ISSN: 0212-8799

198
Volume 37(4)
July - August 2020

Archivos de medicina del deporte

Órgano de expresión de la Sociedad Española de Medicina del Deporte

ORIGINAL ARTICLES

REVIEWS

ARCHIVOS DE MEDICINA DEL DEPORTE

UCAM
Universidad Católica San Antonio

Sociedad Española de Medicina del Deporte

AEPSAD
Agencia Española de Protección de la Salud en el Deporte

CSD
Consejo Superior de Deportes


BIOAltitude
Especialistas en Hipoxia-Altitud Simulada
Generadores, Tiendas, Accesorios (Pulsioxímetros, Analizadores de Oxígeno, Máscaras de Ejercicio,...).
Todo lo que necesitas
para tu entrenamiento
en altura/hipoxia en
shop.biolaster.com
BIOAltitude by BIOLaster Bag
BioLaster
Altitude
Sigue nuestro Blog de Hipoxia:
BIOLaster
www.biolaster.com
T. 943 300 813
M. 639 619 494

Sociedad Española de Medicina del Deporte

Sociedad Española de Medicina del Deporte

Junta de Gobierno
Presidente:
Pedro Manonelles Marqueta
Vicepresidente:
Carlos de Teresa Galván
Secretario General:
Luis Franco Bonafonte
Tesorero:
Javier Pérez Ansón
Vocales:
Miguel E. Del Valle Soto
José Fernando Jiménez Díaz
Juan N. García-Nieto Portabella
Teresa Gaztañaga Aurrekoetxea
José Naranjo Orellana

Edita
Sociedad Española de Medicina del Deporte
C/ Cánovas nº 7, local
50004 Zaragoza (España)
Tel. +34 976 02 45 09
femede@femede.es
www.femede.es

Correspondencia:
C/ Cánovas nº 7, local
50004 Zaragoza (España)
archmeddeporte@semede.es
http://www.archivosdemedicinadeldeporte.com/

Publicidad
ESMON PUBLICIDAD
Tel. 93 2159034

Publicación bimestral
Un volumen por año

Depósito Legal
Zaragoza. Z 988-2020

ISSN
0212-8799

Soporte válido
Ref. SVR 389

Indexada en: EMBASE/Excerpta Medica, Índice Médico Español, Sport Information Resource Centre (SIRC), Índice Bibliográfico Español de Ciencias de la Salud (IBECS), Índice SJR (SCImago Journal Rank), y SCOPUS

La Revista Archivos de Medicina del Deporte ha obtenido el Sello de Calidad en la V Convocatoria de evaluación de la calidad editorial y científica de las revistas científicas españolas, de la Fundación Española para la Ciencia y la Tecnología (FECYT).

Archivos de medicina del deporte

Revista de la Sociedad Española de Medicina del Deporte

Afiliada a la Federación Internacional de Medicina del Deporte, Sociedad Europea de Medicina del Deporte y Grupo Latino y Mediterráneo de Medicina del Deporte

Director
Pedro Manonelles Marqueta

Editor
Miguel E. Del Valle Soto

Administración
Melissa Artajona Pérez

Adjunto a dirección
Oriol Abellán Aynés

Comité Editorial

Archivos
de medicina del deporte

Volumen 37(4) - Núm 198. July - August 2020 / *Julio - Agosto 2020*

Summary / Sumario

Quantification of training load - a basic element of sports performance in the 21st century

La cuantificación de la carga de entrenamiento – elemento básico del rendimiento deportivo en el siglo XXI

Roberto Cejuela Anta

Área Educación Física y del Deporte. Departamento Didáctica General y Didácticas Específicas. Universidad de Alicante.

Monitoring the training load is a hot topic in sports science. Scientists and trainers alike are monitoring training loads on a daily basis, using different multidisciplinary approaches. This search for the best methodologies to collect and interpret the data has led to an exponential increase in applied empirical research.

The training load or stimulus involves the combination of the exercise mode and the volume, intensity and density or frequency level. The relationship between the training load, the state of stress (physical, physiological) caused by the load and recovery, is essential in order to bring about positive adaptations that improve sports performance and prevent over-training. A number of models have been proposed to quantify the load components (volume, intensity, density and frequency). These measure the internal and external load and are primarily differentiated by the indicators to measure or estimate effort intensity.

Internal load

Internal load has been defined as the biological stress (physical, physiological and psychological) imposed on the athlete in relation to the training volume (time). There are a number of indicators to measure this internal load:

- Oxygen consumption (metabolic equivalents)
- Heart rate indicators (training zones, HR variability)
- Concentration of blood lactate
- RPE (rating of perceived exertion) scale
- Biomarker concentration or volume (urea, CK, haemoglobin, ferritin, cortisol, testosterone, oestrogen and progesterone in women, etc.).
- Socio-psychological tests (POMS, Rest-Q-Sport)

External load

The external load is the objective measure of an athlete's performance during training sessions or competitions and it is assessed independently of the internal training load. The main metrics to determine it are:

- Speed and/or acceleration of movement during exercise (m/s, Km/h, m/s2)
- Power produced in the movement: absolute watts (W) or power-to-weight ratio (W/Kg)
- Distance travelled (metres, kilometres)
- Exercise time (seconds, minutes, hours)
- Performance statistics: success or failure during decisive performance actions in each sport (goals, points, hits, passes, stops, blocks, spikes, etc.)

Towards optimal and sport-specific load quantification models

The combination of the internal load and the external load in different models gives greater information on the stress on athletes caused by training. For example, the same external load monotonously repeated in training sessions can cause different reactions in the internal load indicators, involving different stress and fatigue levels.

For this reason, it would be more appropriate to use the model that is best suited to the characteristics of the athletes and sport to be quantified. Over the last few years, a number of models have been proposed in the literature.

Correspondence: Roberto Cejuela Anta
E-mail: roberto.cejuela@ua.es

Team sports

Historically, the external load is the most-used measure to quantify the training load in team sports, where high-intensity effort is combined with short recoveries throughout the game. GPS, accelerometers and motion analysis systems are used to calculate speeds, accelerations and actions performed by the players when training and competing. It has been more difficult to relate these values to the internal load involved in performing the movement. The heart rate has been the most-used indicator of the intensity of exercise recovery in players. Nowadays, data analysis software programmes are essential to quantify the actions performed and their performance intensity. It is extremely important that the analyst filters the information, the most significant actions for the success of the game, which provides the "big data" for fitness coaches and the trainers of each player. This information, together with the internal load indicator of fatigue (heart rate, RPE, biomarkers, socio-psychological test), will be necessary in order to quantify the training load. There is no single model for all sports, due to the wide variety of rules and the diversity of performance factors that are specific to each team sport in order to achieve success.

Aerobic endurance sports or training sessions

The aerobic internal load in relation to the external load, has been extensively studied and measured for endurance sports. This is why there are a number of load quantification models that relate both loads, such as Foster's load index, TRIMP or ECOs

– The load index relates the training time (without considering the pause) of each session to the RPE of each athlete.
– The Training Impulses (TRIMP) relate the training time (without considering the pause) of each session to the effort zone, measured by the heart rate of each athlete.
– The Training Stress Score (TSS) relates the training time (without considering the pause) of each session to the individual effort zone, measured in the external mechanical power generated by the athlete in the training session.
– The Objective Load Equivalents (ECOs) relate the training time (considering density, exercise time/rest time) to the individual effort zone of each athlete (measured in the most suitable unit for each zone, including anaerobic and strength) and the different exercise mode in each sport (running, swimming, pedalling, etc.).

All the models offer the possibility of establishing a relationship between the intended form and the fatigue produced based on recovery time. However, the difference lies in the intensity indicators used by each model. Therefore, the key factor is to use the most appropriate model for each sport with regard to the effort intensity / recovery indicators and the exercise mode, given that the energy expenditure during training is different at the same intensity and for the same time. The method of reference would be to measure the oxygen consumption - energy expenditure at each training session. However this is not very practical at present and remains to be seen in the future.

Strength and power sports or training

Lactic and alactic anaerobic capacity and power are metabolic efforts that cannot be measured internally. For this reason, they are quantified externally as intensity indicators by power and speed of performance of the movements. Accelerometers, linear position transducers, photoelectric cells, inertial sensors or video analysis are used to either estimate or measure the speed or power of performance. The volume in the strength exercises (squat, bench press, etc.) is quantified in numbers of sets and repetitions of exercises with a recovery time between them. While, for sports action, volume is quantified in time of effort (it is very important to take density into account) and, for lactic efforts, the blood lactate value can also be used as an internal effort indicator.

Conclusion

In the 21st century, the training load is a fundamental and valid element that serves to plan training and to calculate the expected state of fitness for the target competitions of each athlete. Different specific models are available for use in each sport in order to optimise performance.

It is an ideal indicator to be used to lessen the risk of injury and overtraining. An individual, intra-subject and longitudinal analysis should be made of the training load over time in order to make it possible to compare the training process against improved performance.

Bibliography

1. Bourdon PC, Cardinale M, Murray A, Gastin P, Kellmann M, Varley MC, Gabbett TJ, Coutts AJ, Burgess DJ, Gregson W, Cable NT. Monitoring athlete training loads: consensus statement. *International Journal of Sports Physiology and Performance.* 2017;12:S2-161-S2-170.
2. Borresen J, Lambert M. The quantification of training load, the training response and the effect on performance. *Sports Medicine*. 2009;39:779–95.
3. Cardona CA, Cejuela R, Esteve-Lanao. *Manual para entrenar deportes de resistencia.* All in your mind. Mérida (México).2019.
4. Cejuela, R, Esteve-Lanao J. Training load quantification in triathlon. En: Migliorini S. (eds) *Triathlon Medicine.* Springer, Cham. 2020.

Analizador Instantáneo de Lactato

Lactate Pro 2

arkray

LT-1730

- Sólo 0,3 µl de sangre
- Determinación en 15 segundos
- Más pequeño que su antecesor
- Calibración automática
- Memoria para 330 determinaciones
- Conexión a PC
- Rango de lectura: 0,5-25,0 mmol/litro
- Conservación de tiras reactivas a temperatura ambiente y
- Caducidad superior a un año

Importador para España:

francisco j. bermell
ELECTROMEDICINA
www.bermellelectromedicina.com
EQUIPOS PARA EL DEPORTE Y LA MEDICINA DEL DEPORTE

c/ Lto. Gabriel Miro, 54, ptas. 7 y 9
46008 Valencia Tel: 963857395
Móvil: 608848455 Fax: 963840104
info@bermellelectromedicina.com
www.bermellelectromedicina.com

---

femede

Monografías Femede nº 12
Depósito Legal: B. 27334-2013
ISBN: 978-84-941761-1-1
Barcelona, 2013
560 páginas.

Índice

Dep. Legal: B.24072-2013
ISBN: 978-84-941074-7-4
Barcelona, 2013
75 páginas. Color

Índice

Información: www.femede.es

Effect of acute supplementation with sodium bicarbonate on the performance of professional military pentathletes in the obstacle course

Sergio Andrés Galdames Maliqueo[1,3], Álvaro Cristian Huerta Ojeda[2,3,5*], Andrea Verónica Pastene Rivas[4]

[1]Facultad de Ciencias de la Actividad Física y del Deporte. Universidad de Playa Ancha de Ciencias de la Educación, Valparaíso, Chile. [2]Facultad de Educación. Universidad de Las Américas sede Viña del Mar, Chile. [3]Grupo de Investigación en Salud, Actividad Física y Deporte ISAFYD. Escuela de Educación Física. Universidad de Las Américas sede Viña del Mar, Chile. [4]Instituto Profesional y Centro de Formación Técnica, Universidad Santo Tomás, Viña del Mar. [5]Centro de Capacitación e Investigación Deportiva Alpha Sports. Valparaíso, Chile.

Received: 12/07/2019
Accepted: 05/12/2019

Summary

Introduction: Sodium bicarbonate (SB) supplementation has been widely used to delay fatigue in high intensity sports. However, there is no evidence on acute supplementation with SB in the obstacle run in Military Pentathlon.
Objective: To determine the effect of acute supplementation with SB on performance on the obstacle run in military pentathletes.
Material and method: Ten professional military pentathletes were part of the study. The design was double blind, cross-over intra-subject, while supplementation was 0.3 g•Kg^{-1} SB diluted in 500 mL of distilled water or 0.045 mg•Kg^{-1} of sodium chloride diluted in 500 mL of distilled water (PL), both solutions ingested 60 minutes before performing the obstacle run. The variables were: execution time (s) and lactate concentration ([La]) in minutes 1, 3, 5, 7 and 9. The statistical analysis was performed through a Student's t test for independent samples, while the effect size (ES) was calculated with the Cohen d test.
Results: The time in the obstacle run showed a significant decrease after the SB supplementation ($p < 0.01$, ES = 0.48, Δ = 3.7%), while the [La] showed significant differences between both groups in the 5, 7, and 9 minutes ($p < 0.05$).
Conclusions: At the end of the study, it was found that acute supplementation with SB increased performance in the obstacle run. Therefore, acute SB ingestion could be considered as an ergogenic aid by military pentathletes.

Key words:
Sodium bicarbonate. High intensity. Physical performance. Military personnel.

Efecto de la suplementación aguda con bicarbonato sódico sobre el rendimiento en la cancha con obstáculos en pentatletas militares profesionales

Resumen

Introducción: La suplementación con bicarbonato sódico (BS) ha sido ampliamente utilizada para retrasar la fatiga en deportes de alta intensidad. Sin embargo, no existe evidencia sobre la suplementación aguda con BS en la prueba de cancha con obstáculos del Pentatlón Militar.
Objetivo: Determinar el efecto de la suplementación aguda con BS sobre el rendimiento en la cancha con obstáculos en pentatletas militares.
Material y método: Diez pentatletas militares profesionales fueron parte del estudio. El diseño fue de doble ciego, cruzado intrasujeto, mientras que la suplementación fue de 0,3 g•Kg^{-1} de BS diluida en 500 mL de agua destilada o 0,045 mg•Kg^{-1} de cloruro de sodio diluido en 500 mL de agua destilada (PL), ambas soluciones fueron ingeridas 60 minutos antes de realizar la prueba de cancha con obstáculos. Las variables fueron: tiempo de ejecución (s) y concentración de lactato ([La]) en los minutos 1, 3, 5, 7 y 9. El análisis estadístico fue realizado a través de una t de Student para muestras independientes, mientras que el tamaño del efecto (ES) fue calculado con la prueba d de Cohen.
Resultados: El tiempo en la cancha con obstáculos evidenció un descenso significativo luego de la suplementación con BS ($p < 0,01$; ES = 0,48; Δ = 3,7%), mientras que las [La] mostraron diferencias significativas entre ambos grupos en los minutos 5, 7 y 9 ($p < 0,05$).
Conclusiones: Al término del estudio, se comprobó que la suplementación aguda con BS aumentó el rendimiento en la prueba de cancha con obstáculos. Por lo tanto, la ingesta aguda con BS podría ser considerada como una ayuda ergogénica por los pentatletas militares.

Palabras clave:
Bicarbonato sódico. Alta intensidad. Rendimiento físico. Personal militar.

Correspondence: Álvaro Cristian Huerta Ojeda
E-mail: achuertao@yahoo.es

Introduction

The Military Pentathlon is the most important sports discipline for the military[1], with a history dating back to 1947. Over the years, it has developed into the most important sports event of the International Military Sports Council (CISM)[2]. The Military Pentathlon is divided into the following contests: shooting with a standard rifle (200 m or 300 m), obstacle run (500 m with 20 obstacles), obstacle swimming (50 m with 5 obstacles), grenade throwing (16 precision throws and 3 maximum power throws) and cross country (8 km)[1]. For the five contests there is a base performance that gives 1000 pentathlon points, with some events associated with a greater score (shooting and grenade throwing). For those athletes performing better than the base, then they will obtain more than 1000 pentathlon points. For obstacle swimming, cross country and the obstacle running course, performance is associated with a lower completion time. Specifically, for the obstacle course, in order to obtain the 1000 pentathlon points, the course must be completed in 2 minutes 40 seconds and, for each second above or below this mark, 7 pentathlon points are either deducted from or added to the 1000 base points, respectively[3].

The obstacle course contest is in the form of a race, in which the athletes are required to complete the course in the shortest possible time, combining their ability to climb, run, jump, crawl and maintain their balance on thin obstacles[4]. Lazar (2011)[4] contends that, during this contest, the heart rate may reach 200 beats per minute with great predominance of the anaerobic metabolism. From a physiological point of view, maximum efforts on the obstacle course, just like tests with glycolytic predominance, accumulate a series of deleterious metabolites (H^+, Pi), which can reduce the force of the active muscles[5]. That is how the accumulation of H^+ may alter the blood pH, disrupting the acid-base balance, the extent of which depends on the intensity and duration of the effort6. As a compensatory measure, the body adjusts its buffers and pulmonary ventilation increases in order to mitigate the pH modifications[7].

It has been postulated that, by exogenously increasing the sodium bicarbonate (SB) levels, it would be possible to reduce the levels of H^+ generated in the anaerobic glucose metabolism, increasing the lactate flow from the active muscles to the extracellular medium[8]. Due to this background information, the intake of SB has been extensively studied for its potential benefits to delay the onset of fatigue in short duration, high-intensity effort[9], proving to be a beneficial buffer in this type of physical stimuli[10]. In the literature, it has been described that the ergogenic effect of SB on exercise is due to the reinforced extracellular bicarbonate buffer capacity to regulate the acid-base balance during exercise[11]. Therefore, the exogenous incorporation of SB would give rise to bicarbonate ions, promoting an alkaline environment in the extracellular fluid compartments[12]. In this way, a review made by Siegler et al. (2016)[11], recommends an SB supplementation between 0.2 to 0.3g•kg^{-1}, although the investigators also concluded that individual supplementation strategies should be sought considering the gastrointestinal discomfort or any physiological change shown by athletes[11].

Some of the studies published to determine the effectiveness of SB supplementation used endurance tests with a short[13], medium[14] and long duration[15] based on foot sports[16], swimming[17], cycling[18] and rowing[19]. In the specific case of military sports, although evidence is available on the use of sports supplements and ergogenic aids in soldiers during a training process[20], the ingestion of creatine[21] and minerals[22], unfortunately this evidence was collected from physically active soldiers and not from military pentathletes. In relation to the studies that relate buffer supplementation and military personnel performance, although there is evidence on the use of beta-alanine[23], due to the little evidence available for the military population, the investigators conclude that the use of beta-alanine as a buffer is not safe for this population.

With regard to SB supplementation in the military population, studies have been reported with an increase in the physical performance of enlisted soldiers through the Wingate power test[24]. However, just like the aforementioned references, this investigation was on enlisted soldiers and not on military pentathletes. In relation to the background information set out above and, to the best of our knowledge, there are no investigations on the ingestion of SB as a buffer supplement in the Military Pentathlon obstacle course contest. Consequently, the main objective of this study was to determine the effect of acute supplementation with SB on the performance of professional military pentathletes in the obstacle course

Material and method

Experimental study of approximation

In this study, the sample comprised 10 professional military pentathletes, equivalent to 100% of the population of professional military pentathletes in the Chilean Navy. It is important to mention that these military pentathletes, as described in the characterisation of this sport, must take part in the five contests forming part of the competition1. As a result of the above, the military pentathletes forming part of the study were solely dedicated to practising this sport. In other words, there was a six-hour daily training time, divided between these five competition events. Furthermore, the inclusion criteria were: male with a minimum experience of three years training for the Military Pentathlon. The exclusion criteria were: the prevalence of musculoskeletal injuries and the inability to perform the obstacle course contest at maximum intensity. For the application of the protocol, a quasi-experimental, cross-over, intra-subject design was used. Each subject performed the obstacle course test twice, 72 hours apart. The supplementation with SB or a placebo (PL) was performed 60 min before each obstacle course test. The administration of SB or PL was based on a double-blind randomised method. Before the start of the study, a measurement was made of the weight, height and skin folds of all subjects. All participants in the investigation were requested to abstain from the intake of caffeine, medicines and any substance that could increase the metabolism during the entire experiment.

Subjects

10 professional military pentathletes took part in the study (age: 25.5 ± 6.0 years; weight: 67.0 ± 2.0 Kg; height: 172.7 ± 3.6 cm; body mass index: 22.5 ± 1.0 kg/m2; fat percentage; 12.0 ± 2.6%. All subjects were informed of the study objective and the possible risks of the experiment, all signed their informed consent before the implementation of the protocol. The informed consent and the study were approved by the Bioethics Committee of the University Playa Ancha de Ciencias de la Educación, Valparaíso, Chile (record number 933).

Instruments

For the characterisation of the sample, the weight and height were measured with the Scales and Stadiometer Health o Meter Professional®. In order to determine the fat percentage, skinfold measurements were taken at the following sites: biceps, triceps, subscapular, supraspinal with an F.A.G.A.® caliper based on the Durnin and Womersley method (1974)[25]. In order to record the obstacle course test time, Chronojump® photocells were used, and chronojump software Version 1.4.6.0®. This measurement considered an open gate and a closed gate and the start and finish of the obstacle course, respectively. The post effort capillary lactate concentration was measured using an h/p/cosmos® lactometer to detect lactate enzymatic amperometric detection with an accuracy of ± 3%.

Standardised warm-up

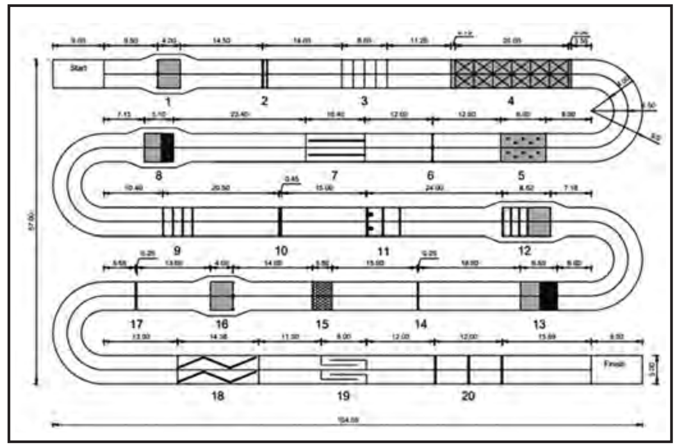
For all evaluations, the standardised warm-up consisted of 10 minutes of joint mobility, performing abduction, adduction movements and rotations of the upper and lower limbs. Subsequently, the pentathletes did a continuous jog for 15 minutes at 130 beats/minute (to record the heart rate, a Polar® model RS300 heart monitor was used), 8 second passive flexibility for each muscle group, heel striking exercises, skipping and three 80-metre accelerations.

Processing

The Military Pentathlon obstacle course contest consists in completing a 500 m circuit with 20 standardised obstacles of varying heights and difficulty levels. It consists in climbing 5 m and 4 m high ladders (obstacles 1 and 17 respectively), crawling through a 20 m long network of wires (obstacle 4), climbing a 3m high sloping wall (obstacle 8), zigzag running along an 8.5 m long balance beam (obstacle 18); only one lane should be used and it is not permitted to move from one lane to the other[3] (Figures 1 and 2).

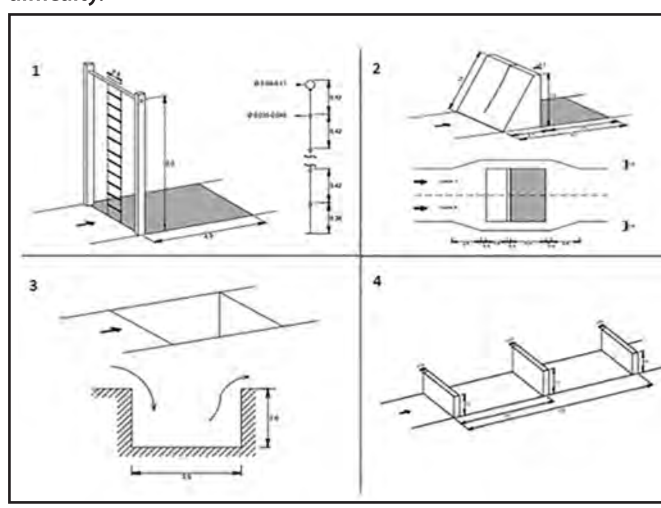
Each pentathlete was measured individually, always following the same order and evaluation time (all evaluations were made in the morning). Each athlete had to perform the obstacle course test with two opportunities, 72 hours apart, with an SB or PL supplement (Figure 3).

Figure 1. Obstacle course.



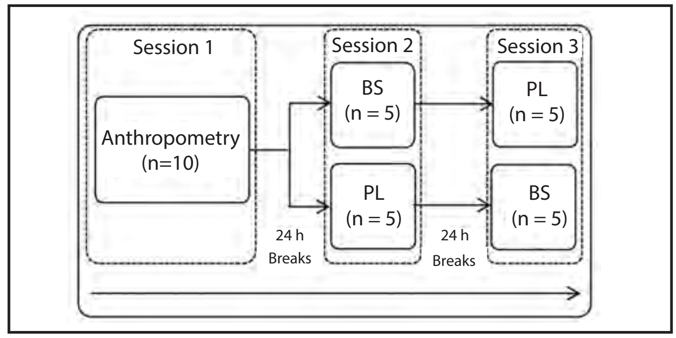
1: 5 m steel rope ladder; 2: double beam; 3: trip wire; 4. network of wires; 5. ford; 6: espalier; 7: balance beam; 8: sloping wall with rope; 9: horizontal beams (over - under); 10: Irish table; 11: tunnel and twin beams; 12: four steps of beams; 13: banquette and pit; 14: assault wall; 15: pit; 16: vertical ladder 4 m; 17: second assault wall; 18: balance beam (zigzag): 19: chicane; 20: 3 assault walls in succession.

Figure 2. Obstacle course stations with the greatest technical difficulty.



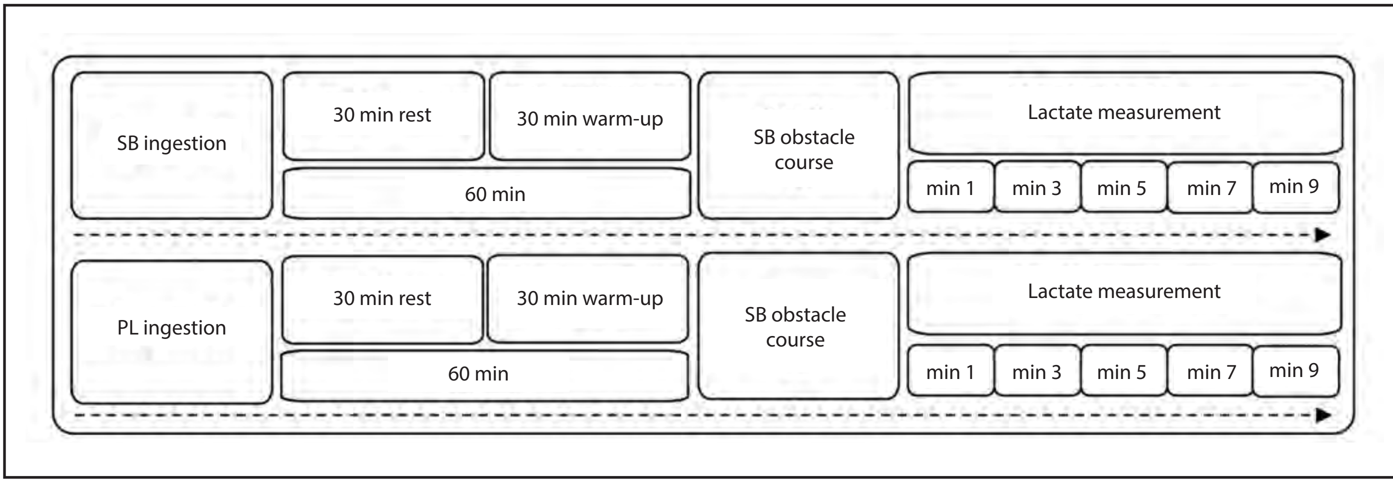
1: 5 m steel rope ladder; 2: sloping wall with rope; 3: pit; 4: assault walls in succession.

Figure 3. Methodological design for the application of the treatment with SB or PL.



h: hours; BS: Sodium bicarbonate (SB) ; PL: Placebo.

Figure 4. Time between the ingestion of SB or PL and the execution of the obstacle course test.



BS: Sodium bicarbonate (SB) ; PL: Placebo; min: minute.

On completion of each test, the time taken was recorded and the post effort capillary [La] (mmol•L^{-1}) was evaluated at minutes 1, 3, 5, 7 and 9 (Figure 4). All the tests were conducted at the obstacle course located on the premises of the Academia Politécnica Naval de Viña del Mar navy school, Chile.

