,6±10,5 mm; body fat mass 17,7±2,1%; skeletal muscle mass 43,1±2,2%; somatotype 2,8±0,5 / 3,5±0.9 / 3,7±1,1 for endo-, meso- and ectomorph components, respectively.

Nutrition: energy intake 2184±406 kcal/d; CHO consumed 4,6±1,1 g/kg; protein consumed 2,1±0,4 g/kg; energy intake from fat 32,8±5,3%.

Haematology and biochemistry: haematocrit 37,±1,8%; haemoglobin 12,4±0,5 g/dl; transferrin 261±36 mg/dl; ferritin 24,7±16,4 ng/ml.

Estimated energy requirements were 2871±358 kcal/d (12,02±1,5 MJ/d). All the swimmers were not in intake/expenditure energy balance. A high percentage of swimmers failed to meet macro- (CHO: 85,7%; Protein: 64,3%; Fat: 78,6%) and/or micronutrient (Fe, Mg: 92,9%; Zn: 100,0%) recommendations for the general population of their age.

Discussion and conclusions

SS is characterized by high and complex physiological demands (Rodríguez-Zamora et al., 2012).

Young synchronized swimmers must be properly conditioned and properly nourished to perform optimally and to meet developmental requirements. A high proportion of the young elite swimmers studied were not in energy balance and/or failed to meet macro- and/or micronutrient recommendations, which may negatively impact performance and physiological development.

More research is needed to understand the unique nutrition needs of this population and to propose general guidelines or recommendations for this high-risk athletic population.

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- **Desequilibrio energético y deficiencias nutricionales:** Las nadadoras de sincro jóvenes de élite suelen presentar un desequilibrio entre ingesta y gasto energético, y deficiencias en macronutrientes y micronutrientes, lo que podría afectar su rendimiento y salud.

- **Impacto del entrenamiento en la hidratación:** Las sesiones de entrenamiento generan deshidratación moderada, especialmente en categorías junior. El uso de herramientas como BIVA es efectivo para monitorear estos cambios.

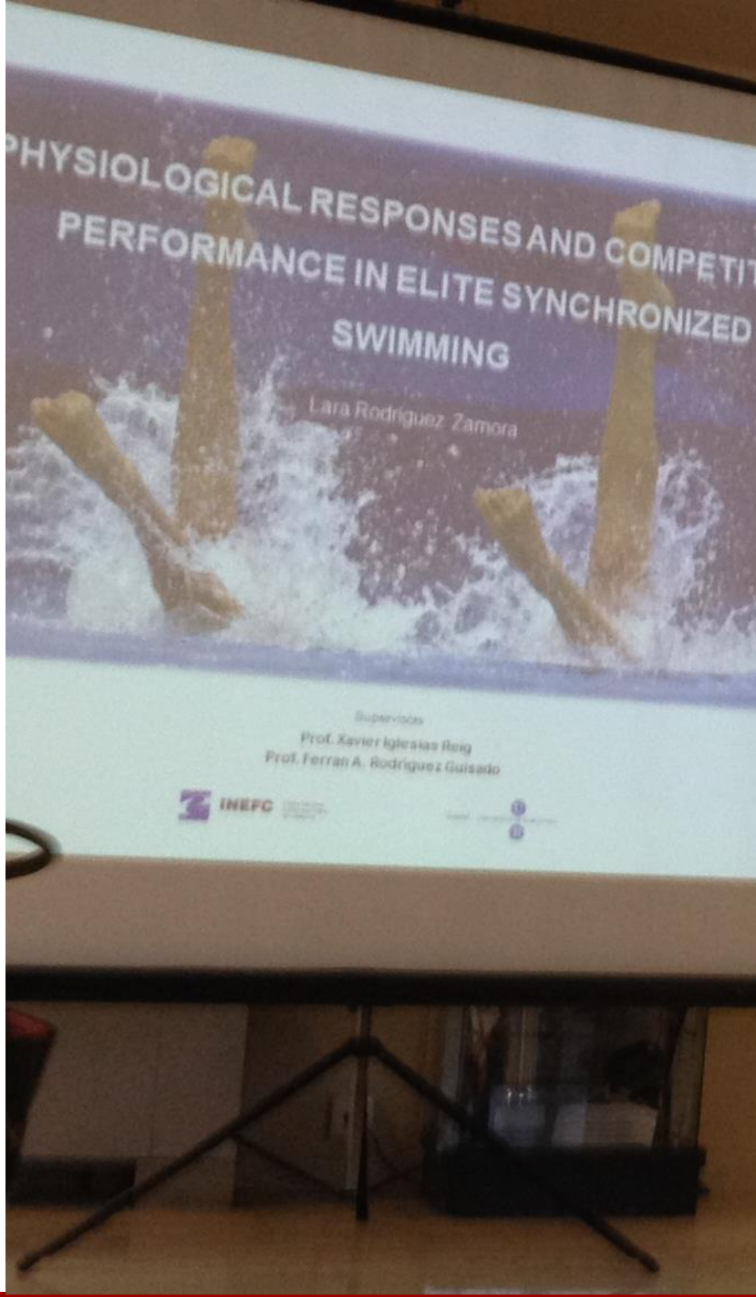
- **Importancia del control:** La combinación del análisis de impedancia bioeléctrica, el balance nutricional y la periodización adecuada del entrenamiento permite optimizar el rendimiento deportivo, minimizar riesgos de salud en nadadoras de natación sincronizada

1. Análisis de las potencialidades y las posibilidades

2. CREACIÓN de un proyecto de investigación

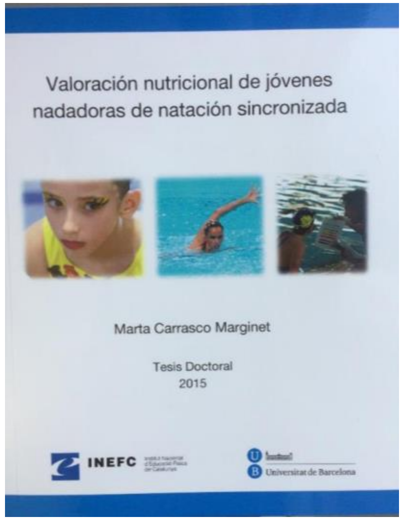
3. EJECUCIÓN del Proyecto

4. TRANSFERENCIA i DIFUSIÓN: Proceso productivo



4. TRANSFERENCIA i DIFUSIÓN: Proceso productivo

2 Tesis doctorales



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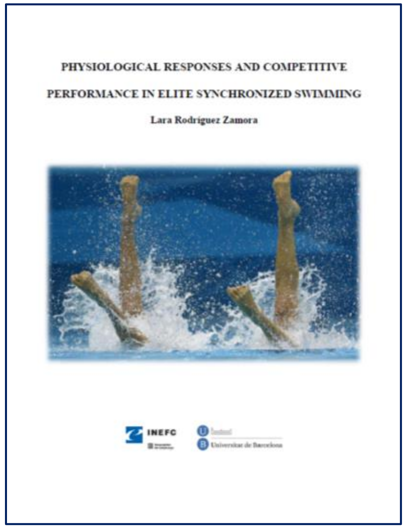

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