Supplementation

Carbohydrate intake prior to the performance of the obstacle course test (nutritional timing). All athletes were available two hours before the start of the obstacle course test under fasting conditions. This was for the purpose of standardising a pre-evaluation meal, comprising 2 g of simple carbohydrates per kilogram of body weight[26].

SB or PL supplementation One hour before the obstacle course test, the athletes ingested a solution of SB or PL[27]. The former had a concentration of 0.3 g•Kg^{-1} of body mass diluted in 500 mL of distilled water[8]. While the latter (sodium chloride) had a concentration of 0.045 mg•Kg^{-1} of body mass diluted in 500 mL of distilled water [28]. The administration of the placebo or sodium bicarbonate solution was random, with a double blind format.

Statistical analysis

The values measured for the variables of time and [La] were subjected to the Shapiro-Wilk test of normality. Subsequently, the time and the [La] were analysed through the Student t-test for independent samples. The size of the effect was calculated using Cohen's d test. This latter analysis considered an insignificant effect (d < 0.2), small (d = 0.2 up to 0.6), moderate (d = 0.6 to 1.2), large (d = 1.2 to 2.0) or very large (d > 2.0). The level of significance for all the statistical analyses was p < 0.05. The data analysis was made with the Graphpad Instat Versión 3.05® software.

Results

Once the Student's t-test was applied, those subjects supplemented with SB showed a statistically significant decrease in the time taken to complete the obstacle course test compared to the supplementation with PL (p < 0.01; ES (effect size) = 0.48).

On the other hand, the post effort lactate concentrations [La] of those subjects with SB supplementation showed a significant increase in comparison to the supplementation with PL for 5, 7 and 9 minutes (Tables 1 and 2).

Discussion

With regard to the main objective of the study, the acute supplementation with SB at a dose of 0.3 g•kg-1 in professional military pentathletes who were then subjected to a maximum intensity glycolytic test, highlighted a significant decrease in the time taken to complete the Military Pentathlon obstacle course when compared to the PL

Table 1. Time to complete the obstacle course, post-ingestion of SB or PL.

		time (s)
Time	Mean PL ± SD	155.0 ± 6.5
	Mean SB ± SD	152.6 ± 9.0
	Δ PL – SB (s)	2.4
	% PL - SB	3.7%
	Student's t-test	**
	Cohen's d-test	0.48

PL: placebo; SB: Sodium bicarbonate; SD: standard deviation; Δ: delta; s (seconds); **(p<0.05)

Table 2. Lactate production before and after the obstacle course trial with ingestion of SB or PL.

	Lactate						
	Start	End	min 1	min 3	min 5	min 7	min 9
PL (mmol•L^{-1})	1.9 ± 0.6	11.6 ± 3.2	15.5 ± 2.5	16.5 ± 2.9	16.2 ± 1.8	15.3 ± 2.7	13.9 ± 2.6
SB (mmol•L^{-1})	2.3 ± 0.6	12.1 ± 4.7	16.6 ± 3.4	18.4 ± 2.3	18.4 ± 2.1	18.9 ± 2.4	17.0 ± 3.2
Δ PL – SB (mmol•L^{-1})	-0.41	-0.50	-1.10	-1.90	-2.20	-3.60	-3.10
% PL - SB	21.0%	4.3%	7.0%	11.5%	13.5%	23.5%	22.3%
Student's t	ns	ns	ns	ns	*	*	*
Cohen's d	0.62	0.14	0.37	0.74	1.08	1.37	1.03

PL: placebo; SB: Sodium bicarbonate; SD: standard deviation;mmol•L-1: millimoles per litre; min: (minute); *(p<0.05): ns: not significant.

group ($p < 0.05$). Although the literature suggests that metabolic alkalinity through SB supplementation would permit a greater performance in maximal intensity stimuli[28], this is the first work to demonstrate an increase in the performance of military pentathletes in the obstacle course event. With regard to the above, it is important to emphasise that the final classification system in a military pentathlon competition depends on the score obtained in each of the events. Therefore, the 2.4 second decrease in the average through SB ingestion allows the athletes to add 17.1 points to the event[3], this increase in performance, associated with the Military Pentathlon scoring system could mean an improvement to the final position or make it possible to win the competition. Likewise, it is important to make an individual analysis of the results obtained against the variation in performance that the athletes may show for protocols of this type[29] (Table 3).

With regard to the post-effort lactate concentrations [La], Saunders *et al.* (2014)[30] consider that the exercise intensity for protocols of this type must be sufficient to achieve a high accumulation of H^+ and, therefore, these efforts are limited by the increase in muscular acidosis. In this study, the post-effort lactate concentrations [La] at minute 3 for the PL group were 16.5 ± 2.9 mmol•L^{-1}. This reflects high metabolic activity and high intensity of effort[31]. A comparison of the group supplemented with SB and the PL group, showed significant post-effort differences at 5, 7 and 9 minutes ($p < 0.05$). In comparison with similar experimental designs, Lindh *et al.* (2008)[10] took a group of swimmers to maximum fatigue, reporting post-effort blood lactate concentrations [La] over 15 mmol•L^{-1}, showing an improvement in the 200 m freestyle performance time, but with a difference in the post-effort lactate concentrations [La] from minute 4 onwards. However, this present study shows significant differences in lactate concentrations [La] between the group supplemented with SB and the PL group from minute 5 up to minute 9. The differences between the study conducted by Lindh *et al.* (2008)[10] and this present investigation could be explained by the fact that swimming efforts generate a far higher and earlier production of lactate than efforts made during running[32]. On the other hand, the significant increase in the production of lactate in the group supplemented with SB in comparison with the PL group, could be associated with an increase in the concentrations of bicarbonate in the blood, given that this buffer produces an increase in parallel to the intracellular / extracellular H^+ gradient, increasing the activity of the lactate/H^+ co-transporters, generating an increase in the flow of H^+ and lactate from the active muscles to the extracellular medium[33]. Therefore, the attenuation of the accumulation of H^+ in the muscles allows the glycolytic resynthesis of ATP to continue in more favourable conditions, delaying muscle fatigue during the high-intensity exercise[33]. This would make it possible to associate greater glycolytic activity with increased performance and higher lactate levels[34]. From the above, Wang *et al.* (2019)[35] maintain that the peak lactate level after exercise represents the body's maximum tolerance to lactic acid. It also reflects the capacity of the glycolytic system to produce ATP.

Table 3. Individual performance delta with PL and SB supplementation

Subjects	Time with PL (s)	Time with SB (s)	Δ (s)	Differences time percentage points between PL and SB (%)
1	151.8	145.4	6.4	9.7
2	149.6	144.6	5.0	7.5
3	164.2	171.1	-6.9	-11.3
4	148.0	146.9	1.1	1.6
5	158.4	154.7	3.7	5.9
6	147.1	141.0	6.1	9.0
7	152.0	151.6	0.4	0.6
8	163.3	155.4	7.9	12.9
9	154,0	153,1	0,9	11,4
10	162.5	162.7	-0.2	-0,3

PL (placebo); SB (sodium bicarbonate); (s) seconds; Δ (delta).

With regard to the SB ingestion protocol and the waiting time between ingestion and the maximum tests, the first studies to analyse this variable suggested waiting times of two hours for the application of the treatment[36]. In contrast to the protocol used by Siegler *et al.* (2010)[36], Maliqueo *et al.* (2018)[14] reported favourable results in a time limit test over the lactic threshold speed, using a 60 minute waiting time between ingestion and the application of the maximum test. Likewise, Miller *et al.* (2016)[18] studied the individual ingestion response time and athletic performance in a speed endurance test, establishing that the mean ingestion time to reach an individual maximum pH level was 68 minutes post-ingestion (a similar time to the one used in this present study). Although the evidence is demonstrating that the time between ingestion and the application of the maximum test must be determined individually[37], it would be of interest to consider the individual variation of elite athletes at different ingestion times, given that most studies either consider recreational athletes or do not specify their sports level[38].

With regard to the dose level used in this study, there are recommendations that a safe dose for humans is 0.3 g•Kg^{-1}[8], thereby maintaining more favourable arterial bicarbonate and pH values[12]. For this reason, and given the lack of background information on sodium bicarbonate supplementation in military athletes, this study established the dose level that had the greatest number of favourable scientific reports, whether for short or long duration running efforts39 or short-duration high-intensity protocols[40].

Conclusions

Based on the results obtains, it can be concluded that the acute supplementation with SB, with a dose of 0.3 g•Kg^{-1} ingested 60 minutes before the obstacle course test, significantly reduces the EXECUTION time of professional military pentathletes, leading to improved performance. Furthermore, the SB ingestion generated a higher post-effort blood lactate concentration, highlighting the effectiveness of the output of this metabolite from the active muscles to the bloodstream. Therefore, military pentathletes could consider the acute supplementation with SB to be an ergogenic aid.

Practical applications

In order to achieve the desired performance effects, firstly the pre-recommended carbohydrate loading needs to be performed[26], avoiding the consumption of sports supplements. The latter for the purpose of minimising gastrointestinal discomfort or the interaction of SB with other substances that could be among the contents of some supplements. It is important for the athletes to have an ad-hoc training level to meet the high metabolic demand and neuromuscular stress generated by this event, this will ensure that the athletes complete the course and do not abandon the race at one of the obstacles. As mentioned in the protocol, the ingestion of SB must be considered as a concentration of 0.3 g•Kg^{-1} of body mass diluted in 500 mL of distilled water[7]. This dose must be ingested 30 minutes before the start of the warm-up, which should contain joint mobility, jogging and exercises that progressively increase the effort intensity.

Acknowledgements

The authors would like to thank the Military Pentathlon team of the Chilean Navy for their impartial participation in this present study.

Conflict of interests

The authors have no conflict of interest at all.

Bibliography

1. Ojeda ÁH. Evolución del Pentatlón Militar como disciplina de alto rendimiento. *Rev Mar.* 2016;5:56-9.
2. Moschopoulos AI, Albanidis E, Anastasiou A, Antoniou P. Organised military sports of the hellenic armed forces for the period 1948–1968. *Int J Hist Sport.* 2015;32:351-66.
3. Council International Military Sports. Military Penathlon Regulations. 2019. (consultado 0807/2019). Disponible en: http://www.milsport.one/sports/military-pentathlon
4. Lazăr I. Motility structure and dynamic specific efforts in obstacle course test. "Mircea cel Batran" *Nav Acad Sci Bull.* 2011;14:184-8.
5. Allen DG, Lamb GD, Westerblad H. Skeletal muscle fatigue: cellular mechanisms. *Physiol Rev*. 2008;88:287-332.
6. Cameron SL, McLay-Cooke RT, Brown RC, Gray AR, Fairbairn KA. Increased blood pH but not performance with sodium bicarbonate supplementation in elite rugby union players. *Int J Sport Nutr Exerc Metab.* 2010;20:307-21.
7. Hood VL, Tannen RL. Protection of acid–base balance by pH regulation of acid production. *N Engl J Med*. 1998;339:819-26.
8. Burke LM, Pyne DB. Bicarbonate loading to enhance training and competitive performance. *Int J Sports Physiol Perform*. 2007;2:93-7.
9. McNaughton LR, Gough L, Deb S, Bentley D, Sparks SA. Recent Developments in the Use of Sodium Bicarbonate as an Ergogenic Aid. *Curr Sports Med Rep*. 2016;15:233-44.
10. Lindh AM, Peyrebrune MC, Ingham SA, Bailey DM, Folland JP. Sodium bicarbonate improves swimming performance. *Int J Sports Med.* 2008;29:519-23.
11. Siegler JC, Marshall PWM, Bishop D, Shaw G, Green S. Mechanistic insights into the efficacy of sodium bicarbonate supplementation to improve athletic performance. *Sport Med.* 2016;2:41.
12. Carr AJ, Slater GJ, Gore CJ, Dawson B, Burke LM. Effect of sodium bicarbonate on [HCO3−], pH, and gastrointestinal symptoms. *Int J Sport Nutr Exerc Metab*. 2011;21:189-94.
13. Russell C, Papadopoulos E, Mezil Y, Wells GD, Plyley MJ, Greenway M, *et al.* Acute versus chronic supplementation of sodium citrate on 200 m performance in adolescent swimmers. *J Int Soc Sports Nutr*. 2014;11:26.
14. Maliqueo SG, Ojeda ÁH, Barrilao RG, Serrano PC. Time to fatigue on lactate threshold and supplementation with sodium bicarbonate in middle-distance college athletes. *Arch Med Deporte.* 2018;35:16-22.
15. George KP, MacLaren DPM. The effect of induced alkalosis and acidosis on endurance running at an intensity corresponding to 4 mM blood lactate. *Ergonomics.* 1988;31:1639-45.
16. Brisola GMP, Miyagi WE, da Silva HS, Zagatto AM. Sodium bicarbonate supplementation improved MAOD but is not correlated with 200-and 400-m running performances: a double-blind, crossover, and placebo-controlled study. *Appl Physiol Nutr Metab.* 2015;40:931-7.
17. Joyce S, Minahan C, Anderson M, Osborne M. Acute and chronic loading of sodium bicarbonate in highly trained swimmers. *Eur J Appl Physiol.* 2012;112:461-9.
18. Miller P, Robinson AL, Sparks SA, Bridge CA, Bentley DJ, McNaughton LR. The effects of novel ingestion of sodium bicarbonate on repeated sprint ability. *J Strenght Cond Res.* 2016;30:561-8.
19. Hobson RM, Harris RC, Martin D, Smith P, Macklin B, Elliott-Sale KJ, *et al.* Effect of sodium bicarbonate supplementation on 2000-m rowing performance. *Int J Sports Physiol Perform.* 2014;9:139-44.
20. Casey A, Hughes J, Izard RM, Greeves JP. Supplement use by UK-based British Army soldiers in training. *Br J Nutr.* 2014;112:1175-84.
21. Armentano MJ, Brenner AK, Hedman TL, Solomon ZT, Chavez J, Kemper GB, *et al.* The effect and safety of short-term creatine supplementation on performance of push-ups. *Mil Med.* 2007;172:312-7.
22. McClung JP, Karl JP, Cable SJ, Williams KW, Nindl BC, Young AJ, *et al*. Randomized, double-blind, placebo-controlled trial of iron supplementation in female soldiers during military training: effects on iron status, physical performance, and mood. *Am J Clin Nutr.* 2009;90:124-31.
23. Hoffman JR, Stout JR, Harris RC, Moran DS. β-Alanine supplementation and military performance. *Amino Acids.* 2015;47:2463-74.
24. Zareyian P. Effect of sodium bicarbonate supplementation before exhaustive activity on physiological parameters of fatigue in conscripts: A study in Sanandaj, Iran. *Ann Mil Heal Sci Res.* 2015;13:62-6.

25. Durnin J, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness : measurements on 481 men and women aged from 16 to 72 years. *Br J Nutr.* 1974;32:77-97.
26. Ojeda ÁH, Contreras-Montilla O, Maliqueo SG, Jorquera-Aguilera C, Fuentes-Kloss R, Barrilao RG. Efectos de la suplementación aguda con beta-alanina sobre una prueba de tiempo límite a velocidad aeróbica máxima en atletas de resistencia. *Nutr Hosp.* 2019;36:698-705.
27. Siegler JC, Midgley AW, Polman RCJ, Lever R. Effects of various sodium bicarbonate loading protocols on the time-dependent extracellular buffering profile. *J Strength Cond Res.* 2010;24:2551-7.
28. Van Montfoort MCE, Van Dieren L, Hopkins WG, Shearman JP. Effects of ingestion of bicarbonate, citrate, lactate, and chloride on sprint running. *Med Sci Sport Exerc.* 2004;36:1239-43.
29. Jones RL, Stellingwerff T, Artioli GG, Saunders B, Cooper S, Sale C. Dose-response of sodium bicarbonate ingestion highlights individuality in time course of blood analyte responses. *Int J Sport Nutr Exerc Metab*. 2016;26(5):445-53.
30. Saunders B, Sale C, Harris RC, Sunderland C. Sodium bicarbonate and high-intensity-cycling capacity: variability in responses. *Int J Sports Physiol Perform.* 2014;9:627-32.
31. Billat LV. Use of blood lactate measurements for prediction of exercise performance and for control of training. *Sport Med*. 1996;22:157-75.
32. Farber HW, Schaefer EJ, Franey R, Grimaldi R, Hill NS. The endurance triathlon: metabolic changes after each event and during recovery. *Med Sci Sports Exerc.* 1991;23:959-65.
33. Junior AHL, de Salles Painelli V, Saunders B, Artioli GG. Nutritional strategies to modulate intracellular and extracellular buffering capacity during high-intensity exercise. *Sport Med.* 2015;45:71-81.
34. Galloway SDR, Maughan RJ. The effects of induced alkalosis on the metabolic response to prolonged exercise in humans. *Eur J Appl Physiol Occup Physiol.* 1996;74:384-9.
35. Wang J, Qiu J, Yi L, Hou Z, Benardot D, Cao W. Effect of sodium bicarbonate ingestion during 6 weeks of HIIT on anaerobic performance of college students. *J Int Soc Sports Nutr.* 2019;16(1):18.
36. Siegler JC, Gleadall-Siddall DO. Sodium bicarbonate ingestion and repeated swim sprint performance. *J Strength Cond Res*. 2010;24:3105-11.
37. Sparks A, Williams E, Robinson A, Miller P, Bentley DJ, Bridge C, *et al*. Sodium bicarbonate ingestion and individual variability in time-to-peak pH. *Res Sport Med.* 2017;25:58-66.
38. Gough LA, Deb SK, Sparks AS, McNaughton LR. The reproducibility of blood acid base responses in male collegiate athletes following individualised doses of sodium bicarbonate: a randomised controlled crossover study. *Sport Med.* 2017;47:2117-27.
39. Freis T, Hecksteden A, Such U, Meyer T. Effect of sodium bicarbonate on prolonged running performance: A randomized, double-blind, cross-over study. *PLoS One.* 2017;12:e0182158.
40. Delextrat A, Mackessy S, Arceo-Rendon L, Scanlan A, Ramsbottom R, Calleja-Gonzalez J. Effects of three-day serial sodium bicarbonate loading on performance and physiological parameters during a simulated basketball test in female university players. *Int J Sport Nutr Exerc Metab.* 2018;28:547-52.

Original article

High-intensity training effects on top-level soccer referees' repeated sprint ability and cardiovascular performance

Daniel Castillo Alvira[1], Jesús Cámara Tobalina[2], Carlo Castagna[3], Jose Antonio Casajús[4], Javier Yanci Irigoyen[2]

[1]Facultad de Ciencias de la Salud, Universidad Isabel I, Burgos. [2]Departamento de Educación Física y Deportiva, Facultad de Educación y Deporte, Universidad del País Vasco, UPV/EHU, Vitoria-Gasteiz. [3]Team-Sports Department, Faculty of Medicine and Surgery, School of Sport and Exercise Sciences, University of Rome Tor Vergata, Rome, Italy. [4]Facultad de Ciencias de la Salud y del Deporte, Universidad de Zaragoza, Huesca.

Received: 02/08/2019
Accepted: 19/12/2019

Summary

Given that the interest for effective and sustainable training methods to develop soccer refereeing performance, the aim of this study was to analyze the effects of a10 weeks high-intensity training (HIT) program on repeated sprint ability (RSA) and aerobic capacity in top-level soccer referees. Sixteen referees were randomly allocated in a HIT program, (EG, n = 8) and a control group (CG, n = 8). All referees were eligible to officiate in the professional Spanish *La Liga* championships (first and second soccer division) or were involved in the talent identification program for promotion to professional level. The training program was carried out during the 10 weeks and referees performed the RSA test and a laboratory incremental treadmill test for maximal oxygen consumption (VO_2max) and ventilatory threshold (VT) assessment both pre and post training intervention. EG improved the RSA performance considered as sprint decrement index over 15 m (Sdec 15 m) and 30 m (Sdec 30 m), and fatigue index over 15 m (Change 15 m) and 30 m (Change 30 m) (ES = -0.52; ±0.31 CL / -0.86; ±0.49 CL; Very Likely small to Very Likely moderate effect after the 10 weeks). In addition, EG decreased the absolute oxygen consumption at ventilatory threshold (VO2VT) (ES = -0.51; ±.60 CL; Likely small). No changes were found in CG performance for in Sdec 15 m, Sdec 30 m, Change 15 m, and Change 30 m (ES = 0.06; ±0.14 CL / 0.78; 1.19CL; Unclear to Likely trivial) or in aerobic performance variables. The results of this study suggest HIT as an effective training intervention to reduce fatigue in RSA and to maintain aerobic capacity on top-level soccer referees.

Key words:
Association football. Match officials. Intermittent exercise. Oxygen uptake. Physical performance.

Efectos del entrenamiento de alta intensidad sobre la habilidad de repetir esprines y el rendimiento cardiovascular en árbitros de fútbol de alto nivel

Resumen

Considerando el interés acerca de los métodos de entrenamiento más efectivos para optimizar el rendimiento físico del árbitro de fútbol, el objetivo de este estudio fue analizar los efectos de un programa de entrenamiento de alta intensidad (HIT) de 10 semanas de duración sobre la habilidad de repetir esprines (RSA) y sobre el rendimiento cardiovascular en árbitros de fútbol de alto nivel. Dieciséis árbitros distribuidos en un grupo experimental (EG) que llevó a cabo un programa HIT (EG, n = 8) y un grupo control (CG, n = 8) participaron en este estudio. Todos los árbitros podían ser elegidos para oficiar a nivel profesional en *La Liga* (Primera o Segunda División) o pertenecían al programa de talentos de árbitros para promocionar al ámbito profesional. El programa de entrenamiento fue realizado durante 10 semanas y los árbitros fueron evaluados del rendimiento en RSA y de un test incremental de laboratorio donde se obtuvo el consumo máximo de oxígeno (VO_2max) y los umbrales ventilatorios (VT) antes y después del programa de intervención. El EG mejoró el rendimiento RSA considerado como el índice de pérdida en el esprint en 15 m (Sdec15 m) y en 30 m (Sdec 30 m), y el índice de fatiga en 15 m (Change 15 m) y en 30 m (Change 30 m) (ES = -0,52; ±0,31CL / -0,86; ±0,49 CL; Muy Probable pequeño a Muy Probable moderado). No se encontraron cambios en el rendimiento del grupo control para las variables Sdec 15 m, Sdec 30 m, Change15 m, and Change 30 m (ES = 0,06; ±0,14CL / 0,78; 1,19 CL; *Unclear to Likely* trivial) ni para el rendimiento cardiovascular tras las 10 semanas de intervención. Los resultados de este estudio sugieren el HIT como una estrategia de entrenamiento efectiva para reducir la fatiga en el RSA y para mantener un óptimo nivel aeróbico en árbitros de alto nivel.

Palabras clave:
Fútbol. Colegiados. Ejercicio intermitente. Consumo de oxígeno. Rendimiento físico.

Correspondence: Daniel Castillo Alvira
E-mail: danicasti5@gmail.com

Introduction

Soccer refereeing was considered as an intermittent high-intensity activity with elite field referees (FRs) exercising at 85-90% of the individual maximal heart-rate (HRmax)[1] and taxing 70-80% of their maximal oxygen up-take[2]. During a competitive match elite-level soccer FRs were reported to cover 10-12 km performing approximately 40 sprints (1539 ± 115 m) at a speed above 18 $km \cdot h^{-1}$[(3)]. Interestingly more than 70 high-intensity accelerations (> 1.5 $m \cdot s^{-2}$) interspersed with less 20 s of recovery were reported in continental cup matches[4] and around the 60% of total accelerations were at high intensity (> 1.5 $m \cdot s^{-2}$)[5]. Considering arbitrary running speed thresholds, FRs were reported to cover almost 25% of the total match distance with short high-intensity actions[3,5]. Given the nature of the internal and external load experienced by elite level FRs during competitive matches high-intensity training (HIT) was proposed to improve aerobic fitness and their ability to perform short sprints with limited recovery time[6].

Despite the interest of HIT on FRs fitness development, only few training studies addressing this interesting issue are available in the international literature[7,8]. Furthermore, they were performed with uncontrolled research design and with variable training protocols performed at exercise intensity in the range of 85-95% of FRs HRmax. However, the provided results were encouraging showing positive effect on intermittent high-intensity aerobic performance (i.e., Yo-Yo Intermittent Recovery Test level 1) and match high-intensity, suggesting the interest of high-intensity interval running in soccer refereeing[2] in order to allow players enhancing better repeated sprint ability (RSA) and aerobic performances.

Although soccer refereeing implies the necessity to perform high-intensity and short actions and a greater cardiovascular capacity to be better positioned throughout the match-play[1,5], unfortunately the mentioned studies did not report the effect of HIT on the RSA considered as relevant physiological ability in FRs and in aerobic fitness key variables[9]. Furthermore, the reported HIT interventions did not consider a control group[7,8]. With the aim to enforce the rule of the game and regulate players' behavior the FRs must keep up with the game whatever the tempo is[7,8]. Match experience and appropriate physical fitness are prerequisite for refereeing at elite level in soccer[7,8]. Given that the interest for effective and sustainable training methods to develop soccer refereeing performance relevant variables are warranted. This with the aim to prepare FRs to cope with game physical demands to attain optimal positioning when making key decisions[1].

Therefore, the aim of this study was to examine the effects of a short-term high-intensity training program (i.e. 10 weeks, HIT) on aerobic-fitness and RSA in top-level soccer FRs. As work hypothesis was assumed the effectiveness of HIT in enhancing either RSA and aerobic-fitness variables of top-level FRs.

Material and method

Participants

Eighteen Spanish soccer referees (age: 28.8 ± 5.1 years; height: 179 ± 7 cm; body mass: 73.2 ± 6.6 kg; body mass index (BMI): 22.82 ± 1.38 $kg \cdot m^{-2}$) volunteered to participate in this study. All referees were eligible to officiate in the professional Spanish *La Liga* championships (first and second soccer division) or were involved in the talent identification program for promotion to professional level. During the 10 weeks training program two referees abandoned the study due to they were involved in international tournaments and, consequently, they did not carry out this training protocol and/or the second testing session. Participants were randomly allocated in either the training experimental group (EG, n = 8, age: 28.8± 5.3 years; height: 176 ± 7 cm; body mass: 68.9 ± 4.9 kg; BMI: 22.12 ± 1.23 $kg \cdot m^{-2}$) or control group (CG, n = 8, age: 28.9± 5.2 years; height: 182 ± 5 cm; body mass: 77.6 ± 5.0 kg; BMI: 23.52 ± 1.22 $kg \cdot m^{-2}$). Each referee had at least 10 years of refereeing experience, trained 3 to 4 times a week and officiated 3 to 4 matches each month during the competitive season. During the study course, all referees were instructed to maintain their usual diet and water intake. Participants were informed of the procedures, methods, benefits, and possible risks involved in the study before giving their written consent. All the FRs were familiar with the procedures considered in this study as they were part of their follow-up measures. The study was conducted according to the Declaration of Helsinki (2013) protocol and was fully approved by the University Ethics Committee (CEISH/261/2014), before the commencement of the assessments and met the ethical standards in Sport and Exercise Science Research[10].

Procedures

This study was carried out during the last 10 weeks of the 2016-2017 (April to June) competitive season. The assessments were carried out pre and post training intervention (T1 and T2, respectively) under similar conditions (temperature: 20-22 ºC; relative humidity: 65-75%; barometric pressure: 720-725 mmHg) and at the same time of the day (09:00-15:00). All testing procedures were preceded by 48 h during which FRs refrained from physical exercise and consumed a diet consisting in 55% carbohydrate, 25% fat, and 20% protein derived calories. Prior to testing participants performed a general standardized warm-up based on continuous running (3 min), 6 min of progressive-speed sprints preceding 2 min of static stretching. The testing procedures order consisted in the RSA test followed by a laboratory incremental treadmill test for maximal oxygen consumption (VO_{2max}) and ventilatory threshold (VT) assessment. According to Weston *et al.*[11] the RSA test consisted in 6 x 30 m sprint with 25 s recovery that was a modified version of the FIFA fitness test at the time of the study used for selecting international level FRs. For consistency the RSA test was performed on an indoor artificial pitch in all the testing occasions. The FRs aerobic-fitness was assessed considering VO_{2max} and VT as they were reported to be associated with physical match-performance in elite-level soccer referees[12]. After T1 the EG was submitted to a 10 weeks HIT protocol performed each Tuesday and Thursday (~60 min each session). The CG during the study period performed on the same occasion unstructured training consisting on endurance training (i.e., extensive running). Training and match internal training load (i.e. TL) were assessed in either group using the differentiated session rate of perceived exertion method (dRPE-based TL)[13] across the study duration.

Repeated Sprint Ability (RSA)

The RSA test consisted in 6 maximum sprints of 30 m with 25 s of active recovery between them. The sprint time was measured using three photoelectric cells (Microgate™ Polifemo Radio Light, Bolzano, Italy) set at 0,15 and 30 m. As indicators of RSA performance the sum of sprint times (i.e., total time, TT) to cover the 6 x 15-m (TT15m) and 6 x 30-m (TT30m) were considered[14]. Sprint performance decrement was considered according to Spencer *et al.*[15] as percentage of ideal time (i.e., best sprint performance) and TT ratio for the 6 x 15-m and 6 x 30-m condition (i.e., Sdec15m and Sdec30m, respectively) and as change in first and last sprint performance (over 15 and 30-m) using the following equation[14]: Change=((RSA last-RSA first)/(RSA first))×100. The validity and reliability of RSA test was reported in football referees[16].

Aerobic test

Aerobic fitness was assessed using a progressive incremental protocol to exhaustion on a monitorised treadmill (ERGelek™ EG2, Vitoria, Spain) according to the procedures used by Casajus *et al.*[17] in elite level FRs. Attainment of VO_{2max} was considered when at least two of the following criteria were satisfied: (a) plateau in VO_2 despite an increase in exercise intensity; (b) HR greater than 90% of the age-predicted maximal value (220-age); (c) a respiratory exchange ratio (RER) greater than 1.15[17]. The exercise HR was recorded every 1 s using short-term telemetry (Polar™ Electro Oy, Kempele, Finland) with peak treadmill test values considered as HRmax. Collected data were downloaded in a computer and processed using the Polar Precision 2.0 software (Polar™, Kempele, Finland). Gas exchange measurements were performed using breath-by-breath technology during the test and for 3 min after exercise exhaustion (Medisoft™ Ergocard, Medisoft Group, Sorinnes, Belgium). The FRs aerobic-fitness variables (i.e., velocity, HR, $VO_{2absolute}$, $VO_{2relative}$) and RPE[18] was assessed considering at VT and at exhaustion.

Differentiated Ratings of Perceived Exertion (dRPE)

Either the EG and CG were supervised by an accredited fitness trainer during all the training period and regularly officiated in championship matches. During the intervention period the CG had freedom in their physical training. The TL was assessed using the 0-10 point scale according to the procedures suggested by Foster *et al.*[19] with RPE recalled by each referee 10 min after the end of each training session and match. With the aim to obtain more detailed information regarding the nature of effort perception a differential approach was considered in this study according to Castillo *et al.*[1]. Indeed during each occasion (i.e., training session or match) the FRs had to provide differentiated RPE (dRPE) for respiratory (RPE_{res}) and leg muscle (RPE_{mus}) exertion perception[20]. In accordance to Foster *et al.*[19] to estimate the RPE-derived TL, the RPE_{res} and RPE_{mus} values were multiplied by the total duration of the training or match (min). Referees were fully familiarized with the 0-10 point scale before the data collection since measurements were part of the used strategies to assess TL during the precedent competitive seasons.

Periodization of training

The post-match training day (MD+1) consisted in a recovery low-intensity session. Similarly the pre-competition day (MD-1) consisted in a low-volume training session. The EG performed each Tuesday (i.e., 48 h post-match) of the 10 weeks intervention HIT training (HIT-1) (Table 1). During each Thursday (HIT-2) of the first 5 weeks of HIT the EG performed according to Weston *et al.*[8] two series, interspersed by 5 min active recovery, of what follows:

- 30 s at 90% HR_{max} followed by 30 s of active recovery
- 60 s at 90% HR_{max} followed by 60 s of active recovery
- 90 s at 90% HR_{max} followed by 90 s of active recovery
- 120 s at 90% HR_{max} followed by 120 s of active recovery

Table 1. Results in pretest (T1) and posttest (T2) in the repeated sprint ability (RSA) test in the experimental (EG) and the control group (GC).

	EG (n = 8)				CG (n = 8)				Paralell Groups
	T1	T2	ES (mean; ±90%CL)	Δ% (% mean ± SD); MBI; Rating	T1	T2	ES (mean; ±90%CL)	Δ% (% mean ± SD); MBI; Rating	ES (mean; ± CL); MBI; Rating
TT15m (s)	15.25 ± 0.68	15.36 ± 0.52	0.15; ±0.56	0.7 ± 2.7; Unclear; 43/44/14	15.27 ± 0.40	15.21 ± 0.37	-0.13; ±0.29	-0.4 ± 0.9; Possibly Trivial; 3/64/33	0.26; ±0.92; Unclear; 57/32/11
TT30m (s)	26.42 ± 1.06	26.74 ± 1.15	0.24; ±0.28	1.2 ± 1.4; Possibly small; 61/38/1	26.77 ± 0.53	26.86 ± 0.51	0.14; ±0.57	0.3 ± 1.3; Unclear; 42/44/14	0.24; ±0.48; Unclear; 56/38/6
Sdec15m (%)	2.79 ± 1.10	2.52 ± 0.96	-0.21; ±0.91	-8.3 ± 49.7; Unclear; 20/29/51	1.72 ± 0.73	2.48 ± 0.90	0.78; ±1.19	44.2 ± 97.5; Unclear; 81/11/8	-0.82; ±1.18; Unclear; 7/11/82
Sdec30m (%)	3.59 ± 1.13	2.83 ± 0.87	-0.63; ±0.67	-21.0 ± 24.2; Likely Moderate; 3/10/87	3.07 ± 2.03	3.84 ± 2.21	0.31; ±0.47	35.5 ± 53.8; Possibly Small; 67/29/4	-0.81; ±0.70; Likely Moderate; 1/6/93
Change15m (%)	4.87 ± 2.68	2.30 ± 2.65	-0.86; ±0.49	-62.6 ± 72.5; Very Likely Moderate; 0/2/98	2.57 ± 1.93	2.78 ± 2.39	0.08; ±0.81	2.8 ± 160.4; Unclear; 39/35/26	-1.07; ±0.82; Very Likely Moderate; 1/3/96
Change30m (%)	6.80 ± 4.12	4.37 ± 3.74	-0.52; ±0.31	-42.7 ± 47.7; Very Likely Small; 0/4/96	5.90 ± 5.34	6.21 ± 5.92	0.05; ±0.14	0.6 ± 19.3; Likely Trivial; 4/95/1	-0.51; ±0.29; Very Likely Small; 0/4/96

Δ%: percentage of change between T2 and T1; ES: effect size; TT15m: total time over 15 m; TT30m: total time over 30 m; Sdec15m: sprint decrement index over 15 m; Sdec30m: sprint decrement index over 30 m; Change15m: change in the fatigue index over 15 m; Change30m: change in the fatigue index over 30 m.; ES: effect size; SD: standard deviation; CL: confidence limits; MBI: magnitude based inferences.

– 90 s at 90% HR_{max} followed by 90 s of active recovery
– 60 s at 90% HR_{max} followed by 60 s of active recovery
– 30 s at 90% HR_{max} followed by 30 s of active recovery

During the remaining 5 weeks Thursdays the EG performed twice during each training session the following interval training protocol[8]:

– 30 s at 90% HR_{max} followed by 30 s of active recovery
– 45 s at 90% HR_{max} followed by 45 s of active recovery
– 60 s at 90% HR_{max} followed by 60 s of active recovery
– 75 s at 90% HR_{max} followed by 75 s of active recovery

Repeated twice, followed by 5 min active recovery before set 2:

– 75 s at 90% HR_{max} followed by 75 s of active recovery
– 60 s at 90% HR_{max} followed by 60 s of active recovery
– 45 s at 90% HR_{max} followed by 45 s of active recovery
– 30 s at 90% HR_{max} followed by 30 s of active recovery

Statistical analysis

Results are presented as means ± standard deviations (SD). We opted to use effect sizes (ES), with the uncertainty of the estimates shown as 90% confidence intervals (CI), to quantify the magnitude of the difference between T1 and T2 performance measures in both EG and CG separately[22]. We used the parallel groups controlled trial with adjustment for a predictor to analyze T1-T2 performance differences between EG and CG. ESs were classified as trivial (<0.2), small (0.2 to 0.6), moderate (0.6 to 1.2), large (1.2 to 2.0), very large (2.0 to 4.0) and extremely large (>4.0)[22]. These changes were then qualified via probabilistic terms and assigned using the following scale: 25–75%, possibly; 75–95%, likely; 95–99.5%, very likely; >99.5%, most likely[22]. Inference was classified as unclear if the 90% confidence limits (CLs) overlapped the thresholds for the smallest worthwhile positive and negative effects[22]. Mean differences, confidence intervals, effect sizes and magnitude-based inferences (MBI) were calculated using a custom-made spreadsheet[23].

Results

The session respiratory perceived exertion training load ($sRPE_{res}$ TL) and the session muscular perceived exertion training load ($sRPE_{mus}$ TL) are reported in Figures 1 and 2, respectively. No between groups significant differences (sRPEres TL: ES = -1.32 ± 1.83 / 0.26 ± 0.72, unclear; $sRPE_{mus}$ TL: ES = -1.45 ± 2.55 / 0.26 ± 0.72, unclear) were reported between EG and CG for the dRPE TL values.

Very Likely small to moderate differences between groups were detected for Sdec30m, Change15m and Change30m. The EG post-intervention performance in Sdec30m, Change15m and Change30m improved (Δ% = -21.0 ± 24.2 / -62.6 ± 72.5, ES = -0.52; ±0.31CL / -0.86; ±0.49CL; Very Likely small to Very Likely moderate). On the other side, in the CG performance no improvements were observed in Sdec15m, Sdec30m, Change15m and Change30m (Δ% = 0.6 ± 19.3 / 44.2 ± 97.5, ES = 0.06; ±0.14CL / 0.78; 1.19CL; Unclear to Likely trivial) (Table 1).

The individual Δ% (T1 to T2) after 10 weeks in Sdec30m (Figure 3A, ES = 1.32; ± 1.13CL; MBI = 95/3/2), in Change30m (Figure 3B, ES = 1.32; ± 0.76CL; MBI = 99/1/0) and in Change15m (Figure 3C, ES = 1.31; ± 0.99CL; MBI = 96/3/1) was better in EG than in CG.

Figure 1. Respiratory perceived exertion training load ($sRPE_{res}$ TL) results during each week of experimental group (EG) and control group (CG).

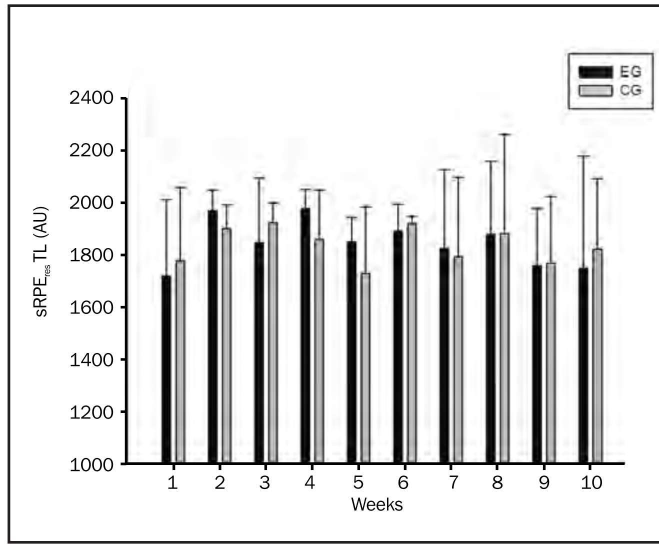
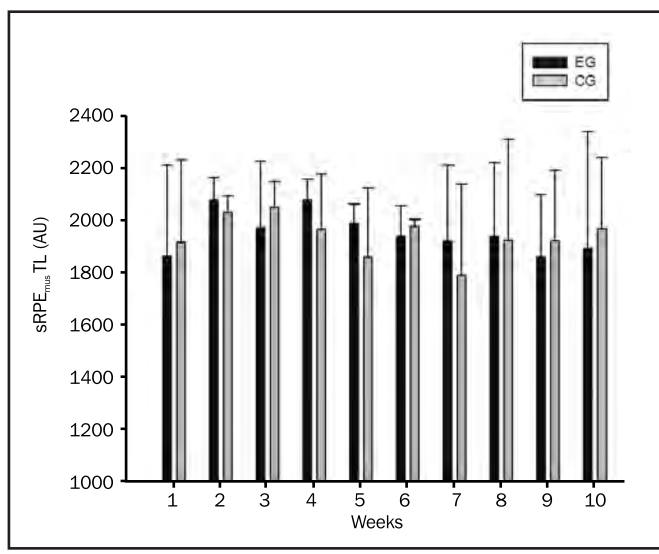


Figure 2. Leg muscle perceived exertion training load ($sRPE_{mus}$ TL) during each week of experimental group (EG) and control group (CG).



Despite in both groups cardiovascular variables at maximal intensities (i.e. Vel_{max}, HR_{max}, VO_{2max} absolute, VO_{2max} relative and RPE_{max}) have not improved in T2 in comparison to T1, at submaximal intensities (VT) CG worsened the performance in velocity at VT (Vel_{VT}) (Δ% = -0.8 ± 1.1, ES = -0.28; ±0.43CL; Possibly small). However the performance in Vel_{VT} (Δ% = -1.1 ± 4.6, ES = 0.16; ±0.55CL; Unclear) in EG did not change significantly. Besides, EG decreased the VO_{2VT} absolute (Δ% = -6.3 ± 7.9, ES = -0.51; ±0.60CL; Likely small). Unclear differences between groups were detected for the maximal values of aerobic-fitness variables considered. The individual Δ% (T1 to T2) after 10 weeks in the cardiovascular variables were unclear in all cases (ES = -0.79; ± 1.65CL / 0.34; 1.91CL) (Table 2).

Figure 3. Differences between experimental (EG) and control group (CG) in the individual percentage changes (Δ%) after 10 weeks training (pretest: T1 to posttest: T2) on Sdec30m (Figure 3A), Change30m (Figure 3B) and Change15m (Figure 3C) on the repeated sprint ability (RSA) test. ES: effect size.

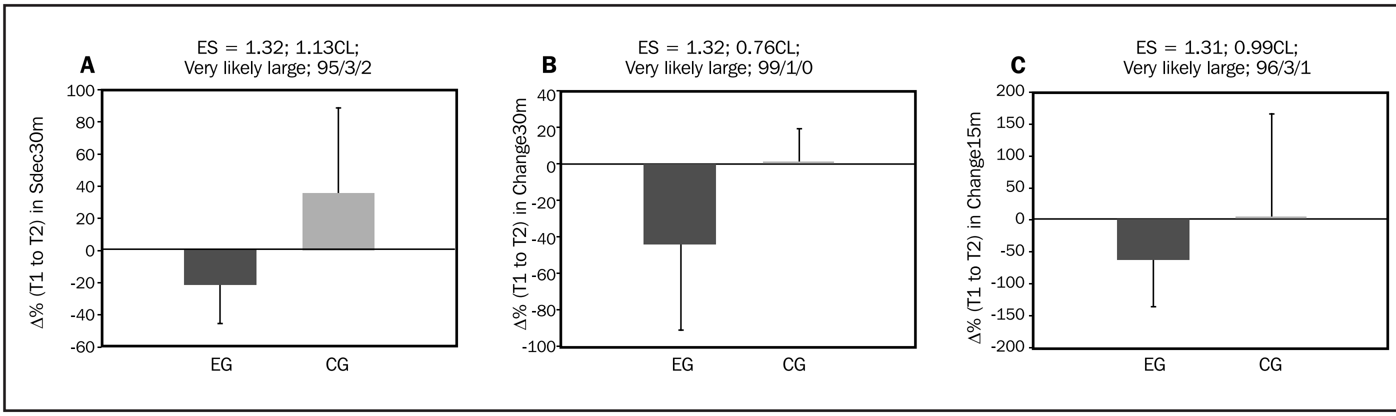


Table 2. Results in pretest (T1) and posttest (T2) in the endurance capacity in the experimental (EG) and the control group (GC).

	EG (n = 8)				CG (n = 8)				Paralell Groups ES (mean; ±CL); MBI; Rating
	T1	T2	ES (mean; ±90%CL)	Δ% (% mean ± SD); MBI; Rating	T1	T2	ES (mean; ± 90%CL)	Δ% (% mean ± SD); MBI; Rating	
Ventilatory threshold (VT)									
Vel_{VT} (Km.h^{-1})	15.80±0.93	15.99±0.11	0.16;±0.55	1.1±4.6; Unclear; 44/43/13	15.55±0.26	15.43±0.42	-0.28;±0.43	-0.8±1.1; Possibly Small; 4/32/64	0.39; ±0.89; Unclear; 66/22/12
HR_{VT} (bpm)	175.83±8.89	175.00±8.29	-0.08;±0.50	-0.5±2.9; Unclear; 16/52/33	175.17±9.43	172.00±6.69	-0.33;±0.63	-1.8±3.6; Unclear; 8/27/65	0.22; ±0.70; Unclear; 53/33/15
$VO2_{VT}$ absolute (l•min^{-1})	3.76±0.33	3.54±0.42	-0.51;±.60	-6.3±7.9; Likely Small; 3/14/83	4.33 ±0.16	4.13±0.49	-0.46;±0.82	-5.1±10.1; Unclear; 8/19/72	-0.06; ±0.89; Unclear; 30/31/39
$VO2_{VT}$ relative (ml•min^{-1}• kg^{-1})	53.00±4.15	51.67±3.72	-0.28;±0.75	-2.5±7.0; Unclear; 13/29/50	55.50±2.59	53.00±6.44	-0.43;±0.73	-5.1± 9.5; Unclear; 7/21/72	0.28; ±1.20; Unclear; 55/21/24
RPE_{VT} (AU)	7.33±0.52	6.83±1.47	-0.38;±0.87	-8.9±22.2; Unclear; 12/23/66	6.67±1.03	6.00±0.89	-0.58;±0.37	-10.0±7.2; Very Likely Small; 0/4/96	0.16; ±1.15; Unclear; 48/24/28
Maximal values (max)									
Vel_{max}	18.50±1.38	18.92±0.66	0.32;±0.59	2.4±4.2; Unclear; 66/28/7	18.47±0.73	18.37±0.50	-0.14;±0.85	-0.5±3.4; Unclear; 23/33/44	0.41; ±0.72; Unclear; 70/22/8
HR_{max}	186.33±9.27	185.50±8.71	-0.08;±0.34	-0.4±1.9; Unclear; 8/67/25	188.33±6.12	188.00±3.90	-0.05;±0.79	-0.2±2.6; Unclear; 27/36/36	-0.06; ±0.61; Unclear; 23/43/34
$VO2_{max}$ absolute (l•min^{-1})	4.02 ±0.33	4.01±0.35	-0.01;±0.48	-0.2±5.4; Unclear; 21/56/23	4.78 ±0.37	4.55±0.49	-0.44;±0.86	-5.0±10.9; Unclear; 10/20/70	0.36; ±0.75; Unclear; 65/5/10
$VO2_{max}$ relative (ml•min^{-1} •kg^{-1})	58.67±5.35	59.00±3.41	0.06;±0.45	0.8±4.2; Unclear; 28/57/15	60.33±3.93	58.50±6.83	-0.28;±0.98	-3.4±12.2; Unclear; 19/25/56	0.40; ±1.24; Unclear; 62/19/19
RPE_{max} (AU)	10.00±1.00	9.91±0.20	-0.49;±0.98	-0.9±1.7; Unclear; 11/18/71	9.50±0.45	9.50±0.55	0.00;±0.76	0.0±4.9; Unclear; 31/38/31	-0.18; ±0.98; Unclear; 24/28/48

Δ Change (%): percentage of change between T2 and T1; Vel_{VT}: velocity at ventilatory threshold; HR_{VT}: heart rate at ventilatory threshold; $VO2_{VT}$ absolute: absolute oxygen consumption; $VO2_{VT}$ relative: relative oxygen consumption; RPE_{VT}: rating of perceived exertion at ventilatory threshold; Vel_{max}: maximum velocity; HR_{max}: maximum heart rate; RPE_{max}: $VO2_{max}$ absolute: maximum absolute oxygen consumption; $VO2_{max}$ relative: maximum relative oxygen consumption; maximum rating of perceived exertion. ES: effect size; SD: standard deviation; CL: confidence limits; MBI: magnitude based inferences.

Discussion

This is the first study that examined the effect of a periodized controlled HIT training intervention on top-class FRs, on aerobic fitness and RSA variables. The main findings of this 10 weeks HIT intervention were a practical and significant improvement in RSA performance with a parallel maintenance of submaximal aerobic fitness variables (i.e., VT variables).

Top- level soccer refereeing is a physical demanding activity involving a high number of total sprints (>18 km•h^{-1}) and high-intensity accelerations (>1.5 m•s^{-2}) during match-play[3,5]. Furthermore the 37% of the distance covered by accelerations are performed by repeated accelerations sequences, defined as a minimum of three consecutive bouts (accelerations > 1.5 m•s^{-2}) during a 45 s time period. Given the logical validity of RSA, effective and sustainable training methods are of practical interest. In the present study, we have demonstrated that 10 weeks of HIT program improved RSA performance (Table 3). Indeed, FRs reported a decrement of cumulative fatigue as shown by significant changes in Sdec30m (Δ% = -21.0 ± 24.2), Change15m (Δ% = -62.6 ± 72.5) and Change30m (Δ% = -42.7 ± 47.7) values. These results come along with those obtained by Arazi *et al.*[24] who demonstrated that the HIT was effective in inducing meaningful improvements in fatigue index in female soccer players. Moreover, it has been observed that a 17-day microcycle (i.e., 13 HIT sessions) in addition to regular training significantly improved the RSA performance in elite tennis players[25]. Furthermore, 2 weeks of HIT training enhanced RSA performance variables in soccer players[26]. Given this study results, the HIT might be considered a promising way to promote large improvements in RSA variables in soccer referees.

Despite many studies have shown that the HIT is an effective training strategy to enhance the aerobic capacity without affecting negatively strength, power, or sprint performance on soccer players[27–34], only a few have been focused on soccer referees[7,8]. In our study, no improvements were reported in maximal aerobic-fitness variables in the EG. Indeed, HIT resulted in a substantial maintenance of Vel_{VT}. It could be speculated that the considered HIT program, might have ameliorated the running economy of the referees at submaximal intensities promoting the reported improvements.

Krustrup *et al.*[7] using a HIT protocol similar to this study observed a 7% increase in treadmill time to exhaustion in top-level Danish FRs. However similarly to this study no significant changes in VO_{2max} were reported. These results are different from those implemented in soccer players during the in-season and the pre-season phases of the training period. Indeed, Sperlich *et al.*[30] observed an improvement of the VO_{2max} of a 7% after 5 weeks period in soccer players. Similar results (i.e., 8-9%) were reported using 8 weeks HIT training by Helgerud *et al.*[35] and Impellizzeri *et al.*[36] in junior male soccer players during the competitive-season and the pre-season, respectively. In addition, improvements of 7-21% were reported in other endurance test (i.e., Yo-Yo intermittent recovery 1, 30-15 intermittent field test) in soccer players[27,32,33]. Interestingly, Ferrari Bravo *et al.*[37] provided evidence of specific effects of HIT and sprint intermittent training (SIT) on aerobic fitness and RSA performance in male soccer players. With SIT improving either aerobic fitness and performance in addition to RSA scores compared to HIT.

In our study, despite EG did not improve the VO_{2max}, it was observed a decrement in the CG, so 10 weeks of a HIT program might help not to worsen the aerobic fitness of match officials. To our knowledge most of studies have found improvements at maximal intensities (i.e., Vel_{max}, VO_{2max}) and in intermittent endurance tests, however, in our study we demonstrated that HIT program was more effective at submaximal intensities in soccer referees. Therefore, HIT program seems to be more effective than a regular training program based on extensive running activities in order to ameliorate the running economy of the referees at submaximal intensities. This could be considered as a relevant issue as the physical performance of the elite soccer referees should be economized in order to keep up the game tempo[9]. Trainers of soccer referees should consider the inclusion of HIT sessions during the in-season period.

In our study there are some limitations which must be acknowledged. Given that this study was conducted with top-level soccer referees, it makes very difficult to have a large sample of participants. Moreover, due to the time constraint of these soccer referees, both RSA and aerobic laboratory test (pre and post occasions) were performed on the same day, but 25-30 min were taken as a rest between each other. Another limitation is the lack of objective measuring method such as global

Table 3. Periodization of the training week in experimental (EG) and control (CG) group during the intervention period.

Groups	MD+1	Tuesday	Thursday	MD-1
EG	30 min running at 65% HR_{max}.	HIT-1 4 series of 4 min performing 15 s running bouts at 120% of maximal aerobic speed (MAS) interspersed by 15 s of passive recovery (21) and 3 min of jogging at 70% of HR_{max}.	HIT-2 5 weeks: interval training protocol of Weston *et al.*[8] 5 weeks: interval training protocol of Weston *et al.*[8]	Progressive sprint-bouts (10-50 m) performed at 90% of the individual maximal
CG	30 min running at 65% HR_{max}.	Unstructured training of endurance training	Unstructured training characterized by extensive running	Progressive sprint-bouts (10-50 m) performed at 90% of the individual maximal

MD: match-day.

positioning system measurements to measure the training and match load, however, we were able to quantify using dRPE.

Conclusions

In conclusion, the present study showed that 10 weeks of HIT, performed two times per week during the in-season period, was effective to reduce the fatigue in RSA and help not to worsen the aerobic fitness and to improve the performance at submaximal intensities on soccer referees. Therefore, HIT is a promising training strategy to improve the physical conditioning of top-level soccer referees.

The main finding of this study suggests a relevant practical application for physical trainers of soccer referees, that is, to implement HIT training programs to improve the physical fitness of top-level soccer referees.

Acknowledgements

The authors would like to thank the participants for their collaboration in this research project.

Conflict of interest

The authors declare no conflict of interest.

Bibliography

1. Castillo D, Yanci J, Cámara J, Weston M. The influence of soccer match play on physiological and physical performance measures in soccer referees and assistant referees. *J Sports Sci.* 2016;34:557–63.
2. Castagna C, Abt G, D'Ottavio S. Physiological aspects of soccer refereeing performance and training. *Sports Med.* 2007;37:625-46.
3. Barbero-Alvarez JC, Boullosa DA, Nakamura FY, Andrin G, Castagna C. Physical and physiological demands of field and assistant soccer referees during America`s Cup. *J Strength Cond Res*. 2012;26:1383–8.
4. Barbero-Alvarez JC, Boullosa D, Nakamura FY, Andrin G, Weston M, Barbero-Alvarez JC, *et al.* Repeated acceleration ability (RAA): A new concept with reference to top-level field and assistant soccer referees. *Asian J Sports Med*. 2014;5:63–6.
5. Castillo D, Castagna C, Cámara J, Iturricastillo A, Yanci J. Influence of team's rank on soccer referees' external and internal match loads during official matches. *J Strength Cond Res.* 2018;32:1715–22.
6. Weston M. Match performances of soccer referees: the role of sports science. *Mov Sport Sci.* 2015;117:113–7.
7. Krustrup P, Bangsbo J. Physiological demands of top-class soccer refereeing in relation to physical capacity: effect of intense intermittent exercise training. *J Sports Sci.* 2001; 19:881–91.
8. Weston M, Helsen W, MacMahon C, Kirkendall D. The impact of specific high-intensity training sessions on football referees' fitness levels. *Am J Sports Med*. 2004;32:54s-61s.
9. Weston M, Castagna C, Impellizzeri FM, Bizzini M, Williams AM, Gregson W. Science and medicine applied to soccer refereeing an update. *Sports Med*. 2012;42:615–31.
10. Harriss D, Atkinson G. Ethical standards in sport and exercise science research: 2016 update. *Int J Sports Med*. 2015;36:1121–4.
11. Weston M, Castagna C, Helsen W, Impellizzeri F. Relationships among field-test measures and physical match performance in elite-standard soccer referees. *J Sports Sci.* 2009;27:1177–84.
12. Castagna C, Abt G, D`Ottavio E. The relationship between selected blood lactate thresholds and match performance in elite soccer referees. *J Strength Cond Res.* 2002; 16:623–7.
13. Castagna C, Bizzini M, Povoas SC, D'Ottavio S. Timing effect on training session rating of perceived exertion in top-class soccer referees. *Int J Sports Physiol Perform.* 2017;12: 1157–62.
14. Pyne DB, Saunders PU, Montgomery PG, Hewitt AJ, Sheehan K. Relationships between repeated sprint testing, speed, and endurance. *J Strength Cond Res.* 2008;22:1633–7.
15. Spencer M, Pyne D, Santisteban J, Mujika I. Fitness determinants of repeated-sprint ability in highly trained youth football players. Int J Sports Physiol Perform 2011; 6: 497–508.
16. Riiser A, Andersen V, Castagna C, Pettersen SA, Saeterbakken A, Froyd C, *et al.* The construct validity of the CODA and repeated sprint ability tests in football referees. Int J Sports Med 2018; 39: 619–24.
17. Casajus JA, Castagna C. Aerobic fitness and field test performance in elite Spanish soccer referees of different ages. *J Sci Med Sport.* 2007;10:382–9.
18. Borg G, Hassmen P, Lagerstrom M. Perceived exertion related to heart-rate and blood lactate during arm and leg exercise. *Eur J Appl Physiol Occup Physiol.* 1987;56:679–85.
19. Foster C, Florhaug JA, Franklin J, Gottschall L, Hrovatin LA, Parker S, *et al.* A new approach to monitoring exercise training. *J Strength Cond Res*. 2001;15:109-15.
20. Castillo D, Weston M, McLaren SJ, Camara J, Yanci J. Relationships between internal and external match load indicators in soccer match officials. *Int J Sports Physiol Perform.* 2017;12:922–7.
21. Zouhal H, Lemoal E, Wong DP, BenOunis O, Castagna C, Duluc C, *et al*. Physiological responses of general vs. specific aerobic endurance exercises in soccer. *Asian J Sports Med*. 2013;4:213–20.
22. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exer*. 2009;41:3-13.
23. Hopkins WG. Spreadsheets for analysis of controlled trials, with adjustment for a subject characteristic. *Sportsci.* 2006;10:46–50.
24. Arazi H, Keihaniyan A, EatemadyBoroujeni A, Oftade A, Takhsha S, Asadi A, *et al*. Effects of heart rate vs. speed-based high intensity interval training on aerobic and anaerobic capacity of female soccer players. *Sports.* 2017;5:E57.
25. Fernandez-Fernandez J, Sanz-Rivas D, Sarabia JM, Moya M. Preseason training: the effects of a 17-day high-intensity shock microcycle in elite tennis players. *J Sports Sci Med.* 2015;14:783–91.
26. Wahl P, Guldner M, Mester J. Effects and sustainability of a 13-day high-intensity shock microcycle in soccer. *J Sports Sci Med.* 2014;13:259–65.
27. Dellal A, Varliette C, Owen A, Chirico EN, Pialoux V. Small-sided games versus interval training in amateur soccer players: effects on the aerobic capacity and the ability to perform intermittent exercises with changes of direction. *J Strength Cond Res.* 2012; 26:2712–20.
28. Faude O, Steffen A, Kellmann M, Meyer T. The effect of short-term interval training during the competitive season on physical fitness and signs of fatigue: a crossover trial in high-level youth football players. *Int J Sports Physiol Perform.* 2014;9:936–44.
29. Macpherson TW, Weston M. The effect of low-volume sprint interval training (SIT) on the development and subsequent maintenance of aerobic fitness in soccer players. *Int J Sports Physiol Perform.* 2015;10:332–8.
30. Sperlich B, De Marees M, Koehler K, Linville J, Holmberg HC, Mester J. Effects of 5 weeks of high-intensity interval training vs. volume training in 14-year-old soccer players. *J Strength Cond Res*. 2011;25:1271–8.
31. Wells C, Edwards A, Fysh M, Drust B. Effects of high-intensity running training on soccer-specific fitness in professional male players. *Appl Physiol Nutr Metab.* 2014; 39:763–9.
32. Eniseler N, Şahan Ç, Özcan I, Dinler K. High-intensity small-sided games versus repeated sprint training in junior soccer players. *J Human Kin.* 2017;60:101–11.
33. Howard N, Stavrianeas S. In-season high-intensity interval training improves conditioning in high school soccer players. *Int J Exer Sci.* 2017;10:713–20.
34. Paul DJ, Marques JB, Nassis GP. The effect of a concentrated period of soccer specific fitness training with small-sided games on physical fitness in youth players. *J Sports Med Phys Fitness.* 2019;59:962-8.
35. Helgerud J, Engen LC, Wisloff U, Hoff J. Aerobic endurance training improves soccer performance. *Med Sci Sports Exer.* 2001;33:1925–31.
36. Impellizzeri FM, Rampinini E, Marcora SM. Physiological assessment of aerobic training in soccer. *J Sports Sci.* 2005;23:583–92.
37. Ferrari Bravo D, Impellizzeri FM, Rampinini E, Castagna C, Bishop D, Wisloff U. Sprint vs. interval training in football. *Int J Sports Med.* 2008;29:668–74.

Heart rate variability as indicator of internal load in female non-athletes: pilot study

Claudio Nieto-Jiménez[1], Carla Bertoglia-Ghiglino[1], Estefanía Soto-Voisier[1], Isabel Morales-Rodríguez[1], Francisca Sepúlveda-Catalán[1], Daiana Quintiliano-Scarpell[1], José F. Ruso-Álvarez[2]

[1]Universidad del Desarrollo, Centro integral de apoyo al deportista (CIAD). Santiago, Chile. [2]Universidad Pablo de Olavide. Sevilla.

Received: 16/08/2019
Accepted: 13/03/2020

Summary

Heart rate variability (HRV) is a non-invasive tool capable to evaluate the sympathetic and parasympathetic modulation and it has been proposed as a valid method to assess the individual response to a workload and, therefore, the training load.
The objective is to use the RMSSD-Slope (square root of the mean of the differences of the sum of the squares between adjacent RR intervals) to analyze the recovery after two different treadmill intensities in non-athletic women, as an internal training load (ITL) measure and its possible relation with the external training load (ETL) 9 healthy, physically active women participated in the study. Two tests were performed, separated from each other for 48-72h. The first was a maximum treadmill test, in which the maximal aerobic speed (MAS) was determined. In the second session, an 80% test of the MAS was carried out. In each of the sessions, Borg scale and HRV was monitored (rest, exercise and recovery) for further analysis with the RMSSD-Slope.
The RMSSD-Slope value in the 80% intensity test was 0.97 (± 0.78), and in the Maximum Test it was 0.84 (± 0.36). Both tests show an R^2 with Borg scale of 0.62 and 0.62 respectively. In the case of the R^2 between the ETL and the RMSSD-Slope it was 0.04 and 0.14 respectively.
The recovery slope of the RMSSD is a good ITL assessment tool in physically active women but not athletes.

Key words:
Parasympathetic. Training load.
Heart rate variability. Recovery.

Variabilidad de la frecuencia cardíaca como indicador de carga interna en mujeres no deportistas: estudio piloto

Resumen

La variabilidad de la frecuencia cardiaca (VFC) es una herramienta no invasiva que permite evaluar la modulación simpática y parasimpática y se ha propuesto como un método válido para valorar la respuesta individual a una carga de trabajo y, por tanto, la carga de entrenamiento.
El objetivo es utilizar la RMSSD-Slope (La pendiente de la raíz cuadrada de la media de las diferencias de la suma de los cuadrados entre intervalos RR adyacentes) para analizar la recuperación tras dos intensidades diferentes en tapiz rodante en mujeres no deportistas, como medida de carga interna (CI) y su posible relación con la carga externa (CE).
Participaron 9 mujeres sanas, físicamente activas. Se realizaron dos test, separados entre sí por 48-72 h. El primero fue una prueba máxima en tapiz rodante, en el que se determinó la velocidad aeróbica máxima (VAM). En la segunda sesión, se realizó una prueba al 80% de la VAM. En cada una de las sesiones se hizo un seguimiento la escala de Borg y de la VFC (reposo, ejercicio y recuperación) para su posterior análisis con la RMSSD-Slope.
El valor de la RMSSD-Slope en la prueba del 80% de intensidad fue de 0,97 (±0,78), y en la Prueba Máxima fue 0,84 (±0,36). Ambas pruebas presentan una R^2 con la escala de Borg (0,62 y 0,62) respectivamente. En el caso de la R^2 entre la CE y la RMSSD-Slope fue de 0,04 y 0,14 respectivamente.
La pendiente de recuperación de la RMSSD es una buena herramienta de valoración de CI en mujeres físicamente activas pero no deportistas.

Palabras clave:
Parasimpático.
Carga de entrenamiento.
Variabilidad de la frecuencia cardíaca.
Recuperación.

Correspondence: Claudio Nieto-Jiménez
E-mail: c.nieto@udd.cl

Introduction

Heart rate variability (HRV) is a non-invasive tool that allows the sympathetic and parasympathetic modulation[1,2] to be assessed, and has been suggested as a valid method to assess the individual response to a work load, and therefore, training load[3,4]. There has been a recent interest in controlling the training load of athletes[5], on the one hand marked by the administrated load or external load (EL), and on the other hand, the way each subject takes on this load and responds to it, which is known as the internal load (IL)[6].

One method used to assess the training load, is to measure the HRV immediately after exercise to observe the way the values are recovered. However, there is no clear rule in terms of the type of load to assess, with studies that measure work loads based on thresholds (as percentage of the maxHR) without adjusting the intensity to duration in laboratory, either with a single exercise intensity[7] or with different intensities[8-11], whilst others assess days or weeks of training with different load types[3,4,11,12], or designed specifically on-site[13]. Recently, Ruso *et al.* (2019) adjusted the VT1 and VT2 to obtain the same training load, and observed that the parasympathetic reduction is independent of the type of work performed, and is inverse to intensity, concluding that recovery from RMSSD would be a good indicator for assessing IL[14].

IL can be assessed with HRV, with studies carried out observing changes in the sympathetic-parasympathetic modulation as indicators of IL in team[15] and individual[16] sports. Along this line, Naranjo *et al.*[17] have proposed a simple tool for assessing IL, through the immediate recovery of the root mean square of successive differences between the adjacent RR intervals (RMSSD) after an exertion of any nature.

Until now, the use of this IL index has been limited to young, physically active demographics[17]. However, there are not yet any literary studies that assess the immediate recovery following exercise in the general, non-athlete population, using the tool proposed by these authors. Even though some indices have been described[9], everyday use on a demographic of active yet non-athlete females has not been implemented.

For this reason, the aim of this study is to use this analysis instrument post-exercise, after two different intensities on a treadmill, on physically active yet non-athlete females, as a measurement of IL and the possible relationship with EL.

Material and method

This study used 9 healthy females, physically active yet non-athletes and non-smokers (age 31.67 ± 4.00 years; body mass 64.82 ± 6.97 kg; height 164.04 ± 0.03 cm; BMI: 24.10 ± 2.90).

Following the general indications of *Task Force*[18], all the subjects were advised not to drink alcoholic and/or caffeinated drinks, and not to participate in any physical activity in the 24 hours prior to each test.

Each subject underwent a medical check to rule out that they were receiving any other treatment or had any cardiovascular disorders, or any other aspects that could impinge upon or alter the state of the autonomic nervous system. All the subjects were informed about the procedure to follow and gave their written consent to participate in the experiment. The local Ethics Committee approved the study, which adhered to all the principles expressed in the Helsinki Declaration[19]. The total duration of the experiment was 1 week, with 2 sessions separated by 48-72 hours, approximately at the same time of day and under stable environmental conditions (temperature and humidity).

In the first session, each subject filled out a questionnaire about antecedents, they were measured and weighed. An incremental and maximum exertion test was carried out on a treadmill (ErgoRun Medical 8, Daum Electronic; Fürth, Germany) following a scaled protocol with an initial load of 6 km/hr and increases of 1 km/hr every 3 minutes to exhaustion, with a gradient of 1%. Between successive levels, a 1 minute break was performed to obtain a finger-prick blood sample to take lactate measurements in capillary blood using a Lactate Pro 2 (Minneapolis, USA) measurer.

For this study, once each test was finished, the maximum aerobic capacity (VO_2max) was established, considering this to be the final level completed to the volitional limit, always when accompanied by a HR of at least 95% of the theoretical maximum HR of each individual and a maximum lactate over 8 mM/l.

In the second session, each subject ran for 20 minutes at a speed of 80% of VO_2max, consistently and without a previous warm-up.

In each session, the EL was calculated as the product of intensity (speed) by volume (time). By expressing the speed in km/hr and time in hours, the EL is expressed as the distance covered in kilometres.

Heart rate variability measurements

A Polar V800 heart rate monitor was used with a chest band H10 HR Sensor (Polar Inc., Kempele, Finland), approved for HRF measurements[20]. The heart rate monitor was started 10 minutes prior to the test and continued for 15 minutes after the test. All the measurements were performed with the subject sitting, in a calm and silent environment. To do this, the subject was asked to sit down immediately after finishing the test (with no active recovery) for the recovery to be measured.

All the registers analysed were five minutes in duration. The final 5 minutes of the rest (Rest) and exercise (Exer.) registers were taken in each session. In terms of recovery, measurements were taken from minute 5 to 10 once the test was over (Rec. 10).

The series of RR time were downloaded using the Polar FlowSync application (version 2.6.2) to be analysed with the Kubios VFC software (version 2.1, University of Eastern Finland, Kuopio, Finland). Each register was examined beforehand to detect the possible presence of abnormal artefacts and/or beats, and where necessary the corresponding filters were applied.

In each exercise session, the subjective perceived exertion rate was recorded using the Borg scale 1-10[21].

RMSSD is the most frequently used variable in assessing parasympathetic activity[2]. Following the methodology proposed by Naranjo *et* *al.*[17], and applying the nomogram put forward, the recovery curve was calculated from the RMSSD values to minute 10 and starting from the final value of the exercise for each of the intensities performed in the experiment (80% and maximum test). The values obtained in both tests were included in the nomogram for graphic representation.

Statistical analysis

First, a descriptive study was carried out, presenting all the data using average and standard deviation. To establish if there were significant differences between the EL and IL variables, the paired t-Student test was applied. In all cases a confidence level of 95% and a $p < 0.05$ value were set. To analyse the connections between the gradients proposed and other load variables, a Pearson correlation analysis was performed. Specifically, the graphic link between the RMSSD gradients at the two intensities was explored.

Results

Characteristics of the tests

Table 1 displays the intensity data (speed), duration, EL and the Borg scale for each of the tests.

Table 2 displays the lactate and heart rate values in the 80% test. For the RMSSD, the levels of the final 5 minutes of exercise are used, following 10 minutes of recovery, and the calculation of the RMSSD-Slope.

Table 3 displays the lactate and heart rate values in the maximum test. For the RMSSD, values are displayed from the final 5 minutes of exercise, after 10 minutes of recovery and the calculation of the RMSSD-Slope.

The values of the RMSSD-Slope for the 80% test (Table 2) and the maximum test (Table 3) do not reveal significant differences ($p = 0.52$).

Figure 1 displays the graphic association between the Borg scale[1-10] and the RMSSD-Slope of the 80% test (A) and with the maximum test (B). The Pearson correlation coefficient for both comparisons was -0.76 and -0.70 respectively.

Figure 2 displays the graphic association between the RMSSD-Slope of the 80% test and the maximum test. This association shows a Pearson correlation coefficient of 0.70.

Figure 3 displays the graphic association between the external load (EL) and the RMSSD-Slope of the 80% test and the maximum test. These relations reveal a Pearson correlation coefficient of -0.19 and -0.37 respectively.

Table 1. Characteristics of the tests.

	80% test	Maximum test
Speed (km/h)	10.62 ± 1.43	13.28 ± 1.79
Time (h)	0.33±0.00	0.42±0.08
External load (km)	3.51 ± 0.47	3.53 ± 0.78
Borg scale (1-10)	6.56 ± 1.01	8.44 ± 0.73

Table 2. Data from the 80% test.

	80% test				
Subject	Lact.	HR	RMSSD Exer.	RMSSD Rec.	RMSSD -Slope
1	5.5	173	2.9	32.00	2.91
2	4.7	166	4.3	11.00	0.67
3	5.7	176	4.1	10.20	0.61
4	5.6	184	4.2	11.40	0.72
5	4.9	184	4.2	13.90	0.97
6	6.6	177	2.3	4.60	0.23
7	7.8	173	3.1	9.40	0.63
8	4.9	173	4	17.00	1.30
9	5.6	162	3.1	10.08	0.70
Average	5.70	174.22	3.58	13.29	0.97
SD	0.97	7.28	0.73	7.77	0.78

Lact: lactate (Mmol); HR: heart rate (b/m); root mean square of successive differences between the adjacent RR intervals; Exer: Exercise; Rec: Recovery; SD: Standard deviation.

Table 3. Data from the maximum test.

	Maximum test				
Subject	Lact.	HR	RMSSD Exer.	RMSSD Rec.	RMSSD -Slope
1	13.5	189	4	18.04	1.40
2	15.4	187	3.47	8.55	0.51
3	12.4	183	3.56	10.88	0.73
4	9.5	182	2.59	16.36	1.38
5	11.1	187	4.72	14.32	0.96
6	12.2	181	2.86	6.77	0.39
7	8.2	175	4	9.88	0.59
8	11.4	183	4.13	13.14	0.90
9	15.6	167	4.57	11.52	0.70
Average	12.14	181.53	3.77	12.16	0.84
SD	2.47	6.77	0.72	3.66	0.36

Lact: lactate (Mmol); HR: heart rate (b/m); root mean square of successive differences between the adjacent RR intervals; Exer: Exercise; Rec: Recovery; SD: Standard deviation.

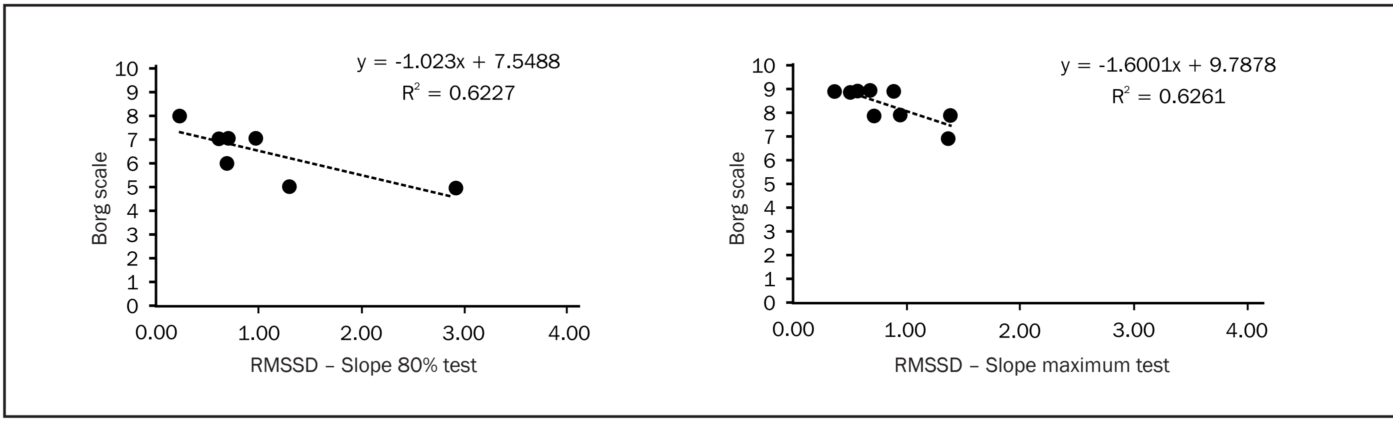
Figure 4 displays the individual results of the RMSSD-Slope from the 80% tests and the maximum test on the nomogram proposed by Naranjo *et al.*[17].

Discussion

The main contribution of this study is the application of the nomogram valuing the post-exercise IL in physically active females, yet non-athletes, after exertions at two different intensities.

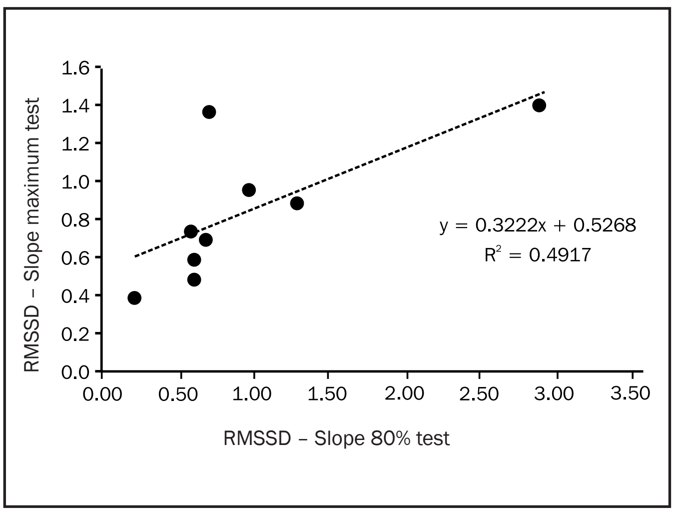
The study performed by Naranjo *et al.*,[17] revealed that the reactivation of the RMSSD after exercise behaves in a linear fashion, at least during the first 30 minutes, allowing for a calculation of the gradient at any time during this time. In our study, the average EL obtained in

Figure 1. Relationship between the Borg scale (1-10) and the RMSSD-Slope.



RMSSD: root mean square of successive differences between the adjacent RR intervals.

Figure 2. Relationship between the RMSSD-Slope of both tests.



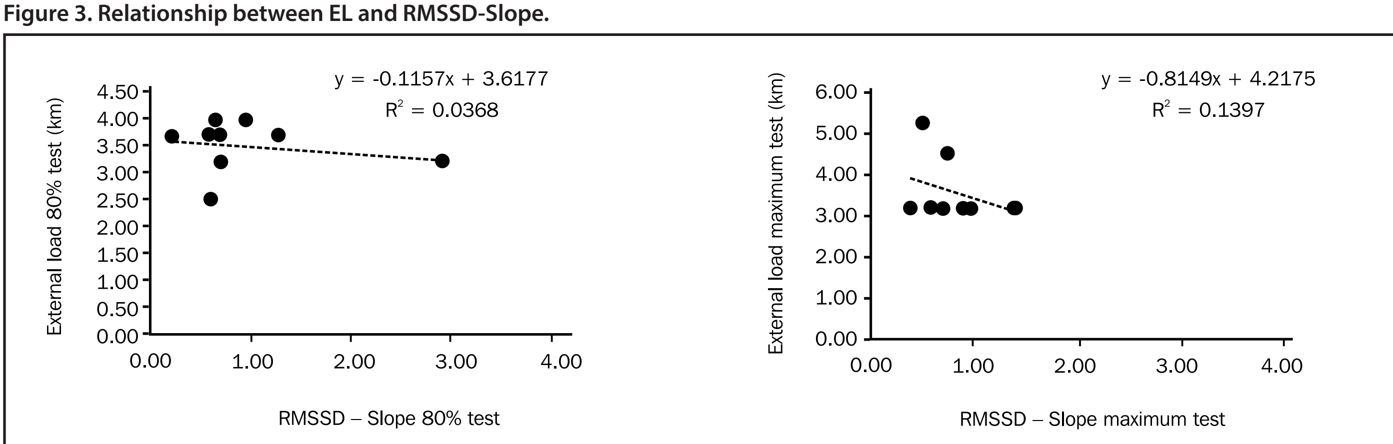
RMSSD: root mean square of successive differences between the adjacent RR intervals.

the 80% test and the maximum test were the same (3.51 ± 0.47 and 3.53 ± 0.78 km) (Table 1). This fact proves that there is no difference between the recovery curve of RMSSD at both intensities (p=0.52), as the response seems to be adjusted to the total load, which in this case is the same. This is referred to by Naranjo *et al.*[17] when the work load exceeds 80% among university students. However, other authors, using different methodologies, report different RMSSD values exceeding intensities of 80%[9,22].

In our studies, during the exercise there is a drop in RMSSD values regardless of the intensity. For the 80% test it is 3.7 ms and for the maximum test it is 3.5 ms (Tables 2 and 3), coinciding with Michael *et al.*,[23] and Naranjo *et al.*[17], referring to values of 5 and 4 ms respectively. Therefore, we can confirm that the suppression of the parasympathetic stimulus during physical exercise is also total in untrained females, regardless of the load performed.

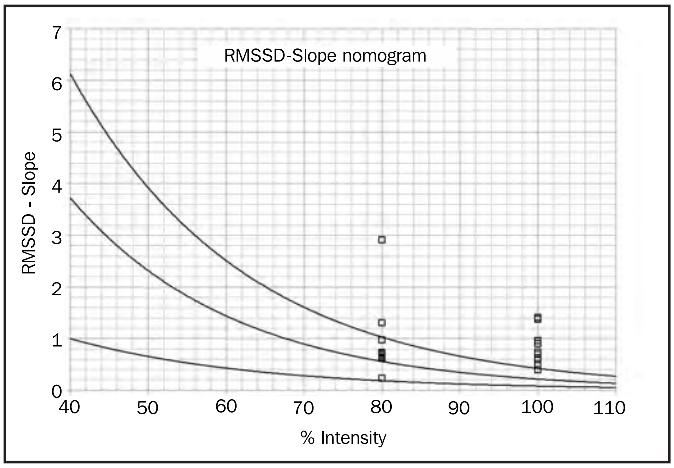
When comparing the IL of both tests with the Borg scale (Figure 1), we find a good linear relationship with a R^2 of 0.62 for the 80% test and 0.63 for the maximum test. It also occurs with Pearson correlation coefficient (r = -0.76 for the 80% test and r = 0.70 for the maximum test),

Figure 3. Relationship between EL and RMSSD-Slope.



RMSSD: root mean square of successive differences between the adjacent RR intervals; CE: external load..

Figure 4. RMSSD-Slope nomogram.



RMSSD: root mean square of successive differences between the adjacent RR intervals.

which even reveals better values than those found by Naranjo *et al.*[17] (r = -0.67) among university students. Therefore, we reaffirm that the positive correlation of the RMSSD-Slope with the Borg scale confirms it as a good IL tool.

By linking the IL values between both tests, an r = 0.70 correlation is obtained, though with a lower linear relationship (Figure 2: R^2 = 0,49). No links were found between IL and HR, or with Lactate. Likewise, the non-athlete females did not reveal any correlation between the EL and the RMSSD-Slope (Figure 3), giving r values of -0.19 and 0.37 in each test. The data obtained reveals a totally individual response, in that each subject took on the load administered and responded to it.

The average RMSSD-Slope value proposed by Naranjo *et al.*[17] to assess the results of a physical load in the second ventilatory threshold is 0.29 and 0.28 for the maximum aerobic speed. In our results (Figure 4) in the 80% test, the females presented an average value of 0.97, and 0.84 for the maximum test. This indicates that both the group average as well as each of the individual responses can be considered positive, not entailing a large IL. One limitation of this study is the low sample size, being a pilot study that will require future research to establish its practical use in a demographic of other characteristics.

It can be concluded that the recovery curve of the RMSSD proposed by Naranjo *et al.*[17] is a useful tool for assessing IL in physically active yet non-athlete females.

Conflict of interest

The authors claim to have no conflict of interest whatsoever.

Bibliography

1. Sandercock GRH, Bromley PD, Brodie DA. Effects of exercise on heart rate variability: Inferences from meta-analysis. *Med Sci Sports Exerc.* 2005;37:433–9.
2. Stanley J, Peake JM, Buchheit M. Cardiac parasympathetic reactivation following exercise: Implications for training prescription. *Sport Med.* 2013;43):1259–77.
3. Pichot V, Roche F, Gaspoz JM, Enjolras F, Antoniadis A, Minini P, *et al*. Relation between heart rate variability and training load in middle-distance runners. *Med Sci Sports Exerc.* 2000;32:1729–36.
4. Kiviniemi AM, Hautala AJ, Kinnunen H, Tulppo MP. Endurance training guided individually by daily heart rate variability measurements. *Eur J Appl Physiol.* 2007;101:743–51.
5. Bourdon PC, Cardinale M, Murray A, Gastin P, Kellmann M, Varley MC, *et al.* Monitoring athlete training loads : Consensus Statement. *Int J Physiol Perform.* 2017;12:161–70.
6. McLaren SJ, Macpherson TW, Coutts AJ, Hurst C, Spears IR, Weston M. The relationships between internal and external measures of training load and intensity in team sports: A meta-analysis. *Sport Med.* 2018;48:641–58.
7. Goldberger JJ, Le FK, Lahiri M, Kannankeril PJ, Ng J, Kadish AH. Assessment of parasympathetic reactivation after exercise. *Am J Physiol Circ Physiol.* 2006;290:H2446–52.
8. Kaikkonen P, Hynynen E, Mann T, Rusko H, Nummela A. Can HRV be used to evaluate training load in constant load exercises? *Eur J Appl Physiol*. 2010;108:435–42.
9. Saboul D, Balducci P, Millet G, Pialoux V, Hautier C. A pilot study on quantification of training load: The use of HRV in training practice. *Eur J Sport Sci.* 2016;16:172–81.
10. Kaikkonen P, Hynynen E, Mann T, Rusko H, Nummela A. Heart rate variability is related to training load variables in interval running exercises. *Eur J Appl Physiol*. 2012;112:829–38.
11. Seiler S, Haugen O, Kuffel E. Autonomic recovery after exercise in trained athletes: Intensity and duration effects. *Med Sci Sports Exerc.* 2007;39:1366–73.
12. Plews DJ, Laursen PB, Kilding AE, Buchheit M. Heart rate variability and training intensity distribution in elite rowers. *Int J Physiol Perform*. 2014;9:1026–32.
13. Schumann M, Botella J, Karavirta L, Häkkinen K. Training-load-guided vs standardized endurance training in recreational runners. *Int J Sports Physiol Perform.* 2017;12:295–303.
14 Ruso-Alvarez J, Nieto-Jiménez C. La racuperación parasimpática tras el esfuerzo como medida de carga de trabajo. En prensa: *Arch Med Deporte.* 2019;194: 356-59.
15. Miranda-Mendoza J, Reynoso-Sanchez LF, Hoyos-Flores JR, Quezada-Chacón JT, Naranjo J, Rangel-Colmenero B, *et al.* Stress Score and lnRMSSD as internal load parameters during competition. *Rev Int Med Cienc Act Fis Deporte.* En prensa Disponible en: http://cdeporte.rediris.es/revista/inpress/artstress1105e.pdf [Consultado el 15 de enero de 2019].
16. Nieto-Jiménez C, Pardos-Mainer E, Ruso-Álvarez JF, Naranjo-Orellana J. Training Load and HRV in a Female Athlete: A Case Study. *Rev Int Med Cienc Act Fis Deporte.* En prensa. Disponible en: http://cdeporte.rediris.es/revista/inpress/artcarga1143e.pdf [Consultado el 20 de enero de 2019]
17. Naranjo Orellana J, Nieto-Jiménez C, Ruso-Álvarez JF. Recovery slope of heart rate variability as an indicator of internal training load. *Health*. 2019;11:211–21.
18. Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology. Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. *Eur Heart J.* 1996;17:354–81.
19. WMA Declaration of Helsinki – Ethical principles for medical research involving human subjects – WMA – The World Medical Association. Disponible en: https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/ [Consultado el 15 de diciembre de 2018]
20. Giles D, Draper N, Neil W. Validity of the Polar V800 heart rate monitor to measure RR intervals at rest. *Eur J Appl Physiol.* 2016;116:563–71.
21. Borg GAV. Phychophysical bases of perceived exertion. *Med Sci Sports Exerc.* 1982;14: 377–81.
22. Michael S, Jay O, Halaki M, Graham K, Davis GM. Submaximal exercise intensity modulates acute post-exercise heart rate variability. *Eur J Appl Physiol*. 2016;116:697–706.
23. Michael S, Graham KS, Davis GM. Cardiac autonomic responses during exercise and post-exercise recovery using heart rate variability and systolic time intervals. A review. *Front Physiol.* 2017;8:1–19.

Prevalence of cardiovascular risk factors in elite athletes following retiring from competition

Mireia Parra[1], Kelly Ferri[2], Maite Doñate[1], Teresa Puig[3], Ignasi Gich[3], Ricard Serra-Grima[1]

[1]Servicio de Cardiología. Hospital de la Santa Creu i Sant Pau. IIB Sant Pau, Barcelona. [2]Facultad de Psicología, Educación y Ciencias del Deporte. Blanquerna. Universitat Ramón Llull. Barcelona. [3]Servicio de Epidemiología Clínica y Salud Pública. Hospital de la Santa Creu i Sant Pau IIB Sant Pau. UAB. CIBERCV, Barcelona.

Received: 16/08/2019
Accepted: 13/03/2020

Summary

Introduction: Epidemiological studies show that cardiovascular risk factors (CVRF) increase with age in the general population.
Aim: To study the Cardiovascular Risk Factors (CVRF) in elite athletes who had retired from competitive sports for a minimum of five years prior to participation in the follow-up examination.
Material and method: longitudinal follow-up study in 157 former elite athletes who had sinus bradycardia (n = 157) 122 men and 35 women. Age = 47 ± 5.9 years. Track and field (n = 66 42%) swimming (n = 35 22%) and others (n = 56 36%). To determine the presence of CRF, a structured questionnaire was used at the time of inclusion of the study and in the follow-up. A descriptive analysis was performed depending on whether the variables were qualitative or quantitative and a bivariate analysis in relation to sinus bradycardia and CRF. The results have been compared with data from the general population.
Results: Smoking 9.0% men and 8.6% women versus the general population 30.9% men and 20.5% women; Hypertension 9.8% men and 0% women versus 22.6% and 23.7%; Diabetes Mellitus 2.5% men and 0% women versus 7.6% and 7.9%; Obesity 4.1% men and 0% women versus 15.7% and 14.0%; Hypercholesterolemia 18.2% men and 2.9% women versus 16% of the total in the general population. 85% men and 82.9% women versus 84.5% and 81.1% regularly exercise. 47 (29.9%) performed moderate physical exercise, 32 (20.4%) intense physical exercise, 21 (13.3%) very intense physical exercise.
Conclusion: The majority of elite athletes continue to regularly exercise and their CRF are lower than those of the general population.

Key words:
Cardiovascular risck factor. Physical exercise. Elite athletes

Prevalencia de factores de riesgo cardiovascular en deportistas de élite después de abandonar la competición

Resumen

Introducción: Estudios epidemiológicos muestran que los factores de riesgo cardiovascular (FRCV) aumentan con la edad en la población general.
Objetivo: Estudiar los FRCV en deportistas de élite que habían abandonado la alta competición como mínimo desde hace 5 años.
Material y método: Estudio descriptivo longitudinal de una cohorte de ex–deportistas de élite con bradicardia sinusal extrema (n= 157) 122 hombres y 35 mujeres. Edad= 47 ±5,9 años. Atletismo (n= 66 42%) natación (n=35 22%) y otros (n=56 36%). Para determinar la presencia de FRCV se utilizó un cuestionario estructurado en el momento de inclusión del estudio y en el seguimiento. Se realizó un análisis descriptivo según las variables fueran cualitativas o cuantitativas y un análisis bivariado en relación a la bradicardia sinusal y los FRCV.
Resultados: Se han comparado con datos de la población general. Tabaquismo 9,0% hombres y 8,6% mujeres *versus* población general 30,9% hombres y 20,5% mujeres; Hipertensión arterial 9,8% hombres y 0% mujeres *versus* 22,6% y 23,7%; Diabetes *Mellitus* 2,5% hombres y 0% mujeres *versus* 7,6% y 7,9%; Obesidad 4,1% hombres y 0% mujeres *versus* 15,7% y 14,0%; Hipercolesterolemia 18,2% hombres y 2,9% mujeres *versus* 16% del total en la población general. Practican ejercicio físico regularmente 85% hombres y 82,9% mujeres *versus* 84,5% y 81,1%. 47 (29,9%) realizaban ejercicio físico moderado, 32 (20,4%) ejercicio físico intenso, 21 (13,3%) ejercicio físico muy intenso.
Conclusión: La mayoría de los deportistas de élite continúan realizando ejercicio físico regular y sus FRCV son inferiores a los de la población general.

Palabras clave:
Riesgo cardiovascular. Ejercicio físico. Deportistas élite.

Work awarded best oral communication in the 7th National Sports Medicine Conferences, organised by the Spanish Sports Medicine Society and Regidoria d´Esports of the l'Ajuntament de Reus, held 22nd-23rd November 2019. Study partially funded by SUR of the DEC Generalitat de Catalunya and European Union 2019FI BI 00168.

Correspondence: Ricard Serra-Grima
E-mail: jserra@santpau.cat

Introduction

Lifestyle and healthy habits are key to promoting health and preventing cardiovascular diseases and constitute the foundation for athletic performance from an inclusive level right up to top competition.

High intensity training programmes call for the adoption, among other aspects, of changes that affect schedules, specific nutrition, and eliminating toxic elements such as smoking. All this has a direct repercussion on short and long-term health and physical performance.

Giving up top-level competitive sport generates modifications that span from the psychological profile - with reduced stress linked to competition - to flexibility in lifestyle standards. The greatest change is the reduction of hours spent training, which triggers the most important lifestyle variation.

If healthy eating habits and a lack of toxic habits - particularly smoking - are maintained once competition sport is left, and physical exercise is continued at a different level, the probability that the most widespread cardiovascular risk factors (CVRF) such as high blood pressure[1,2], dyslipidaemia or diabetes[3-5] appear, is simply lower, or otherwise, they appear at a more advanced chronological age.

The possibility of comparing CVRF that appear at the start of top-level competition sport with those that appear after at least five years after retiring from competition, enable us to observe if there are any differences in this demographic compared to those observed in the general public with no antecedents of performing regular sport[6].

As our study group is a cohort of athletes subject to the discipline of top-level competition for years, it is of interest to discover if they continue to perform physical exercise, and at what intensity, or if they have become sedentary. We know the indirect estimation of the level of physical activity, objectively, by assessing whether the sinus bradycardia - the most common sign in the electrocardiogram of the athlete - remains the same, has reduced, or is not observed[7]. An electrocardiogram was performed at the start of top-level competition training and currently, having retired from competition.

Material and method

Longitudinal descriptive study of ex-athletes that had participated in top-level competition and that had left competition at least 5 years previously.

Study of the demographic

This group comprises a cohort of 157 ex top-level competition athletes whose initial heart rate electrocardiogram was lower than 50 beats/minute. 122 males (78%) and 35 females (22%) registered between 1960 and 1990 in the Sports Medicine and Health Unit of the Blume Residency, Sant Cugat CAR and Medical Service of the Barcelona Football Club.

The data was collected in a structured questionnaire with information about the initial history and follow-up. It includes information about the type of sport, hours of training per week during competition, years of participation and years past since retiring from competition. Information was also collected about the level of physical exercise that they are performing. Four levels of intensity were established: light (2-3 hours/week), moderate (3-5 hours/week), intense (5-7 hours/week) and very considerable (over 7 hours/week). Family history of cases of cardiovascular disease in first-generation family members, affectation of cardiovascular events, prevalence of CVRF (smoking, high blood pressure, dyslipidaemia, type 1 and 2 diabetes and obesity) and if they are undergoing medical treatment. All the participants underwent an initial electrocardiogram and another at the time of follow-up.

The sporting level was assessed through participation in national and international competitions, as well as by medals won (Table 1).

Information about the general public was collected through the 2018 Catalonia Health Survey[6].

This study was approved by the Hospital de la Santa Creu i Sant Pau ethics committee, and all participants signed the informed consent form.

Statistical analysis

A descriptive analysis was performed for the quantitative variables. For qualitative variables, contingency tables and the Mcnemar test were used. The results of the quantitative variables were presented as average and standard deviation. The paired t-test was used in individual comparisons.

A bivariate analysis was performed and the odds ratio (OR) and 95% confidence interval (95% CI) were calculated for each factor in relation to current bradycardia. The statistical package SPSS® (v 22.0) was used.

Results

A total of 157 ex-elite athletes participated in this study, 122 males and 35 females. The average age of starting competition was 17±4.6 years, and the average age of retirement from competition was 30±7.4 years. The average age at follow-up (current age) is 47±5.9 years. The most frequently practised sport was long-distance running in athletics

Table 1. Sporting history of participants in Spanish and International Championships (1960-1990).

Sporting participations	N
World level medals: gold/silver/bronze	
Olympic Games	2
World championships	8
European championships	27
State level medals: gold/silver/bronze	
Spanish championships	489
Participation in national teams	3,850
World level sporting participation	
World championships	105
Olympic Games	52
European championships	122

(42%), followed by swimming (22%) and others (36%), including football, basketball, volleyball, triathlon, pentathlon, rugby, cycling, judo, sailing and roller hockey. The average number of years participating in top-level competition were 12±7.4, and the average number of hours spent training each week during this time were 19±7.4 per week. Table 1 displays the number of participations in national and international competitions, as well as the number of medals won.

Sinus bradycardia

In accordance with the inclusion criteria, all the participants had a marked sinus bradycardia in the initial electrocardiogram (below 50 beats/minute) and 14% of participants had a heart rate of below 40 beats/second. In the follow-up study, 64% presented sinus bradycardia (below 60 beats/minute) and 18% had marked sinus bradycardia linked to the continuation of more intense physical exercise.

Cardiovascular risk factors

All the CVRF that were assessed at the start and during the follow-up of the study are displayed in Table 2. At the start of the study, 7% of the participants claimed to be smokers, and at follow-up, 8.9% smoked regularly, 5.7% smoked occasionally, and 21.7% were ex-smokers. At the start of the study, one participant (0.6%) had high blood pressure. At the time of follow-up, 12 participants (7.6%) had high blood pressure, of whom 4 took anti-hypertensive medication. None of the participants had diabetes at the start of the study, and 3 had diabetes treated with oral anti-diabetics (OAD) at the time of follow-up. A total of 13 participants (7.6%) at the start of the study had a BMI (body mass index) between 25 and 30 - considered overweight - and none were obese. At the time of follow-up, 49 (31.2%) were overweight, and 10 (6.3%) were obese (BMI >30).

Table 2. Prevalence of CVRF at the start of elite sport (initial) and currently (today).

	Initial		Current	
	N	%	N	%
Smoking	11	7		
Ex-smokers			34	21.7
Irregular smokers				
<1 cigarette/day			9	5.7
Smokers			14	8.9
Hypertension	1	0.6	12	7.6
Medication			4	
Cholesterol	4	2.5	23	14.6
Medication			7	
Diabetes	0	0	3	1.9
OAD Medication		3		
BMI				
Excess weight (BMI ≥25 ≤30)	13	7.6	49	31.2
Obesity (BMI>30)	0	0	10	6.3

IMC: índice de masa corporal; ADO: antidiabéticos orales.

Table 3. Comparison of prevalence of current CVRF of the elite athlete demographic and the CVRF of the general population.

	Ex-athletes (%)	General population (%)
Smoking		
Males	9	30.9
Females	8.6	20.5
High blood pressure		
Males	9.8	22.6
Females	0	23.7
Mellitus diabetes		
Males	2.5	7.6
Females	0	7.9
Obesity		
Males	4.1	15.7
Females	0	14
Hypercholesterolemia		
Males	18.2	16%*
Females	2.9	
Perform regular exercise		
Males	85	84.5
Females	82.9	81.1**

*No difference between males and females; **Result of international physical activity questionnaire (IPAQ - short).

The comparison of the prevalence of CVRF of the ex-athletes with those of the general population, is displayed in Table 3. In terms of smoking, there is a percentage difference for both males and females, as well as in high blood pressure and obesity. The values of hypercholesterolemia among males are similar. However, there is a difference between female ex-athletes and data from the general public. In terms of diabetes, differences can be seen among males and female ex-athletes compared to the general reference demographic.

Physical exercise

Regarding physical exercise, 24 (15.3%) of ex-athletes reported not performing any kind of regular exercise, 33 (21%) performed light activity, 47 (29.9%) moderate exercise, 32 (20.4%) intense activity, and 21 (13.3%) very considerable (Figure 1). The prevalence of sinus bradycardia is significantly higher among ex-athletes that performed higher-intensity physical exercise ($p<0.01$) (Figure 2).

Discussion

The changes in athletes produced through training, particularly of the cardiovascular system, have been studied in the so-called "athlete's heart"[8] context. Since the first references in which the only assessment was performed with an Electrocardiogram and thorax x-ray, to today, when assessments are made using a 24-hour electrocardiogram using the Holter method and image techniques with the echo-cardiogram,

Figure 1. Current physical exercise of ex-elite athletes.

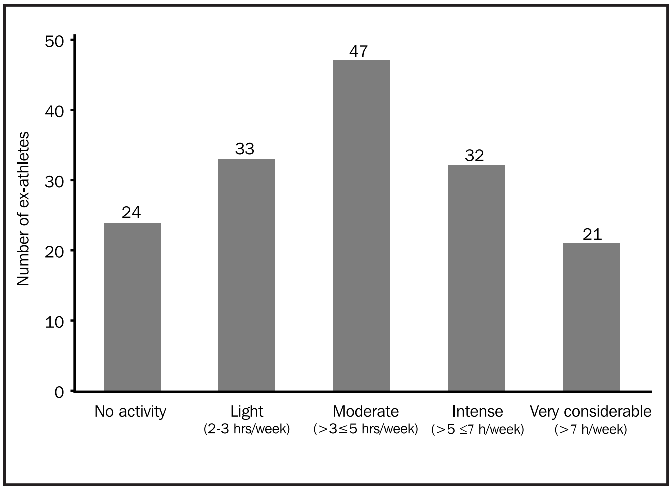
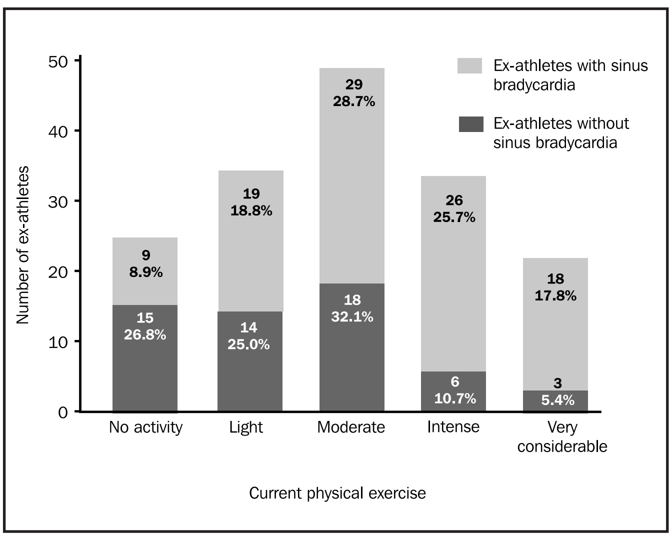


Figure 2. Relationship between current bradycardia and physical exercise.



magnetic nuclear resonance and isotopic nuclear medicine studies, new aspects are being discovered about structural changes, remodelling and function[8-11]. The continuance of physical exercise among ex top-level competition athletes or demographics who have trained for long periods of time, has generated interest in terms of discovering the cardiovascular changes in veteran athletes that have retired from top-level competition[12]. In these cases, in addition to those linked to age, are the appearance of cardiovascular risk factors (CVRF) associated with years, and that levels of training are generally less intense.

Competitive physical exercise has different aspects to consider, including health and sporting performance. Sport is associated with performance, but the foundation of this is a good state of health. For over 50 years, sporting aptitude has been assessed with marked clinical profile criteria, so the history of an athlete was similar to that of patients. The clinical history examination consisted in collecting family and personal data, physical exploration, electrocardiogram and basic analysis.

Currently, reviews have the same profile, which allows for broad information about health and aptitude for competition sport. In the Blume Residence medical centre and in the Sant Cugat CAR, these requisites are fulfilled, which has allowed us to have more information about family antecedents, CVRF such as blood pressure, smoking and plasma lipids. With this data, follow up has been performed on the athletes retired from top-level competition for at least 5 years. The current history provides the same information obtained with the personal interview, structured questionnaire and electrocardiogram. This allows the CVRF to be assessed in the athletes, and for comparison with the general public.

Bibliographic references generally focus on two separate aspects. On the one hand, the modifications that take place through training, and on the other, those observed in veteran athletes that have left top-level competition. Our study was performed on a cohort for whom there is a medical, sporting and analytical history, and knowledge of whether there have been cardiovascular risk factors. After retiring from competition, the presence of CVRF was analysed, as well as if there have been cardiovascular episodes, and the evolution of heart rate, which would be a key general indicator of the continuance of physical exercise or whether the subjects are sedentary, which is a less relevant risk factor.

The physical exercise they perform has been assessed in hours per week, as displayed in Figure 1, and the lowest heart rate is linked to moderate-high levels of activity. This data is consistent enough to be linked to CVRF that alter with physical exercise[1-4].

Studies have been carried out on veteran athletes that have retired from competition but have remained active. Pihl[13] studied active and sedentary athletes and compared them to veteran athletes who performed recreational sport. The CVRF (cholesterol and blood pressure) were lower and were linked to continuing to perform physical activity to date. Along the same line, Melekoglu[14] studied veteran football players, among whom the most active had better controlled CVRF than the least active members. The recommendation is the same as for the general population. Perform regular exercise and as far as possible, under a well-structured training programme.

The prevalence of coronary heart disease increases with age, particularly when there are also CVRF. Physical training causes a remodelling of the coronary arteries, so their diameter is wider, and they are more distensible, increasing the coronary reserve capacity[15].

Mengelkoch[16] has demonstrated that CVRF remain stable and low after a follow-up of 20 years of top-level athletes aged between 60 and 92 years, and who perform regular physical exercise. The recommendations made in primary and secondary cardiovascular disease prevention linked to physical exercise are extremely solid and insist upon method and regularity as basic elements. Optimum results can only be achieved this way. Another study performed on mass-level veteran athletes with lighter levels of training, also revealed that CVRF were lower, and also linked to the continuance of physical exercise to the current day[17], reaching similar conclusions about a broad sample, split into levels of physical exercise, and excluding carriers or those with a family history of CVRF. The higher the intensity of the physical exercise performed by veteran athletes, the lower the risk of coronary heart disease and heart illnesses linked to maintenance. Sarna[18] carried out a study in Finland with athletes who had participated in at least one top-level competition between 1920 and 1965. For aptitude, they included those who served military service. The follow-up on morbidity, mortality and life expectancy were better and the CVRF were lower than among sedentary groups. The type of exercise, preferentially aerobic and intense, is associated to increases in survival indices[19].

The active recommendation of the medical community in most specialities regarding the practice of physical exercise is due to the evidence of its favourable effects[20]. However, the presence of side-effects cannot be ignored, particularly in high-intensity physical exercise and veterans, which can be prevented or reduced by following indications and the appropriate method.

The results of our study of high-level ex-athletes were obtained by comparing all the initial clinical and CVRF information with that obtained after 5 years, at least, following retirement from competition, despite the challenge of finding said ex-athletes after so many years (Table 2).

The percentage differences with the general public are evident, for both males and females alike (Table 3). In terms of cholesterol, the differences are very slight among men and marked among women.

Regarding obesity in ex-athletes, 7.6% were overweight, whilst today this figure stands at 31%, with 6% obese. In any case, the values are lower than among the general public. Physical exercise level has been linked to the persistence of bradycardia given the close tie between both factors. Figure 2 displays the relationship between the continuation of physical exercise and current sinus bradycardia.

In summary, the study results from a cohort of 157 ex top-level competition athletes, on the one hand reveal the appearance of risk factors association to age, yet on the other, the prevalence is lower than among the general public, and they are physically more active.

Acknowledgements

Mrs Mónica Ortega, documentation manager of the Consell Català de l´Esport. Generalitat de Catalunya, Spain and the Cors Units Foundation.

Conflict of interest

The authors claim to have no conflict of interest whatsoever.

Bibliography

1. Boyer JL, Kasch FW. Exercise therapy in hypertensive men. *JAMA Cardiol.* 1970;211:1668-71.
2. Martin JE, Dubbert PM, Cushman WC. Controlled trial of aerobic exercise in hypertension. *Circulation.* 1990;81:1560-7.
3. Goldberg L, Elliot DL. The effect of exercise on lipid metabolism in men and women. *Sports Med.* 1987;4:307–21.
4. Rigla M, Sanchez-Quesada JL, Ordonez-Llanos J, Prat T, Caixas A, Jorba O, Perez A. Effect of physical exercise on lipoprotein(a) and low-density lipoprotein modifications in type 1 and type 2 diabetic patients. *Metab.-Clin. Exp.* 2000;49:640-7.
5. Sánchez-Quesada JL, Homs-Serradesanferm R, Serrat-Serrat J, Serra-Grima JR, González-Sastre F, Ordóñez-Llanos J. Increase of LDL susceptibility to oxidation occurring after intense, long duration aerobic exercise. *Atherosclerosis.* 1995;118:297-305.
6. Departamento de salud Generalitat de Catalunya. Resultados de la encuesta de salud de Cataluña (ESCA 2018). Disponible en: http://salutweb.gencat.cat/ca/el_departament/estadistiques_sanitaries/enquestes/esca/resultats_enquesta_salut_catalunya/.
7. Serra-Grima R, Puig T, Doñate M, Gich I, Ramon J. Long-term follow-up of bradycardia in elite athletes. *Int J Sports Med.* 2008;29:934-7.
8. G Pons Lladò F, Carreras JR, Serra Grima, *et al*. Insuficiencia valvular mitral detectada por ecocardiografia doppler en deportistas corredores de maratón. *Med Clin.* 1987;89:95-8.
9. Carrió I, Serra-Grima R, Berná L, Estorch M, Martinez-Duncker C, Ordoñez J. Transient alterations in cardiac performance after a six-hour race. *Am J Cardiol.* 1990;65:1471-4.
10. Martinez Dunker R, Carrió I, Serra-Grima J R, Berná L, Torres G, Estorch M. Adaptacion funcional biventricular durante una carrera de larga duración. *Rev Esp Cardiol.* 1992; 45:390-6.
11. Pujadas S, Doñate M, Chi-Hion Li, Merchan S, Cabanillas A, Pons-Lladó G, Alomar X, Serra-Grima R, Carreras F. Myocardial remodelling and tissue characterisation by cardiovascular magnetic resonance (CMR) in endurance athletes. *BMJ Open Sport Exerc. Med.* 2018; 4:e000422
12. Serra Grima JR, Doxandabaratz J, Ventura JL. The veteran athlete. An exercise testing electrocardiographic, thorax X-ray and echocardiographic study. *J Sports Med Phys Fitness.* 1981;21:122-9.
13. Pihl E, Jürimäe T, Kaasik T. Coronary heart disease risk factors in middle-aged former top-level athletes. *Scand. J Med Sci Sports.* 2007;8:229-35.
14. Melekoğlu, T, Sezgin, E, Işın, A, Türk, A. The effects of a physically active lifestyle on the health of former professional football players. *Sports (Basel).* 2019;7:75.
15. Thijssen DJH, Redington A, George KP, Hopman MTE, Jones H. Association of exercise preconditioning with immediate cardioprotection: A review. *JAMA Cardiol.* 2018;3:169-76.
16. Mengelkoch LJ, Pollock ML, Limacher MC, Graves JE, Shireman RB, Riley WJ, Leon AS. Effects of age, physical training, and physical fitness on coronary heart disease risk factors in older track athletes at twenty-year follow-up. *J Am Geriatr Soc*. 1997;45:1446-53.
17. Martin JE. Dubbert PM, Cushman WC. Controlled trial of aerobic exercise in hypertension. *Circulation.* 1990;81:1560–7.
18. Sarna S, Kaprio J, Kujala UM, Koskenvuo M. Health status of former elite athletes: The finnish experience. *Aging Clin Exp Res.* 1997;9:35-41.
19. Teramoto M, Bungum TJ. Mortality and longevity of elite athletes. *J Sci Med Sport.* 2010;13:410–6.
20. Harmon KG, Clugston JR, Dec K, Hainline B, Herring SA, Kane S, Roberts WO. American Medical Society for Sports Medicine position statement on concussion in sport. *Br J Sports Med.* 2019;29:87-100.

Evaluation of anthropometric and nutritional assessment of basketball players

Antonio J. Zamora[1], María L. Belmonte[2]

[1]Güel Centro de wellness. Murcia. [2]Universidad de Murcia.

Received: 16/08/2019
Accepted: 13/03/2020

Summary

Introduction: The aim of this study is to assess the nutritional status and measurement of body composition of basketball players from four teams of Valencia, three of them belonging to First National League and one belonging to the EBA League, in order to establish adequate dietary guidelines and anthropometric ideals.
Material and method: This is a study whose sample includes 17 men and 15 women. They were measured using the ISAK criteria, while intake was assessed by 3-days 24-hours food questionnaire.
Results: Significant differences ($p < 0.05$) were found in men by playing position in relaxed and flexed arm perimeters between centers and forwards, and height between guards and forwards, and guards and centers. Whereas in women there were significant differences ($p < 0.05$) in the wrist of guards and shooting guards, and shooting guards and forwards, also in the femur of shooting guards and center and height between guards and centers, and guards and shooting guards. No significant differences were found for somatotype. Statistically significant differences in the iron and fiber consumption between men and women were found. There were also statistically significant differences in fluid intake and training session time. Dietary intake was characterized by high fat and carbohydrates and protein moderate, with deficits in vitamin A, D, folic acid, calcium, zinc and magnesium for both genders. Women showed a specific deficit in iron. Furthermore, only 17.6% of men and 6.7% of women drank isotonic drinks during high intensity training, so the remaining players could worsen performance.
Conclusion: In order to enhance performance, a balanced diet which meets the physiological demands of the game could overcome these deficits.

Key words:
Anthropometry. Nutritional status. Diet. Basketball.

Evaluación antropométrica y nutricional de jugadores de baloncesto

Resumen

Introducción: El objetivo de este estudio es valorar el estado nutricional y medición de la composición corporal de jugadores de baloncesto pertenecientes a cuatro equipos de Valencia, tres de ellos pertenecientes a Liga Primera Nacional y uno perteneciente a la Liga EBA, con el fin de establecer unas pautas dietéticas apropiadas y unos ideales antropométricos.
Material y método: Se trata de un estudio cuya muestra está formada por 17 hombres y 15 mujeres, que fueron medidos siguiendo los criterios del ISAK, y cuya ingesta fue valorada mediante recuerdos 24-horas de alimentos durante 3 días alternos.
Resultados: Se encontraron diferencias significativas ($p<0.05$) en los hombres según la posición de juego en los perímetros de brazo relajado y flexionado entre aleros y pívots, y la talla entre bases y aleros, y bases y pívots. Mientras que en mujeres existieron diferencias significativas ($p<0.05$) en la muñeca de escoltas y bases, y escoltas y alteros, en el fémur de escoltas y pívots y la talla entre bases y pívots, y bases y escoltas. En cuanto al somatotipo, no se encontraron diferencias significativas. Respecto a la dieta, se encontraron diferencias estadísticamente significativas en el consumo de hierro y fibra entre hombres y mujeres. Y en el consumo de líquidos y el tiempo que duraba la sesión de entrenamiento. La ingesta dietética se caracterizaba por ser alta en grasas y moderada en carbohidratos y proteína, con déficits en vitamina A, D, ácido fólico, calcio, cinc y magnesio para ambos sexos. Las mujeres mostraron un déficit específico en hierro. Además, sólo el 17.6% de los hombres y 6.7% de las mujeres tomaban bebidas isotónicas durante el entrenamiento de alta intensidad, por lo que los restantes jugadores podrían empeorar el rendimiento.
Conclusión: Es por ello, que una dieta equilibrada a las demandas fisiológicas del juego podría solventar estos déficits y aumentar el rendimiento.

Palabras clave:
Antropometría. Estado nutricional. Dieta. Baloncesto.

Correspondence: María L. Belmonte
E-mail: marialuisa.belmonte@um.es

Introduction

Basketball is a sport in which, a combination of ability to hit, speed of movement, defensive capacity and strength with a high level of physical and technical-tactical demand takes place[1]. This sport requires a high demand of aerobic metabolism that would provide the energy required to maintain the effort during the game time, while anaerobic metabolism would serve to perform the most demanding game actions, therefore, it is the predominant metabolism in the positions with less mobility.

There are studie[2-5] in which there have been differences in anthropometric variables, body composition and somatotype of players of different sports, and even differences between athletes of the same sport according to his role in the team. specifically, in basketball, depending on the position, having shown that there is variability among athletes who practice team sports, depending on the area or position in which they play[6], there are guards, shooting guards, strikers and centers, each of them with specific anthropometric and somatotype characteristics to achieve athletic success.

In basketball, anthropometric characteristics are decisive in sports performance[7]. The kinanthropometry allows the study of the body composition using a minimally invasive method by the sum of skinfolds and corrected perimeters[8].

Establish an adequate nutrition procedure and hydration strategies are critical to success nutrition interventions, because an inadequate nutrition can impair physical performance and health in athletes. Court team sports are characterized by intermittent activity with a big requirement of dietary carbohydrate sources to maintain and replenish glycogen, so inadequate carbohydrate consumption can lead to overtraining[9]. Athletes who perform high intensity exercise do best on a diet rich in carbohydrates with a recommended amount depending on the intensity and duration of the training[10]. Moreover, micronutrients can impact on the exercise capacity and performance when intakes are less than recommendations some functional impairments occur[11]. Maintaining a correct energy balance and a nutrient dense diet with a proper training and rest are the keys to enhance performance[12]. With the purpose to optimize performance and promote healthy habits in basketball players a well-designed nutritional intervention is necessary[13].

Therefore, the aim of this study was to examine body composition differences by position and sex and assess nutritional status in male and female basketball players in order to improve their physical performance.

Material and method

A cross-sectional descriptive study of 32 male and female basketball players of Spanish lower leagues was completed. Inclusion criteria were: men and women over 18 years, not currently injured.

Height, weight, skinfolds and corporal diameters and circumferences were measured according to the International Society for the Advancement of Kinanthropometry (ISAK) criteria. Using an OMROM BF 5-11 weigh scale, a Tanita Leicester stadiometer, a CESCORF bicondylar caliper, a CESCORF Skinfold caliper and a 1.5m flexible tape.

Data about macronutrient and micronutrient intakes of each person in this study were collected using 24-hour dietary recall and food frequency intakes.

A questionnaire about lifestyle habits related to nutrition and intensity of exercise was conducted in order to calculate the total expenditure waste of each athlete. Data were collected in the form of questionnaires about sex, age, player position, training intensity, rest in sport and general lifestyle habits in order to define the study population. Both dietary questionnaires were processed by the EasyDiet Program, which is a software for design and analysis of diets, based on Spanish food composition tables and recommendations.

Patients were informed of the purpose, conditions, procedures and time schedule, accepting voluntarily participate in the study. They all signed an informed consent approved by the Ethics Committee of the University of Valencia, in order to apply the principle of patient autonomy.

In this paper, all population data were collected in Microsoft Excel 2010, and exported to SPSS version 21.0 (SPSS Inc., Chicago, IL, USA) for statistical analysis.

In order to study the characteristics of basketball players with different sex, the study population was divided into two groups: male and female players. For anthropometric valuation, every gender group was subdivided into four subgroups according to their position on the court: guards, shooting guards, forwards and centers.

The mean, standard deviation and percentages of the total population and the sample size defined by sex were calculated for all descriptive and frequency variables under study.

According to normality and homocedasticity criteria Student's *t*-test or Mann- Whitney U test were used to determine statistically significant differences between populations divided by gender respecting to the sociodemographic characteristics of the population (age, sex, exercise intensity, etc.), anthropometric (Body Mass Index, waist- hip ratio, body fat, body mass, etc.), total waste expenditure, macronutrients and micronutrients intake, and percentage of these that meet the nutritional requirements for Spanish population.

The association between qualitative variables of the two populations with different sex (sociodemographic characteristics of the population) and somatotype were determined using the Chi-square test of Pearson.

Results

Sociodemographic characteristics of total population

We can see sociodemographic data of basketball players by sex (Table 1).

Anthropometry

Table 2 shows the anthropometric differences between basketball players by sex and court position. The only one anthropometric variable with significant differences ($p<0.05$) in men by playing position were relaxed and flexed arm between forwards and centers and the height between guards and forwards, and guards and centers. On the other hand, there were found some significant differences ($p<0.05$) for women by court position in wrist diameter between shooting guards and guards, and between shooting guards and forwards. Moreover, femur diameter between shooting guards and centers had significant differences and height between guards and centers, and between guards and shooting guards.

Table 1. Sociodemographic data of basketball players by sex.

	Male players	Female players
Total population (%)	53.1%	46.9%
Age (medium ±SD)	21.3±3.2	22.1±3.1
Basketball team (%)		
Valencia basket male	41.2%	0%
Nacional paterna	58.8%	0%
Valencia basket female	0%	66.7%
El Pilar	0%	33.3%
Court position (%)		
Guard	11.8%	20.0%
Shooting guard	17.6%	13.3%
Forward	29.4%	40.0%
Center	41.2%	26.7%

SD: Standard deviation.

For somatotype components, no significant differences were found by position in endomorphy, mesomorphy or ectomorphy. The somatochart by court position of male player can be observed in Figure 1 and the somatochart of female player can be observed in Figure 2.

Nutritional status assessment

There were no statistically significant differences in thee intake of any parameter by court position. There were significant differences by sex in the percentages of the daily recommended intake of iron and fiber. In the macronutrients analysis, male players consumed 2.7±0.8 gr•kg^{-1}•day of carbohydrates while protein intake was 1.4±0.4 gr•kg^{-1}•day. For female players, carbohydrate intake were 1.4±0.4 gr•kg^{-1}•day, while protein were 1.4±0.5 gr•kg^{-1}•day. Table 3 shows the average values obtained from the 24 hours food intake recall questionnaires. Figure 3 shows the macronutrients distribution in male basketball players. This distribution also can be seen in Figure 4 for female players. Table 4 shows the percentage of people who meet the daily nutritional requirements according to the daily recommended intake.

Table 2. Anthropometric data of basketball players by sex and court position.

	Male players							
	Guard	S. Guard	Forward	Center	Guard	S. Guard	Forward	Center
Weight (kg)	87.5±1.6	93.1±18.9	85.6±4.0	96.0±9.0	69.9±12.2	63.1±4.2	69.0±2.8	70.1±4.2
Height (cm)	179±0.1	189±0.1	193±0.1	195±0.1	168±0.1	171±0.1	175±0.1	180±0.1
Arm circumference (cm)	32.0±0.8	32.8±4.2	30.8±0.6	34.7±2.1	29.0±5.2	27.0±2.1	28.0±1.6	27.4±0.8
Flexed arm circumference (cm)	34.0±1.7	34.9±5.2	32.7±1.2	37.1±1.8	28.9±4.7	26.9±1.7	28.6±1.3	27.9±0.7
Waist circumference (cm)	87.6±0.7	85.1±6.6	76.2±10.5	86.2±4.7	76.1±8.0	70.7±6.8	74.8±3.0	72.0±2.3
Hip circumference (cm)	103.4±1.6	107.7±10.7	100.4±2.5	106.1±4.7	103.4±7.9	100.0±1.0	101.9±3.3	104.1±3.4
Thigh circumference (cm)	60.8±4.9	60.0±3.5	57.2±2.8	65.8±11.1	60.5±6.2	55.7±3.5	57.4±2.6	58.0±1.9
Leg circumference (cm)	42.4±1.5	37.3±2.5	38.9±1.9	40.6±3.1	37.2±1.2	34.7±0.9	36.4±2.4	36.4±1.4
Subescapular skinfold (mm)	11.1±0.2	12.4±4.6	9.4±2.5	10.3±4.3	10.9±4.0	10.9±3.3	11.7±2.5	9.6±2.1
Tricipital skinfold (mm)	12.7±1.7	13.9±2.0	9.9±3.9	12.2±5.6	14.9±7.2	14.2±4.6	16.7±4.6	18.6±3.0
Bicipital skinfold (mm)	5.1±0.5	7±0.9	3.7±1.6	5.6±3.0	8.9±6.8	6.7±3.5	7.9±2.2	5.9±0.3
Ileocrestal skinfold (mm)	20±1.7	15.1±3.2	12.2±3.9	16.0±6.8	17.6±4.9	18.7±8.5	18.3±4.4	14.4±1.0
Supraespinal skinfold (mm)	13±1.7	11.9±1.9	7.8±2.5	12.9±6.9	17.5±9.4	12.0±5.3	13.7±3.3	12.2±2.3
Abdominal skinfold (mm)	23.7±8.8	22.1±4.5	13.4±4.7	23.2±7.6	23.7±11.0	20.0±7.8	24.7±8.6	20.7±3.9
Anterior thigh skinfold (mm)	15.1±1.9	19.2±7.9	13.0±4.9	16.4±6.2	28.9±4.7	25.6±6.9	24.9±4.9	26.8±3.3
Leg skinfold (mm)	10.2±2.8	12.1±4.5	7.4±2.0	8.0±4.1	16.0±5.3	12.5±8.5	15.2±7.8	16.5±2.0
Femur diameter (cm)	10.1±0.1	10.3±0.7	10.3±0.3	10.3±0.2	9.3±0.3	8.5±0.7	9.2±0.3	9.4±0.1
Wrist diameter (cm)	6.1±0.2	6.1±0.6	6.2±0.2	6.1±0.1	5.4±0.2	4.9±0.1	5.3±0.1	5.2±0.1
Endomorphy	3.6±0.1	3.5±0.4	2.4±0.9	3.1±1.4	4.3±1.7	3.7±1.4	4.1±0.9	3.9±0.4
Mesomorphy	5.5±0.5	3.8±2.0	3.5±0.4	4.2±1.1	3.6±0.6	2.2±0.9	2.4±0.9	2.3±0.1
Ectomorphy	1.0±0.1	2.2±1.6	3.6±0.8	2.7±1.1	1.5±1.0	2.9±1.5	2.8±0.6	3.3±0.2
Muscle mass (%)	36.3	39.4	43.6	41.5	36.7	37.1	37.7	36.7
Bone mass (%)	15	15.8	17.7	15.9	14.9	14.8	15.7	16.0
Fat mass (%)	17.7	23.7	12.2	17.0	21.6	19.0	20.7	19.0
Residual mass (%)	22.6	23.7	26.5	25.6	26.7	29.1	25.8	28.3

Figure 1. Somatochart in male basketball players by position.

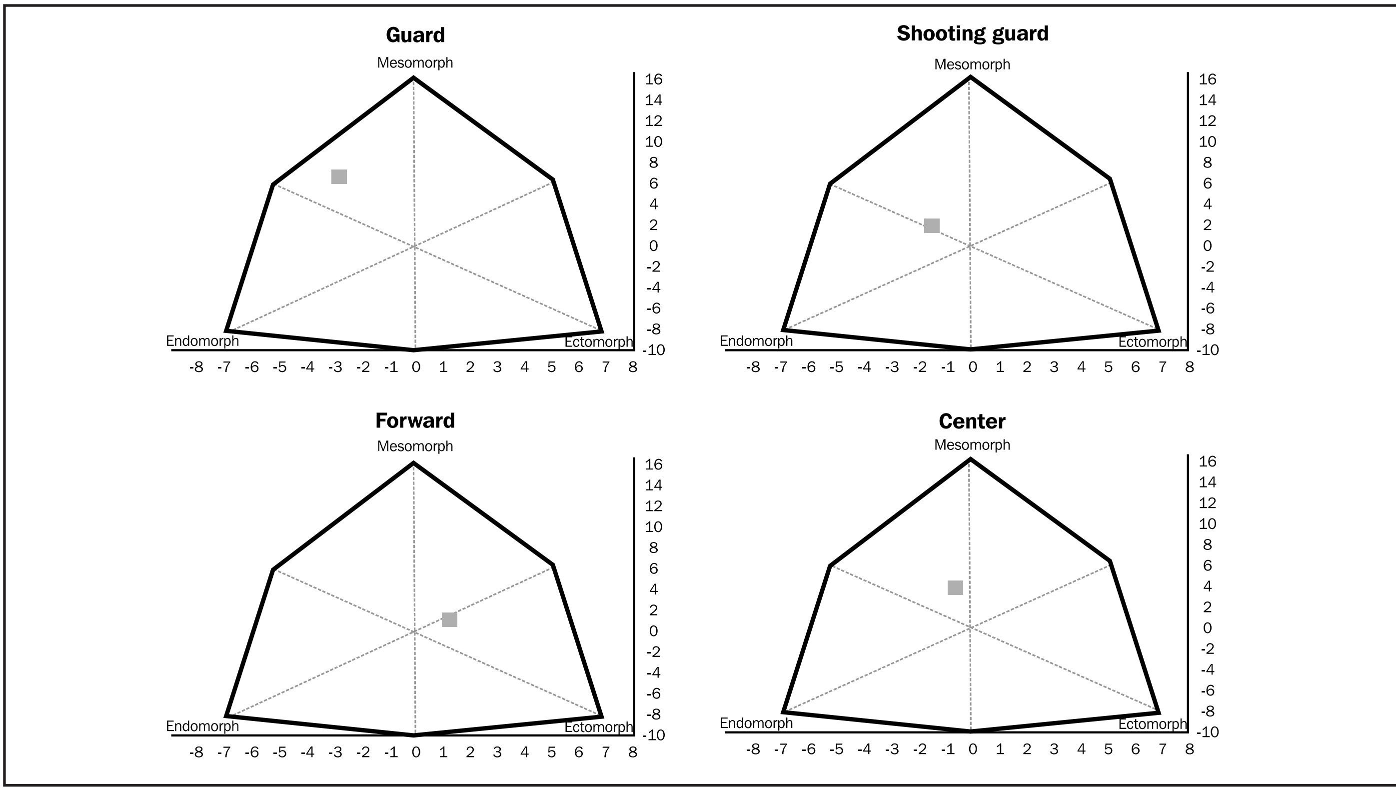


Figure 2. Somatochart in female basketball players by position.

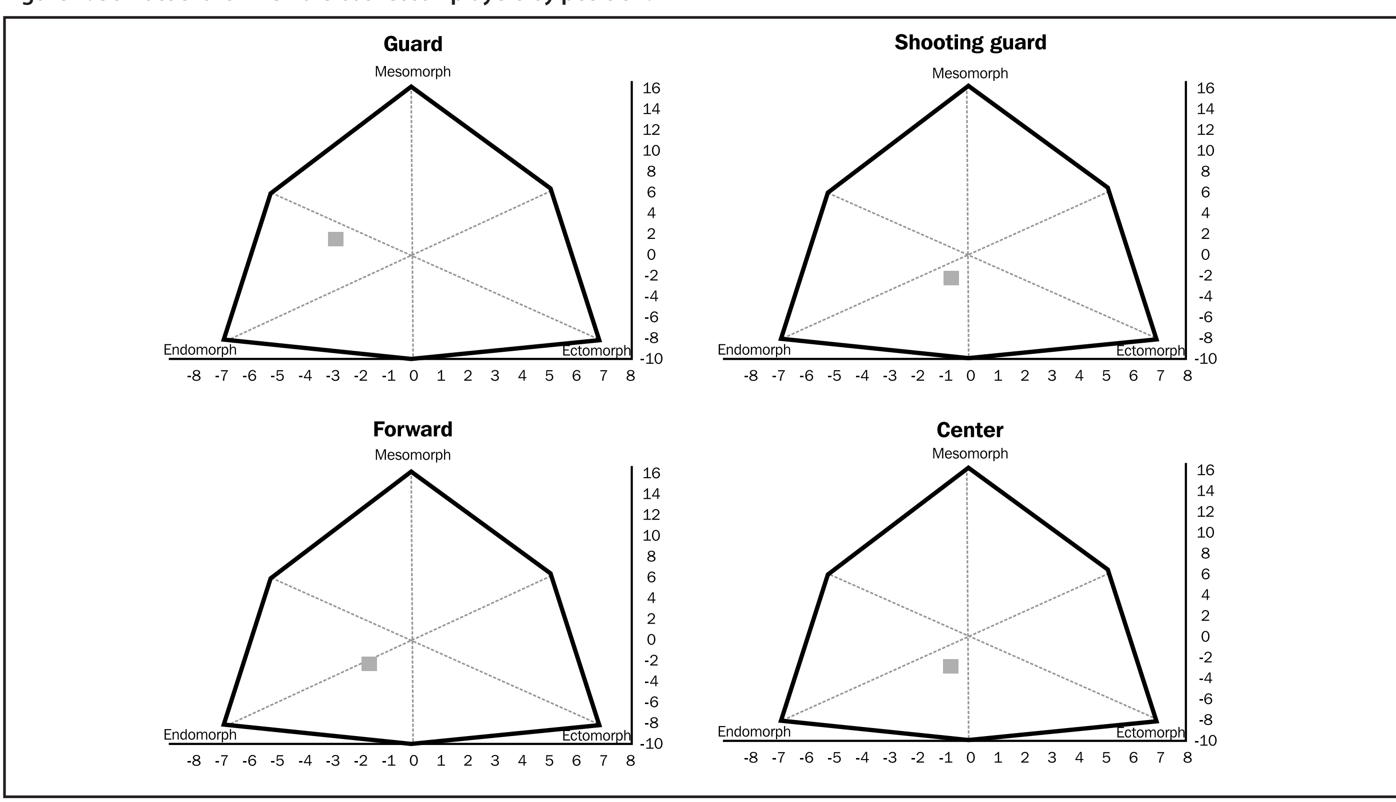


Table 3. Macronutrients and micronutrients intake obtained by 24-hours recall and percentage of the dietary recommended intake.

	Male players			Female players		
	Medium	SD	DRI percentage	Medium	SD	DRI percentage
Energy (kcal)	2313.8	380.0	73.8	1973.9	612.7	82.3
Protein (gr)	122.8	27.5	76.4	99.2	30.3	78.8
Folic acid (µg)	354.3	173.7	88.6	297.4	120.2	74.4
Monounsaturated fatty acids (gr)	43.1	9.8	168.9	41.6	14.4	190.1
Polyunsaturated fatty acids (gr)	12.1	0.7	47.0	14.3	11.4	59.6
Saturated fatty acids (gr)	27.6	8.6	133.6	24.7	12.3	138.1
Calcium (mg)	864.8	289.7	78.1	781.1	248.7	64.0
Cinc (mg)	12.4	4.1	83.0	10.1	3.4	84.2
Fiber (gr)	29.8	11.1	99.4	21.5	8.7	71.7
Phosphore (mg)	1752.7	496.5	203.5	1382.8	408.4	186.8
Carbohydrates (gr)	249.2	55.1	55.7	193.8	69.1	56.8
Iron (mg)	16.3	6.1	151.2	12.7	4.1	84.9
Fats (gr)	90.4	19.9		88.7	39.5	
Magnesium (mg)	395.0	142.2	98.7	295.0	96.0	83.6
Niacine (mg)	37.3	14.4	201.9	24.0	9.5	160.0
Potasium (mg)	3733.7	966.5	124.4	3105.3	997.2	103.5
Sodium (mg)	3032.2	950.3	202.1	1981.0	795.6	132.1
Vitamine A (µg)	852.9	414.1	85.3	784.5	552.6	98.1
Vitamine B1 (mg)	2.0	0.9	165.7	1.5	0.9	140.2
Vitamine B12 (µg)	8.7	4.0	361.3	6.6	5.0	273.9
Vitamine B2 (mg)	2.1	1.0	126.5	1.9	0.6	152.3
Vitamine B6 (mg)	3.0	1.1	199.2	2.1	0.9	160.0
Vitamine C (mg)	111.0	65.9	185.1	114.2	65.1	190.3
Vitamine D (µg)	3.4	3.0	68.3	1.7	1.2	33.1
Vitamine E (µg)	11.0	0.6	109.64	10.5	4.6	130.7

Figure 3. Macronutrients distribution of male basketball players.

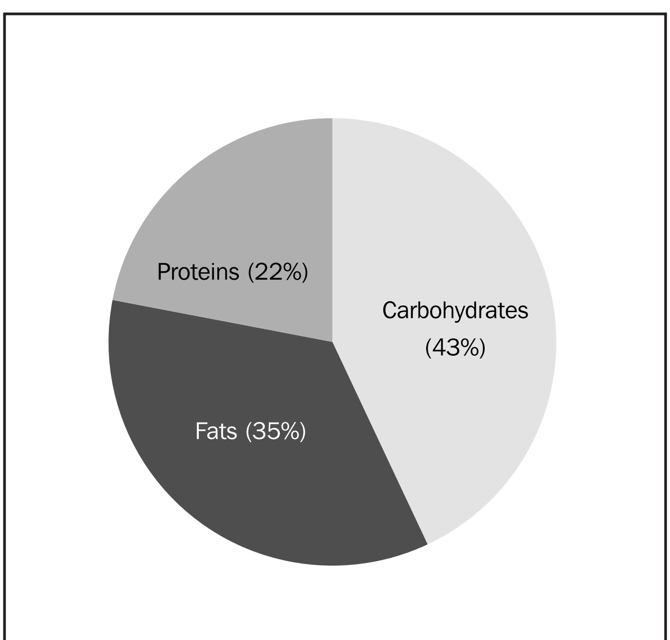


Figure 4. Macronutrients distribution of female basketball players.

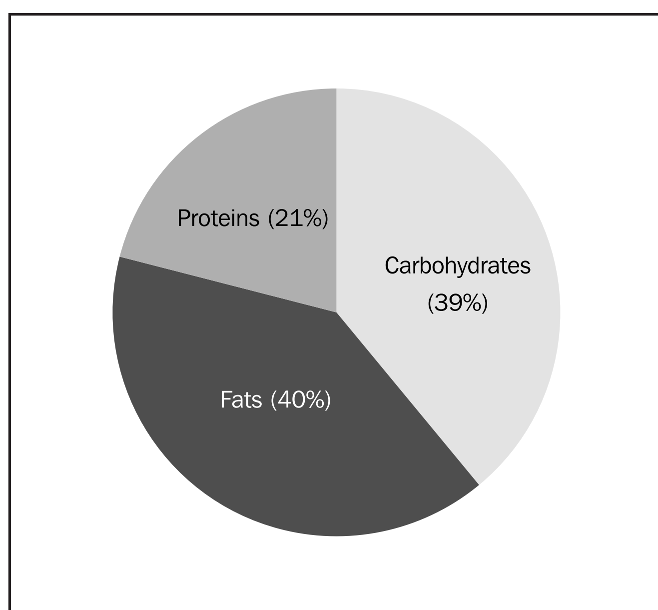


Table 4. Percentage of basketball players who meet the dietary recommended intake.

	% Dietary recommended intake	Male	Female
Energy	<100	82.4	92.9
	≥100	17.6	7.1
Protein	<100	82.4	71.4
	≥100	17.6	28.6
Carbohydrates	<100	100.0	92.9
	≥100	0	7.1
Folic acid	<100	76.5	86.7
	≥100	23.5	13.3
Calcium	<100	82.4	86.7
	≥100	17.6	13.3
Cinc	<100	76.5	80.0
	≥100	23.5	20.0
Fiber	<100	52.9	86.7
	≥100	47.1	13.3
Phosphore	<100	0	6.7
	≥100	100	93.3
Iron	<100	11.8	66.7
	≥100	88.2	33.3
Magnesium	<100	64.7	73.3
	≥100	35.3	26.7
Niacine	<100	5.9	6.7
	≥100	94.1	93.3
Vitamine A	<100	82.4	60.0
	≥100	17.6	40.0
Vitamine B1	<100	11.8	26.7
	≥100	88.2	73.3
Vitamine B12	<100	5.9	20.0
	≥100	94.1	80.0
Vitamine B2	<100	41.2	6.7
	≥100	58.8	93.3
Vitamine B6	<100	5.9	13.3
	≥100	94.1	86.7
Vitamine C	<100	29.4	26.7
	≥100	70.6	73.3
Vitamine D	<100	76.5	100.0
	≥100	23.5	0
Vitamine E	<100	41.2	40.0
	≥100	58.8	60.0

Table 5. Basketball player's liquid intake during training time.

	Male players	Female players
Water	76.5%	93.3%
Sweet drinks	5.9%	0
Isotonic drinks	17.6%	6.7%

Dietary habits

There were found significant statistically ($p<0.05$) differences between trainings session duration and the fluid intake during the training session. Liquid water was consumed by the 83.3% of player, while the 13.3% consume isotonic drinks and 3.3% of them drink sweetened drinks during the training session. The hydration behavior during the training session can be seen in Table 5. Only 5.9% of men and 6.7% of women did not drink any liquid during the training session, which duration was 107.6±15.2 minutes for male players and 114.0±12.4 minutes for female players.

Statistically analysis

Medium and standard deviation were calculated of all quantitative variables and percentages were calculated for qualitative variables.

All anthropometric parameters follow normality and homoscedasticity criteria, so the ANOVA test was used in order to study the significant differences of basketball players by sex and according to their court position

In the analysis of nutrient intake by sex, the percentage of iron consumed not follow the normality criteria so the statistical Mann-Whitney *U* test was used. In the other side, the percentage of fiber follows the normality and homoscedasticity criteria so the Student's *t*-test was used to calculate their signification level. Similarly, the Mann- Whitney *U* test was used to calculate the level of significance between fluid intake and workout time because they did not follow normality and homoscedasticity criteria.

Discussion

The success in collective sports depends on numerous external and internal factors, among which the anthropological characteristics of the players are of special interest. In addition, one of the main components of these anthropological characteristics is, without a doubt, the anthropometric characteristics, object of long-term studies by sports scientists[14].

The anthropometric study of athletes is an instrument used for the functional characterization of athletes[15].

In basketball the most common is ecto-mesomorph somatotype. It is a very homogeneous somatotype, and has little tendency to endomorphy[8]. In the study population the results are variables by sex and position. The average somatotype in male guards and centers were endo-mesomorph, in male shooting guards had a mesomorph-endomorph somatotype and male forwards had a mesomorph-ectomorph somatotype so anyone of these group of basketball players. Comparing each position with the somatotype reference values in elite sports[16] there are some differences. Most common somatotype in male guards is 2.4 – 5 – 3 and in this study population were 3.6 – 5.5 – 1.0 so the endomorphic and mesomorphic components are above the mean values while ectomorphic component is under the mean value for guards. The same happens in shooting guards where most common somatotype is 2.1 – 4.4 – 3.5 and the somatotype in this group of basketball players were 3.5 – 3.8 – 2.2 so can be observed again how ectomorphic and mesomorphic component is under recommendation and endomorphic component is above recommendation. In elite forwards basketball players, the most common somatotype are 2.2 – 4.7 - 3.3 and in that study population the somatotype values were 2.4 – 3.5 – 3.6 where endomorphic and ectomorphic component were really similar to elite standards but mesomorphic compound is under recommended values. For elite centers the recommended somatotype values are 2.8 – 3.9 – 3.7

and the values of these study centers were 3.1 - 4.2 – 2.7, so as can be endomorphic and mesomorphic values are really similar to recommendation but again ectomorphic value is under recommendation. These variations could be caused by the fact that the study population are not elite basketball players. In the case of female basketball players, there isn't as much data in elite sport to compare the somatotype by position, but in general terms female basketball players presents great heterogeneity and tendency toward the meso-endomorphy[8]. There is a study which compares female elite basketball players somatotype and the findings of this study show that guards are more mesomorphic than centres and less ectomorphic than both forwards and centers[17]. The same happens in this study population where guards were the most mesomorphic and less ectomorphic comparing every court position which can be generate competitive advantages for this female guards group. In our study population that heterogeneity also can be seen where the most common somatotype in female guards were the meso-endomorphy too but this somatotype changed in the other positions, shooting guards and centers had an ecto-endomorph somatotype and female forwards had a balanced-endomorph somatotype.

Height affects both men and women, but more decisive in females. There are variables that provide competitive advantages. Some of the most significant differences in men are: femur biepicondylar diameter and mesomorphy; and women: height, percentage of fat, endomorphy and mesomorphy[8]. Based on this, in the guards male players studied there are a smaller femur diameter than the other positions, but mesomorphy is bigger than any other player position. Meanwhile female centers studies had more height than any other player position however were female guards who had more fat percentage, endomorphy and mesomorphy than any other court position.

Fat mass index could be a competitive advantage in female basketball players[8]. However, there are studies that recommend an optimal fat percentage in basketball players of about 6-12% in men and 10-16% in women[18]. According to this information all basketball players in this study had more fat than the recommendation, so that excess fat wouldn't be a competitive advantage in women. Only male forwards with a 12.2% of fat are closer to the upper interval of the recommendation, so a smaller percentage of fat could improve the player performance.

The recommended amount of macronutrient intakes varies between some authors. Carbohydrates are important to restore glycogen levels and improve physical performance, according to Burke the recommended amount is between 5-7g·kg^{-1}·day (Burke). In the study population the average amount of carbohydrates intake was 2.8±0.8 g•kg•day in men and 2.8±1.g•kg•day in women. This means that almost the whole population had an intake below the recommendations which can affect in their glycogen recover after exercise and might not be sufficient for a rapid recovery from training and competition, high intensity, intermittent activity typical for team sports can deplete muscle glycogen stores by up to 72% in less than 10 minutes[19]. The fact that the 92.1% of these players didn't meet the carbohydrates requirement means that they should increase their carbohydrates intake until meeting the requirement using low glycemic index foods rich in fiber before exercise and high glycemic index foods poor in fiber after exercise for a quickly glycogen recover[20].

In the last years basketball is evolving to a game faster and more physique than before. Regarding the proteins, an adequate intake is essential to maintain the lean mass promoting the protein synthesis. The amount recommended varies by the nature of the effort, so in a physique game like basketball the protein intake should be 1.8g·kg^{-1}·day[21]. Proteins don't have an important energetic function during the physical activity but have a main role to have an optimal physical performance. In the sample size of the present study male and female basketball players protein intake were 1.4g•kg^{-1}•day which is less than recommendation for both groups and this is lower than that observed in Spanish elite basketball players (2.3g•kg^{-1}•day)[22]. In these training levels a protein deficit might produce a decreased capacity to generate the maximum strength power which can be traduced in less physical performance in the court[21].

In respect of fats, it is important to know what the main sources of the diet is. Recommendations about saturated fatty acids, polyunsaturated fatty acids and monounsaturated fatty acids are 7-8% for SFA, 10% for PUFA and more than 10-15% for MUFA maintaining total fats in a 20%-35% interval[23]. The male basketball players in this study had a fat intake of 35%, meanwhile female basketball players had a fat intake of 40% being above the recommended interval, having both groups an increased intake of saturated fatty acids instead of polyunsaturated fatty acids which are under the recommended percentage.

Related to micronutrient intake, in the assessment of vitamins intake it can be seen that vitamin A and D are below the recommended requirements for male and female basketball players according to Spanish recommendations[24]. On the other hand, the mineral intake assessment shows that minerals such as folic acid, calcium, cinc and magnesium are below recommendations for both groups and female players have a specific deficit in iron.

Almost any of these players met the carbohydrates recommendations, in terms of improving their performance male and female basketball players should meet the recommendation eating sources of non-processed carbohydrates like whole grains, fruits and vegetables in order to meet the fiber recommendation especially in female players who presents a bigger deficit. In order to meet the protein requirements for basketball male and female player should eat more lean meats, sea food and eggs which are sources with a high protein and low saturated fat contain. Saturated fats which can be found in fatty meats, full fat dairies and processed foods that contain these fats should be reduced instead polyunsaturated fats sources like fatty fishes, seed oils and nuts.

Micronutrients as vitamins and minerals play an important role in some metabolic pathways (energy production, hemoglobin synthesis, maintenance of healthy bones, immunology function, protection against oxidative stress, etc.)[23]. Liposoluble vitamins like vitamin A and D can be stored in the adipose tissue. Vitamin A has an important role in the immune function maintaining the epithelial cell functions. In this study population it is observed a deficit for male and female players. In the scientific literature there are only a small percentage of athletes with an inadequate intake of vitamin A and there is no evidence that these athletes have biochemical deficiencies. In terms of performance, whether β-carotene provide any ergogenic effect is yet to be determined[11]. An inadequate intake of vitamin D is observed for both groups. When cutaneous endogenous production is limited like happens in indoor sport like basketball, diet is the main source of vitamin D. Fatty fish is the main source of dietary vitamin D, so if the basketball player dislikes fatty fish or consume only a limited amount of it, vitamin D supplementation could be required to avoid deficits. The consumption in male players of this study were 3.4±3.0 µg which is similar to the results of Bescós and Guisado in a study with Spanish professional basketball players were the dietary vitamin D intake were 3.5±1.9 µg[25]. In the other hand, water-soluble vitamins cannot be stored so there is necessary to intake them daily. In our study population, Folic acid is the only one water-soluble vitamin under recommendations. A deficiency of folate causes abnormal cell replication in the erythropoietic system which could cause megaloblastic anemia. There are limited data about physiological benefits of folate supplementation in order to improve physical performance[11].

Calcium is involved in a several number of physiological processes of the energy metabolism and muscular contraction. It also enhances the absorption of vitamin D[25] and magnesium. That magnesium could have an important role in strength performance specially when there is an inadequate intake[26] however these effects in performance does not happen when magnesium status is normal. In our sample size male and female player had an intake under recommendations of calcium and magnesium with coincide with other studies in team sports athletes[25]. In addition, there is observed a zinc deficit for male and female players. Physical activity reduces the levels of serum zinc which can produce a lower physical performance[27]. Some studies have found iron depletion and anemia in elite basketball players[28]. Female players in this study had a low iron intake with a 84.9% of the DRI's and this deficit could be greater when these female players have the iron menstruation losses[29]. Iron deficiency without anemia impairs work performance promoting skeletal muscle fatigue[11] so iron repletion will decrease fatigue improving overall vitality and performance[28].

An adequate hydration status is fundamental in order to do a physical activity which guarantees an optimal health and physical performance. An exogenous amount of glucose can decrease the consumption of muscular glycogen during the physical activity and the addition of sodium and potassium amounts can maintain an adequate hydration status avoiding the hyponatremia. In general terms, during a high intensity physical activity it is recommended an isotonic drink consuming 150-200 ml every 15-20 minutes[30]. In this study population the most consumed drink during exercise was water in a 76.5% of male players and 93.3% of female players. Categorizing basketball as a high intensity physical activity and viewing that the exercise duration is near 120 minutes an isotonic drink it is necessary to better maintain skill and sprint performance than when ingesting water alone[31].

In summary, anthropometric measurement of a group of male and female basketball players of the National Spanish Basketball League was characterized by an excess of fat mass in both groups except for male forwards, so that high percentage could cause worse physical performance. The average somatotype in male guards and centers were endo-mesomorph, in male shooting guards were mesomorph-endomorph and male forwards were mesomorph-ectomorph which differs of the homogenous ecto-mesomorph somatotype for male players described previously. In the case of female players, the heterogeneity of their somatotype was shown in the present study.

Dietary intake was characterized by a high fat consumption. Saturated fat intakes were higher than recommended for a healthy diet and polyunsaturated were above recommendations. Hypovitaminosis and hypomineralosis were found in almost all micronutrients studied, moreover the main fluid intake during the long high intensity training comes to water instead of isotonic drinks, which can result in a worse performance. These results indicate that a more professional advice, ideally by sport nutritionists, would be necessary to improve dietary habits and drinking patterns of male and female basketball players.

Conflict of interest

The authors do not declare a conflict of interest.

Bibliography

1. Paredes CA, Pérez-Rodríguez M. Estrategia para la selección de talentos en el baloncesto, categoría liga cantonal de milagro. *Revista Científica Olimpia.* 2019;16:1-12.
2. Alacid F, Mayor JM, López-Miñarro PA. Perfil antropométrico del canoísta joven de aguas tranquilas. *Int J Morphol*. 2011;29:835-40.
3. Guillén L, Ayuso J, Norte-Navarro A, Cejuela R, Cabañas MD, Martínez-Sanz JM. Composición corporal y somatotipo en triatletas universitarios. *Nutr Hosp*. 2015;32:799-807.
4. Chena M, Pérez-López A, Álvarez I, Bores A, Ramos-Campo DJ, Rubio-Arias JA. Influencia de la composición corporal sobre el rendimiento en salto vertical dependiendo de la categoría de la formación y la demarcación en futbolistas. *Nutr Hosp.* 2015;32:299-307.
5. Mangine GT, Hoffman JR, Frafala MS, Vazquez J, Krause MC, Gillett J. Effect of age on anthropometric and physical performance measures in professional baseball players. *Journal Strenght Cond. Research*. 2015;27:375-81.
6. Amador M, Mermelo M. Métodos para evaluar la composición corporal en humanos. Coordinación Académica Faces. Caracas: UCV; 2013.
7. Garcia-Gil M, Torres-Unda J, Esain I, Duñabeitia I, Gil SM, Gil J, Irazusta J. Anthropometric parameters, age, and agility as performance predictors in elite female basketball players. *J. Strength Cond. Res*. 2018;32:172-330.
8. Herrero de Lucas A, Esparza-Ros F, Cabañas-Armesilla MD. Características antropométricas de los deportes olímpicos de verano. En: Cabañas MD, Esparza F. Editores. *Compendio de Cineantropometría*. Madrid: CTO; 2009; 295-8.
9. Holway FE, Spriet LL. Sport-specific nutrition: practical strategies for team sports. *J. Sports Sci.* 2011;29:115-25.
10. Antonio J, Kalman D, Stout J, Greenwood M, Willoughby D, Haff G. *Essentials of sports nutrition and supplements.* New Jersey. Humana Press; 2008;38.
11. Lukaski HC. Vitamin and mineral status: effects on physical performance. *Nutrition.* 2004;20:632-44.
12. Kreider RB, Wilborn CD, Taylor L, Campbell B, Almada AL, Collins R, Cooke M, Earnest CP, Greenwood M, Kalman DS, Kerksick CM, Kleiner SM, Leutholtz B, Lopez H, Lowery LM, Mendel R, Smith A, Spano M, Wildman R, Willoughby DS, Ziegenfuss TN, Antonio J. ISSN exercise & sport nutrition review: research & recommendations. *J Int Soc Sports Nutr.* 2010;7:7.
13. Mujika I, Burke LM. Nutrition in team sports. *Ann Nutr Metab.* 2010;57:26-35.
14. Pireva A. Anthropometric and body composition differences among elite kosovo basketball, handball and soccer players. *International Journal of Morphology.* 2019;37:1067-72.
15. Gajardo-Burgos R, Barría-Vargas C, Flández-Valderrama J, Avendaño-Chipón R, Barría-Pailaquilén RM, Monrroy-Uarac M. Perfil antropométrico de basquetbolistas sub-14 chilenos. *International Journal of Morphology*. 2018;36:943-7.
16. Sociedad Internacional para el Avance de la Kineantropometría (ISAK). *Estándares internacionales para la valoración antropométrica*. Australia. 2001.
17. Carter JEL, Ackland TR, Kerr DA, Stapff AB. Somatotype and size of elite female basketball players. *J Sports Sci*. 2005;23:1057-63.
18. Wilmore JH, Costill DL. *Fisiología del esfuerzo y del deporte*. Barcelona. Editorial Paidotribo; 2004.
19. MacDougall JD, Ward G, Sale D, Sutton J. Muscle glycogen repletion after highintensity, intermittent exercise. *J Appl Physiol.* 1977;42:129-32.

20. Burke L. *Nutrición en el deporte: un enfoque práctico.* Madrid. Médica panamericana; 2009.
21. Urdampilleta A, Vicente-Salar N, Martinez Sanz JM. Necesidades proteicas de los deportistas y pautas dietético-nutricionales para la ganancia de masa muscular. *Rev Esp Nutr Hum Diet*. 2012;16:25-35.
22. Schröder H, Navarro E, Mora J, Seco J, Torregrosa JM, Tramullas A. Dietary habits and fluid intake of a group of elite spanish basketball players: a need for professional advice?. *Eur J Sport Sci.* 2004;4:1-15.
23. Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sport Medicine: nutrition and athletic performance. *J Am Diet Assoc*. 2009;109:509-27.
24. Ortega RM, Requejo AM, Navia B, López Sobaler AM. *Ingestas diarias recomendadas de energía y nutrientes para la población española.* Madrid. Universidad Complutense de Madrid; 2004.
25. Bescós R, Rodríguez Guisado FA. Low levels of vitamin D in professional basketball players after wintime: relationship with dietary intake of vitamin D and calcium. *Nutr Hosp.* 2011;26:945-51.
26. Santos DA, Matias CN, Monteiro CP, Silva AM, Rocha PM, Minderico CS, Bettencourt Sardinha L, Laires MJ. Magnesium intake is associated with strength performance in elite basketball, handball and volleyball players. *Magnes Res.* 2011;24:215-9.
27. Rico JI, Pérez-López M. La actividad física y el zinc: Una revisión. *Arch Med Deporte.* 2011;141:36-44.
28. Dubnov G, Constantini NW. Prevalence of iron depletion and anemia in top- level basketball players. *Int J Sport Nutr Exerc Metab.* 2004;14:30-7.
29. Martínez-Sanz JM, Urdampilleta A, Mierlgo-Ayuso J. Necesidades energéticas, hídricas y nutricionales en el deporte. *Eur J Hum Mov.* 2013;30:37-52.
30. Urdampilleta A, Martínez-Sanz JM, Julia-Sánchez S, Álvarez-Herms, J. Protocolo de hidratación antes, durante y después de la actividad físico- deportiva. *Eur J Hum Mov.* 2013;31:57-76.
31. Ali A, Williams C, Nicholas CW, Foskett A. The influence of carbohydrate- electrolyte ingestion on soccer skill performance. *Med Sci Sports Exerc.* 2007;39:1969-76.

Original article

Educational intervention among football players to prevent muscular-skeletal injuries

Jorge E. Moreno-Collazos[1], Harold F. Cruz- Bermúdez[2], Eva. Segura- Orti[3], Iván D. Pinzón-Rios[4]

[1]Programa de Fisioterapia. Fundación Universitaria de Ciencias de la Salud. Bogotá-Colombia. [2]Enfermero. Especialista en Estadística aplicada. [3]Departamento de Fisioterapia. Universidad CEU Cardenal Herrera. [4]Fisioterapeuta. Especialista en Pedagogía Universitaria. Magister en Ciencias de la actividad Física y deporte.

Received: 02/02/2019
Accepted: 03/04/2020

Summary

Introduction: Health education based on interventions with new information and communication technologies are increasingly used in primary prevention. Physiotherapy in the field of sport has demonstrated in recent years scopes of evidence-based practice since its interventions from the field of public health, therapeutic clinical in the scheme of integral rehabilitation.
Aim: To compare the effectiveness of an educational physiotherapy intervention in soccer players, in face-to-face mode (conference) versus an intervention mediated by the technologies of the information and communication [TIC], on the risk of injury measured with the Functional Movement Screen [FMS].
Material and method: A randomized clinical trial (RCT) was carried out. The population consisted of 100 participants divided into two groups (TIC n = 50) and (Conference n = 50), with an average age of 18.2 vs 18.3 years for a conference and TIC respectively.
For the collection of information, an evaluation questionnaire for self-completion was developed based on the considerations of the sports science team (sports specialist, physiotherapists, nutritionists, sports biomechanics, sports trainers, sports professional) of the club sports. A total of 17 question-type items were distributed in seven categories of knowledge about injury prevention, which should be addressed by the health education plan from Physiotherapy.
Results: A T test was performed for the FMS score applied in relation to the conference group vs. TIC, a bilateral significance was found $p < 0.001$, which concluded that the TIC methodology in relation to the increase in the score in the average FMS after the intervention was higher in the methodology that implemented TIC.
Conclusions: An educational intervention in physiotherapy based on Information and Communication Technologies is more effective than a conference intervention (in person) to increase the score in the knowledge questionnaire for the prevention of sports injuries in football.

Key words:
Physical activity. Physical therapy specialty. Public health. Soccer (MeSH).

Intervención educativa en futbolistas para la prevención de lesiones músculo esqueléticas

Resumen

Antecedentes: La educación en salud basada en intervenciones con nuevas tecnologías de la información y comunicación [TIC] son cada vez más utilizadas en la prevención primaria. La fisioterapia en el ámbito del deporte ha demostrado en los últimos años alcances de práctica basada en la evidencia desde sus intervenciones desde ámbito de la salud pública, clínico terapéutico en el esquema de la rehabilitación integral.
Objetivo: Comparar la eficacia de una intervención educativa de Fisioterapia en futbolistas, en modalidad presencial (conferencia) frente a una intervención mediada por las tecnologías de la información y comunicación [TIC], sobre el riesgo de lesión medido con el *Functional Movement Screen* [FMS].
Material y método: Se realizó un ensayo clínico aleatorio [ECA] la población estuvo conformada por 100 participantes distribuidos en dos grupos (TIC n=50) y (Conferencia n=50), con un promedio de edad de 18,2 vs 18,3 años para conferencia y TIC respectivamente. Para la recolección de la información se construyó un cuestionario de evaluación para auto diligenciamiento elaborado a partir de las consideraciones del equipo de ciencias del deporte (médico especialista en deporte, fisioterapeutas, nutricionistas, biomecánico del deporte, entrenadores deportivos, profesional del deporte) del club deportivo. Se establecieron un total de 17 ítems tipo preguntas distribuidas en siete categorías de conocimientos sobre la prevención de lesiones, que debía de abordar el plan de educación para la salud desde Fisioterapia.
Resultados: Al realizarse la prueba de T para puntaje de FMS aplicado en relación al grupo de conferencia vs TIC se encontró una significancia bilateral $p< 0{,}001$ donde concluye que efectivamente la metodología TIC en relación al aumento de la puntuación en el FMS promedio tras la intervención fue mayor en la metodología que implementó las TIC.
Conclusión: Una intervención educativa en fisioterapia basada en las Tecnologías de Información y Comunicación es más eficaz que una intervención en conferencia (presencial) para aumentar la puntuación en el cuestionario de conocimientos para la prevención de lesiones deportivas en el fútbol.

Palabras clave:
Actividad física. Especialidad de terapia física. Salud pública. Fútbol (DeCS).

Correspondence: Jorge E. Moreno-Collazos
E-mail: jemoreno1@fucsalud.edu.co

Introduction

The model for researching sporting injury prevention follows a conceptual process described by Van Mechelen[1]. There are four steps to this model: 1. Establish the injury rate, 2. Establish the injury prevention mechanism, 3. The design and implementation of the interventions, and finally, 4. Re-assessment of the injury rate.

In practice, a large group of athletes or teams are chosen randomly, or a control group or intervention group, and the injuries obtained over a complete season are registered.

In the 1980s, Ekstrand *et al*.,[2-4] published the results of the first injury prevention trials in professional football. Yet it was not until the mid to late 90s when the prevention trials were implemented on a broad scale. There were two types of trials: trials to prevent a specific injury, and those designed to prevent a larger spectrum of injuries. Ankle sprain has been one of the most common injuries in this sport; several studies have been published with the aim of reducing the frequency rate of this pathology in the sporting field[5-15]. The aim of other projects has been to prevent other common injuries, such as tendon injury[16], stretched hamstrings[17-21], stretched groin[22,23], and knee strains - in particular the anterior cruciate ligament[24-30] - without reaching the health education of the participants of injury prevention programmes in sport.

Material and method

A study was performed on two random clinical trial groups [RCT] to assess the effectiveness of educational intervention of Physiotherapy in person (conference) compared to an educational intervention via Information and Communication Technologies [ICT] in increasing knowledge about muscular-skeletal injuries obtained whilst playing football within a primary injury prevention programme in physiotherapy.

This project was registered in the Clinical Trials Registrar (https://clinicaltrials.gov/)[31].

Sample

Players from the sub-20 group of athletes from the professional football league team that fulfilled the criteria of being professional-league athletes aged over 18 years with a sporting career of over three years, with an examination of physical condition performed by the interdisciplinary team prior to entry, or at the start of the sporting club membership, resident in Bogotá or municipalities of Cundinamarca. All the participants took part voluntarily and signed an informed consent form, complying with the ethical rules of the Research Committee and the Helsinki Declaration.

Instruments or scales used

To gather the information a self-administrated assessment questionnaire was built, created from the considerations of the sports science team (specialist sports doctors, physiotherapists, nutritionists, sports biomechanics, sports trainers, sporting professionals) from the sports club. A total of 17 question-type items were established, split into seven knowledge categories about injury prevention, which should address the education plan for health from Physiotherapy. The score was calculated as follows: each question answered correctly with the YES or NO option earned a point, the correctly answered questions were added up, and divided by the total number of questions. To calculate the score a rule of three was used, transforming the score into a scale of 0 to 100.

In order to validate the data gathered from the questionnaire, a pilot test was performed with 20 subjects, who completed the questionnaire, and from the opinions of these subjects, adjustments were made to the questionnaire before applying it to the study subjects. Furthermore, before the start of the study and with the aim of obtaining better quality information from the questionnaire, the instrument was subject to a content validation process by 10 experts in the area of physiotherapy, physical activity or sport, all with the minimum level of training of a master, doctorate or post doctorate recognised in the field of sports science. Next, to establish reliability and internal consistency, the Cronbach Alfa statistic was applied, with a result of 0.80.

The questionnaire was applied at two points in time, with three blinded physiotherapists assessing the study intervention, who interacted before the start of the educational programme and at the end, to provide comparative information in terms of levels of knowledge about sporting injury prevention in football players. To assess the risk of injury, the Functional Movement Screen battery of tests was used. The study group was assigned using a table of random numbers, using the Microsoft Excel 2010© programme. A document was created with the randomisation keys, in which the numeric codes were ordered from lowest to highest, and opposite was the group corresponding to the previously performed random allocation.

Statistical analysis

The data collected was analysed using the statistics package SPSS by IBM© Version 19 [Chicago, USA]. The analysis plan was performed considering the objectives of the RCT. It was considered that the data followed normal distribution, given that the sample was greater than 30. The descriptive statistic for quantitative variables displays the average and standard deviation, with their respective confidence intervals of 95% [CI95%], and absolute and relative frequencies for qualitative variables.

Results

The study population comprised 100 participants distributed into two groups (ICT n=50 and Conference n=50), with an average age of 18.24 vs. 18.34 years for conference and ICT respectively; for the "sporting age" variable, the average was 110.1 vs. 106.8 sporting months for conference and ICT respectively; upon applying the test to establish the

Table 1. Comparison of quantitative variables against the intervention groups.

Variable		Average	S.D	CI 95% for Difference		P Value*
Age (years)	Conference	18.2	0.5	-0.3	0.1	0.3
	ICT	18.3	0.5			
Sporting age (months)	Conference	110.1	21.0	-2.5	9.3	0.2
	ICT	106.8	10.3			

*t test for significant independent samples (<0.05); ICT: Information and communication technologies.
Source: Own creation.

Table 2. Cronbach alpha statistic as intervention instrument in education.

Cronbach alpha*	No. of elements	Cases
0.9	14	20

*> 0.8 (Minimum recommended level of Reliability).
Source: Own creation.

difference of the two groups, the T statistic was applied, revealing that no statistically significant differences were found in any of the comparisons (P value = 0.37 Age and 0.25 sporting age) (Table 1).

With regards to the content validation of the general knowledge about sporting injuries instrument, 0.8 was obtained, which was therefore applied in terms of football sports injury prevention.

In terms of the reliability analysis using the internal consistency measurement, it was applied to 20 people per item, revealing a global Cronbach of 0.9+ (Table 2).

T test to compare the ICT and conference groups in terms of knowledge scores

At the start of the study the conference group obtained an average of 20.7 points compared to 26.1 points obtained by the ICT group, whilst after the intervention the conference group obtained 40.8 points and the ICT group 74.8 (Table 3).

In a graphic representation of the two measurement times, it can be descriptively appreciated how the change took place more markedly in the ICT-led group (Figure 1).

The hypothesis that the average scores obtained with the ICT were greater than those obtained by conference methodology scores was checked. To check this hypothesis, a T-test was developed, which compared the results obtained after the interventions (single tail T-test, bilateral significance of 0.05, alpha 10, so that each tail was 0.05 and a confidence level of 95% to contrast the null hypothesis). The Levene test was checked first, and it was verified that Homoscedasticity assumption was fulfilled (P=0 22). Normality was not verified, as sufficiently large samples were present (n>30) to assume this.

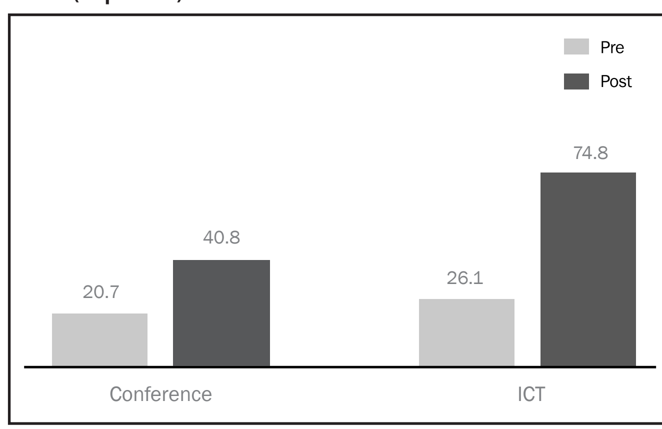
The table revealed a bilateral significance with a p value of <0,001, meaning the null hypothesis was rejected and it can be concluded that effectively, the average performance was greater among those following the ICT methodology (Table 4).

Table 3. Descriptive statistics for initial and final score divided by intervention group.

Score	Type of Intervention	No.	Average	S.D
Initial	Conference	50	20.7	11.8
	ICT	50	26.1	9.8
Final	Conference	50	40.8	13.7
	ICT	50	74.8	17.7

ICT: Information and communication technologies.
Source: Own creation.

Figure 1. Scoring obtained at two points of intervention: conference (in person) vs. ICT.



T-test to compare the application of FMS in ICT and conference groups

The descriptive statistics of the FMS battery test scores reveal an initial score of 8.8 points for the conference group, and 8.1 points for the ICT group. In terms of data following the intervention, the conference group revealed an average score of 14.0 points and the ICT group 17.4 (Table 5).

To check the statistical significance of this result, a comparison test was performed of averages. The hypothesis that the average scores obtained with the ICT for the battery of FMS tests were greater than those obtained by conference methodology scores was checked. To test out this hypothesis, a t-test was developed, which compared the results obtained after the interventions. The Levene test was checked first, and it was verified that Homoscedasticity assumption was not fulfilled

Table 4. Summary of T test for Final Conference Score vs. ICT.

Independent samples test								
Model T test		Levene test for equality of variance		T test for equality of averages				
		F	Sig	t	P value	Mean difference	90% confidence interval for the difference	
							Inferior	Superior
Initial score	Equal variances have been assumed	0.5	0.4	-2.4	0.01	-5.41	-9.0	-1.7
Final score	Equal variances have been assumed	1.5	0.2	-10.6	0.00	-34.00	-39.2	-28.7

Source: Own creation.

Table 5. Descriptive statistics for initial and final FSM divided by intervention group.

Score	Type of Intervention	No.	Average	S.D
Initial	Conference	50	8.8	1.3
	ICT	50	8.1	1.1
Final	Conference	50	14.0	2.7
	ICT	50	17.4	1.2

ICT: Information and communication technologies.
Source: Own creation.

($P< 0.01$). Normality was not verified, as sufficiently large samples were present ($n>30$) to assume this.

For the average comparison test, a unilateral confidence level of 95% was taken (bilateral significance of 90%) to contrast with the null hypothesis:

$$H_0 \text{ FSM: } \mu_{Tics} < \mu c_{onferences}$$
$$H_1 \text{ FSM: } \mu_{Tics} > \mu c_{onferences}$$

The table reveals bilateral significance $p<0.001$, which means that the null hypothesis is rejected and it can be concluded that effectively,

Table 6. Summary of t-test for FMS score applied in relation to the Conference vs. ICT group.

Independent samples test								
Model T test		Levene test for equality of variances		T test for equality of averages				
		F	Sig	t	P value	Mean difference	90% confidence interval for the difference	
							Inferior	Superior
FMS (pre)	Equal variances have been assumed	0.4	0.4	2.5	0.0	0.6	0.2	1.0
	Equal variances have not been assumed			2.5	0.0	0.6	0.2	1.0
FMS (post)	Equal variances have been assumed	20.6	0.0	-8.0	0.0	-3.3	-4.0	-2.6
	Equal variances have not been assumed			20.6	0.0	-8.0	0.0	-3.3

Source: Own creation.

the development of the ICT methodology in connection with the increased score in the average FMS following intervention, was greater in the methodology that implemented ICT, despite the difference between the groups in the pre-interventions values in favour of the conference group (Table 6).

Discussion

The results reveal that educational physiotherapy intervention via ICT is more effective at increasing knowledge about muscular-skeletal injuries in footballers than in-person interventions.

These results follow the same line of previous studies that use ICT to education diverse populations. Blachard *et al.*[32] relate how young students revealed a higher level of attendance to health promotion programmes given through ICT, and that these programmes favour accessibility in health education issues. King *et al.*[33] used ICTs to teach a group of Physiotherapy students about sporting injury prevention (10 males, 16 females, average age = 22.4 ± 3.6 years). The researchers compared two groups: CD-ROM (n = 15) and conference (n= 11) and they analysed attitudes towards computer-assisted instruction and the use of the CD-ROM programme. Upon reviewing the results of the research, significant differences were found (p = 0.05) between the groups in the scores obtained by students, both in written and practical assessments, in the advantage of the CD-ROM group. Zaremohzzabieh *et al*[34] indicate that young people use ICTs as an integral part of their daily life. On the other hand, Moulin *et al.*[35] performed a study about the impact of information and communication technologies on hospital administration and user handling, concluding that they facilitate the implementation of innovation practices that aim to provide a high level of quality and that promote effective on-going education.

With regards to the FMS result as a predictor of sporting injury risk among footballers, and the relationship with the knowledge questionnaire, our ICT study group revealed a significantly greater improvement in FMS score (14.0 vs. 17.4 points), along with a higher score in injury prevention knowledge compared to the conference group (in-person). Only the ICT group (17.4 ± 1.2 points), managed to surpass the threshold of 14 points in the FMS, indicating how the point below this holds an increased risk of injury[36], revealing that the most effective intervention for reducing this risk is that of the ICT.

These results are aligned with that indicated in the literature, as the relationship between self-knowledge and sporting injury rate on the playing field can be seen[37].

Doyscher *et al.*[38] consider that the FMS test presents moderate reliability. Under ideal circumstances, the test data distribution would be normal, and the total FMS score would be stable. However, an important prerequisite for these conclusions would be the normal distribution of data and a clear factorial structure, which would indicate an underlying construct. Possible causes that explain the decrease[39-41]. It was discovered that the greater the assessment experience of assessors, the higher the objectivity and reliability compared to inexpert assessors. In our study the assessors had both training and experience in using this series of tests. However, a systematic review with meta-analysis from 2017, which reviewed 24 publications and that applied this assessment tool, reported moderate evidence to recommend it as a test to predict injuries in football, and for other demographics (including American football, university sports, basketball, ice hockey, running, the police and fire-fighters), the evidence was limited or conflictive[42].

The questionnaire about knowledge to prevent sporting injuries among footballers, obtained a validity index of general content of 0.8, revealing it to be a valid instrument in exploring knowledge about preventing sporting injuries in football. In terms of the reliability analysis using the internal consistency measurement, it was applied to 20 people per item, revealing a global Cronbach of 0.9. This value is somewhat higher than that obtained from the validation of a psychological characteristics questionnaire linked to sporting performance of 40 items organised into five sub-scales with a Cronbach Alfa co-efficient of 0.8[43].

Conclusion

Education physiotherapy intervention based on Information and Communication Technologies is more efficient than a conference intervention (in person) in increasing scores in the knowledge questionnaire for preventing sporting injuries in football.

Education physiotherapy intervention based on Information and Communication Technologies is more efficient than a conference intervention (in person) in reducing the risk of injury via the battery of tests Functional Movement Screen.

Acknowledgements

The Cardenal Herrera University and the representative bodies of football in Colombia who made it possible to carry out all the immersed processes in researching the line of Physiotherapy in Sport.

Funding

None declared by the authors.

Conflict of interest

The authors claim to have no conflict of interest whatsoever.

Bibliography

1. Van-Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Med.* 1992;14:82-99.
2. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport.* 2006;9:3-9.
3. Mc Glashan AJ, Finch CF. The extent to which behavioral and social sciences theories and models are used in sport injury prevention research. *Sports Med*. 2010;40:841-58.
4. Verhagen EA, Van-Stralen MM, Van-Mechelen W. Behaviour, the key factor for sports injury prevention. *Sports Med*. 2010;40:899-906.
5. Goossens L, Cardon G, Witvrouw E, De-Clercq D. Efficacy of a physical education teacher education inherent injury prevention program. *Br J Sports Med.* 2014;48:600.

6. Bolling C, Barboza SD, Van-Mechelen W, Roeline H. How elite athletes, coaches, and physiotherapists perceive a sports injury. *Transl. Sports Med*. 2019;2:1723.
7. Van-Beijsterveldt AMC, Krist MR, Schmikli SL, Stubbe JH, De-Wit GA, Inklaar H, *et al.* Effectiveness and cost-effectiveness of an injury prevention programme for adult male amateur soccer players: design of a cluster-randomised controlled trial. *Inj Prev.* 2011;17:1-5.
8. World confederation for physical therapy. What is physical therapy?. Disponible en: http://www.wcpt.org/what-is-physical-therapy.
9. Van-Mechelen W. Sports injury surveillance systems. 'One size fits all'? *Sports Med.* 1997;24:164-8.
10. Ekstrand J. The frequency of muscle tightness and injuries in soccer players. *Am J Sports Med.* 1982;10:75-8.
11. Schneiders AG, Davidsson A, Hörman E, Sullivan SJ. Functional movement screen normative values in a young, active population. *Int J Sports Phys Ther.* 2011;2:75-82.
12. O'Connor FG, Deuster PA, Davis J, Pappas CG, Knapik JJ. Functional movement screening: predicting injuries in officer candidates. *Med Sci Sports Exerc.* 2011;43:2224-30.
13. Li Y, Wang X, Chen X, Dai B. Exploratory factor analysis of the functional movement screen in elite athletes. *J Sports Sci.* 2015:1166.
14. Henley LD, Frank DM. Reporting ethical protections in physical therapy research. *Phys Ther*. 2006;86:499-509.
15. Fredberg U, Bolvig L, Andersen NT. Prophylactic training in asymptomatic soccer players with ultrasonographic abnormalities in achilles and patellar tendons: The danish super league study. *Am J Sports Med.* 2008;36:451-60.
16. Arnason A, Andersen TE, Holme I, Engebretsen L, Bahr R. Prevention of hamstring strains in elite soccer: an intervention study. *Scand J Med Sci Sports*. 2008;18:40-8.
17. Askling C, Karlsson J, Thorstensson A. Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload. *Scand J Med Sci Sports.* 2003;13:244-50.
18. Brooks JH, Fuller CW, Kemp SP, Redding DB. Incidence, risk, and prevention of hamstring muscle injuries in professional rugby union. *Am J Sports Med*. 2006;34:1297-306.
19. Croisier JL, Ganteaume S, Binet J, Genty M, Ferret JM. Strength imbalances and prevention of hamstring injury in professional soccer players: a prospective study. *Am J Sports Med.* 2008;36:1469-75.
20. Gabbe BJ, Branson R, Bennell KL. A pilot randomised controlled trial of eccentric exercise to prevent hamstring injuries in community-level australian football. *J Sci Med Sport.* 2006;9:103-9.
21. Holmich P, Larsen K, Krogsgaard K, Gluud C. Exercise program for prevention of groin pain in football players: a cluster randomized trial. *Scand J Med Sci Sports.* 2010;20:814-21.
22. Tyler TF, Nicholas SJ, Campbell RJ, Donellan S, McHugh MP. The effectiveness of a preseason exercise program to prevent adductor muscle strains in professional ice hockey players. *Am J Sports Med*. 2002;30:680-3.
23. Caraffa A, Cerulli G, Projetti M, Aisa G, Rizzo A. Prevention of anterior cruciate ligament injuries in soccer. A prospective controlled study of proprioceptive training. *Knee Surg Sports Traumatol Arthrosc.* 1996;4:19-21.
24. Gilchrist J, Mandelbaum BR, Melancon H, Ryan GW, Silvers HJ, Griffin LY, *et al.* A randomized controlled trial to prevent noncontact anterior cruciate ligament injury in female collegiate soccer players. *Am J Sports Med.* 2008;36:1476-83.
25. Hewett TE, Lindenfeld TN, Riccobene JV, Noyes FR. The effect of neuromuscular training on the incidence of knee injury in female athletes. A prospective study. *Am J Sports Med.* 1999;27:699-706.
26. Kiani A, Hellquist E, Ahlqvist K, Gedeborg R, Michaëlsson K, Byberg L. Prevention of soccer-related knee injuries in teenaged girls. *Arch Int Med*. 2010;170:43-9.
27. Mandelbaum BR, Silvers HJ, Watanabe DS, Knarr JF, Thomas SD, Griffin LY, *et al.* Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes: 2-year follow-up. *Am J Sports Med.* 2005;33:1003-10.
28. Myklebust G, Engebretsen L, Braekken IH, Skjølberg A, Olsen OE, Bahr R. Prevention of noncontact anterior cruciate ligament injuries in elite and adolescent female team handball athletes. *Inst Course Lect.* 2007;56:407-18.
29. Pfeiffer RP, Shea KG, Roberts D, Grandstrand S, Bond L. Lack of effect of a knee ligament injury prevention program on the incidence of noncontact anterior cruciate ligament injury. *J Bone Joint Surg Am.* 2006;88:1769-74.
30. Kirkendall DT, Junge A, Dvorak J. Prevention of football injuries. *Asian J Sports Med.* 2010;1:81-92
31. Boutron I, Moher D, Altman DG, Schulz KF, Ravaud P. Extending the consort statement to randomized trials of nonpharmacologic treatment: explanation and elaboration. *Ann Intern Med.* 2008;148:295-309.
32. Blanchard M, Metcalf A, Degney J, Herman H, Burns J. Rethinking the digital divide: findings from a study of marginalised young people's information communication technology use. *ACYS.* 2008;27:35.
33. King CD, Lawrence LA, MacKinnon GR. Using multimedia technology in jamaican athletic training education: A case-based learning approach. *IJLT.* 2014;4:40-49.
34. Zaremohzzabieh Z, Abu-Samah B, Omar SZ, Bolong J, Shaffril HAM. Youths' sustainable livelihood with information and communication technologies: toward an ICT for development quality model. *Am J Appl Sci.* 2014;11:947-58.
35. Moulin T, Retel O, Chavot D. The impact of information and communication technologies on hospital administration and patient management: The aides network for diagnosing and treating neurological emergencies. *Sante Publique.* 2003;15:191-200.
36. Ekstrand J, Healy JC, Waldén M, Lee JC, Inglés B, Hägglund M. Hamstring muscle injuries in professional football: the correlation of MRI findings with return to play. *Br J Sports Med.* 2012;46:112-17.
37. Woods C, Hawkins RD, Maltby S, Hulse M, Thomas A, Hodson A, *et al.* The football association medical research programme: an audit of injuries in professional football-analysis of hamstring injuries. *Br J Sports Med.* 2004;38:36-41.
38. Doyscher R, Schütz E, Kraus K. Evidenz des functional movement screen im leistungssport–ein strukturierter review mit eigenen daten. Sports orthopaedics and traumatology sport-orthopädie-Sport-Traumatologie. 2016;32:4-13.
39. Kraus K, Doyscher R, Schüt E. Methodological item analysis of the functional movement screen. *Dtsch Z Sportmed.* 2015;66:263-8.
40. Teyhen DS, Shaffer SW, Lorenson CL, Halfpap JP, Donofry DF, Walker MJ, *et al.* The functional movement screen: a reliability study. *JOSPT.* 2012;42:530-40.
41. Garrison M, Westrick R, Johnson MR, Benenson J. Association between the functional movement screen and injury development in college athletes. *Int J Sports Phys Ther.* 2015;10:21-8.
42. Moran RW, Schneiders AG, Mason J, Sullivan SJ. Do functional movement screen composite scores predict subsequent injury? A systematic review with meta-analysis. *Br J Sports Med*. 2017;51:1661-9.
43. López S, Ismael J. Adaptación para futbolistas del cuestionario características psicológicas relacionadas con el rendimiento deportivo. *CPD*. 2013;13:21-30.

Exercise associated hyponatremia in endurance sports: a review with practical recommendations

Volker Scheer[1,2], Beat Knechtle[3,4]

[1]Ultra Sports Science Foundation, Pierre-Benite, France. [2]Health Science Department, Universidad a Distancia de Madrid (UDIMA). Madrid, Spain. [3]Medbase St. Gallen Am Vadianplatz, St. Gallen, Switzerland. [4]Institute of Primary Care, University of Zurich. Zurich, Switzerland.

Received: 25/09/2019
Accepted: 07/02/2020

Summary

Participation in endurance activities is popular and growing. Proper hydration is important for performance and to avoid medical complications. Overconsumption of fluids, in combination with inadequate secretion of the hormone arginine vasopressin can lead to exercise associated hyponatremia (EAH). These two factors are the main underlying mechanism for the development of EAH, leading to water retention and a dilutional hyponatremia. EAH is defined biochemically by serum sodium concentrations < 135 mol/L during or up to 24 hours after exercise. Athletes may be asymptomatic, or symptomatic, with mild cases presenting with non-specific symptoms and signs, such as nausea, vomiting or weight gain. Severe cases or cases of exercise associated hyponatremic encephalopathy (EAHE) may present with headaches, altered mental state, seizures or coma and represent a medical emergency. Treatment is warranted with intravenous hypertonic saline solution and can be lifesaving. Other risk factors include exercise duration over 4 hours, exercising in the heat or humid conditions, event inexperience, inadequate training, slow running pace, high or low body mass index (BMI) and free availability of fluids at races. Prevention can generally be achieved by adhering to appropriate hydration strategies, such as drinking to thirst. Education of athletes, coaches and medical personnel about EAH is important and may help reducing the incidence of EAH and prevent further fatalities.

Key words:
Hypertonic saline solution. Cerebral oedema. Fluid. Ultramarathon. Cycling. Swimming. Triathlon.

Hiponatremia asociada al ejercicio en deporte de resistencia: revisión con recomendaciones prácticas

Resumen

La participación en actividades de resistencia se ha popularizado y está en continuo crecimiento. La hidratación adecuada es importante para el rendimiento y para impedir complicaciones médicas. El consumo excesivo de líquidos, en combinación con una secreción inadecuada de la hormona arginina vasopresina puede llevar a una hiponatremia asociada al ejercicio (EAH). Estos dos factores, son los mecanismos principales en el desarrollo de una EAH, mediante la retención de agua, resultando en una hiponatremia dilucional. La EAH se define bioquímicamente como la concentración de sodio sérico <135 mmol/L durante o dentro de 24 horas tras el ejercicio. Los atletas pueden estar asintomáticos o sintomáticos, presentado en casos leves síntomas inespecíficos como náuseas, vómitos o incremento de peso. En casos severos como es la encefalopatía hiponatrémica asociada al ejercicio (EAHE) pueden presentar cefaleas, alteración del nivel de conciencia, convulsiones incluso coma, lo que representa una emergencia médica. El tratamiento de elección es la administración de una solución salina hipertónica intravenosa que puede salvar la vida del paciente. Otros factores de riesgo para el desarrollo de EAH son la práctica de ejercicio de más de 4 horas, ejercicio en clima caluroso y/o húmedo, inexperiencia en el evento, entrenamiento inadecuado, correr a ritmo lento, índice de masa corporal alto o bajo y acceso libre a líquidos durante la carrera. La prevención es posible mediante la adherencia a una estrategia de hidratación apropiada como es beber según la sed *(drink to thirst)*. La educación de los atletas, entrenadores y personal médico sobre el EAH es importante y puede contribuir a disminuir la incidencia de EAH y prevenir consecuencias fatales.

Palabras clave:
Solución salina hipertónica. Edema cerebral. Fluidos. Ultramaratón. Bicicleta. Natación. Triatlón.

Correspondence: Volker Scheer
E-mail: volkerscheer@yahoo.com

Introduction

Participation in endurance sports has seen an important rise over the last twenty years, especially in activities such as running[1-5], but also in cross country skiing, triathlons, and cycling[6-8].

Medical problems can be observed in endurance sports, but most are minor in nature[9-11], however serious medical problems also occur, such as cardiovascular issues, exertional heat illness, hypothermia, accidental falls or exercise associated hyponatremia (EAH)[9,12,13].

EAH is defined as a serum sodium concentration [Na$^+$] below standard laboratory measurements of < 135mmol/L either during or up to 24 hours after exercise[13]. The main mechanisms leading to EAH are overconsumption of fluids and inappropriate secretion of the hormone arginine vasopression (AVP)[13-16]. The result is a positive fluid balance leading to a dilutional hyponatremia and EAH[15-17]. Symptoms can range from mild to severe and life threatening[13]. Mild symptoms are often non-specific and can generally be treated with fluid restriction or oral hypertonic saline[13,15,18]. Severe EAH or exercise associated hyponatremia encephalopathy (EAHE) with cerebral oedema is a life-threatening condition and prompt treatment with intravenous hypertonic saline is necessary to avoid unfavourable outcomes and fatalities[15,17,19,20]. Prevention, early recognition and appropriate treatment of EAH is important to reduce the burden of this illness[15,16,21,22].

We summarized the pertinent literature related to EAH in this educational review and give an overview of the definition, pathophysiology, history, incidence, risk factors, clinical signs and symptoms, diagnosis, treatment and prevention of EAH. Further we are giving practical advice and recommendations for athletes participating at endurance events, as well as for the medical staff caring for those athletes.

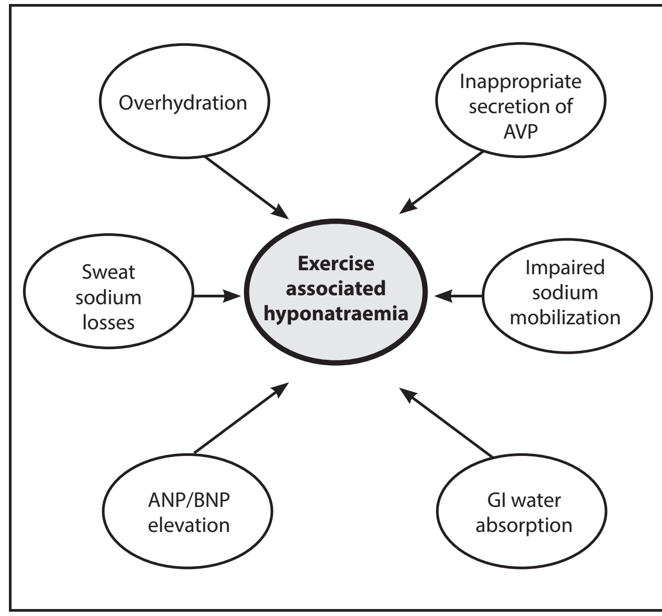
Definition

EAH is defined as a serum sodium concentration [Na$^+$] below standard laboratory measurements of < 135mmol/L either during or up to 24 hours after exercise[13,15,20]. EAH can be classified as mild ([Na$^+$] of 130-134 mmol/L), moderate ([Na$^+$] of 125-129 mmol/L), or severe ([Na$^+$] <125 mmol/L)[13,15,20]. Clinically it may be asymptomatic or symptomatic with mild, moderate or severe clinical features[13,23,24]. Clinical symptoms may not correspond to the severity in drop in serum sodium concertation but with the speed in which this decline occurs[13,20]. Severe symptomatic EAH or EAHE can present as life-threatening medical emergency and prompt recognition and treatment is necessary to avoid fatalities[13,21]. Severe cases can also lead to EAH with pulmonary oedema[14].

Pathophysiology

There are several factors involved in the pathophysiology of EAH (Figure 1). The main underlying mechanisms are overconsumption of fluids and inappropriate secretion of the hormone arginine vasopressin (AVP)[13,15]. Drinking beyond thirst and/or overconsumption of fluids beyond fluid losses during exercise (such as sweat, urine or insensible fluid losses) lead to a dilutional hyponatremia, resulting in a relative excess of body water in relation to the total content of exchangeable body sodium[13,16].

Figure 1. Pathophysiological mechanisms leading to exercise associated hyponatremia.



The two larger circles represent the main underlying cause. AVP=arginine vasopressin, ANP=atrial natriuretic peptide, BNP=brain natriuretic peptide, GI=gastro-intestinal.

Most symptomatic cases have been observed with overconsumption of fluids and weight gain or inadequate weight loss[25,26] but symptomatic EAH has also been described with dehydration[27], although this is rare. The other main mechanisms is the inappropriate secretion of AVP or anti diuretic hormone (ADH)[13]. AVP is the main hormone regulating the water and fluid balance within the human body. The secretion of AVP is regulated through changes in plasma osmolality but can also be stimulated via non-osmotic stimuli such as stress, pain, nausea, vomiting, hypoglycaemia, heat, non-steroidal anti-inflammatory (NSAID) and IL6[13,15,16]. These non-osmotic stimuli, often encountered in ultra-endurance events, lead to an inappropriate secretion of AVP and can further exacerbate fluid retention, and worsening symptoms of EAH[13,15,16,28-30].

There are a number of other contributing factors, which exacerbate the development of EAH, such as the rapid absorption of fluids from the gastro-intestinal tract after exercise cessation, through an increase in splanchnic blood flow[15]. Other factors that are less well investigated include the inability to mobilize the non-osmotic form of sodium which is bound to bone, skin and cartilage and the activation of the renin angiotensin aldosterone system with decrease in renal filtration and reduction in water excretion[15,26,31] and sodium losses through sweat and urine through elevated levels of atrial natriuretic peptide (ANP) and brain natriuretic peptide (BNP)[32,33].

EAHE is a severe form of EAH with neurological affectation due increased intracranial pressure from cerebral oedema. This form is due to a low serum sodium concentration in the cerebral blood flow when extra cellular water follows an osmotic gradient into the intracellular compartment causing swelling or oedema. This can also occur in the lungs, leading to pulmonary oedema[13].

Historical perspective

EAH was first described in 1981 by Tim Noakes[34] during the Comrades Marathon in South Africa. The first scientific publication in 1985 described four cases of endurance athletes with severe hyponatremia[35]. Shortly afterwards further reports of EAH were published[36]. Since then, a growing number of reports about EAH exists, including cases of fatalities[14,15,17,19,25]. Interestingly, up to 1969, athletes were advised not to consume fluids during exercise and to avoid drinking altogether[37] and no cases of EAH were reported. This advice subsequently changed and between 1987-2007 the American College of Sports Medicine (ACSM) and the US Military advised to drink as much as tolerable during exercise, supported by the drink industry[37,38]. This may have led to a rise in cases of EAH. The current advice is to drink to thirst, which not only provides an effective preventative strategy for EAH but also has positive effects on performance[15,39-42].

Incidence according to type of sports

EAH develops during exercise, with less than 1% of athletes having low pre-race sodium concentrations[13]. The incidence of EAH varies among sports with the highest numbers being reported in rowers, during a four week training camp[43]. In running the incidence seems to increase with an increase in exercise duration[14,44,45]. For example, no reports are available in half-marathon distance runners[46] whereas in marathon running, reports range from 0 to 22% with an average incidence of around 8%[14]. In ultra-endurance distances the average incidence in races below 100 km is <1%, in 100 km races < 3% and races with 100 miles distances this grows to over 20%[14] with some races reporting incidences of up to 51%[24]. In multi stage ultra-distance events the incidence goes up to 42%, however all of those athletes were asymptomatic[23].

Similarly, for triathlon, the incidence of EAH increases with increasing race distance. The incidence in Ironman triathlons has been reported to be around 20%[47] whereas in Triple Iron ultra-triathlon distance this goes up to 26%[48].

In long-distance open-water swimming, 36% of women and 8% of men showed biochemical signs of EAH[49]. In road cycling and mountain biking, the incidence is generally lower ranging from no reported cases to 12%[32,50-52], but severe cases of EAH[53] and EAHE can occur[27]. Incidence among rugby players has been reported to be 33% after a rugby match[15].

Fatalities are rare but have been reported in runners, triathletes, canoeists, hikers, American football players, soldiers and the police[14-16,54].

Risk factors

The development of EAH is multifactorial and several risk factors have been described (Table 1). However, the main risk factor is overhydration[13]. Exercise duration over 4 hours, event inexperience, inadequate training, slow running pace, high or low body mass index (BMI), availability of fluids at races are all associated risk factors[13,15,16].

The first case of EAH was documented in a women[34,35] but apparent sex differences with an increased incidence in women is not statistically significant[13]. Women may be more at risk however due to an increased fluid intake compared to men[55,56]. Extreme temperature range seems to be a risk factor, especially in thermal stressing environments especially in the heat but also in extreme cold[57,58]. Heat seems to be a risk factor with more cases reported in extreme environmental conditions[23,24,58-61]. Humidity may also be a risk factor[62]. In temperate climates, EAH is relatively uncommon[14,48,51,63,64]. Interestingly enough, the geographic location seems to have an influence on EAH incidence, as races in Northern America[14,24,45,60,65,66] have shown higher numbers of EAH compared to European races[14,51,67]. In other geographical areas such as South Africa, Asia or Oceania cases of EAH are less likely and rare[14,28,49,68,69].

Table 1. Risk factors for the development of exercise associated hyponatraemia.

- Overconsumption of fluids
- Exercise duration over 4 hours
- Event inexperience
- Inadequate training
- High or low body mass index (BMI)
- Female sex
- Use of non-steroidal anti-inflammatory drugs (NSAID)
- Thermal stressing environment (extreme heat, cold, humidity)
- Geographical location where race is held

Clinical signs and symptoms

In the early stages of EAH, symptoms are fairly non-specific[13,15] and are summarized in Table 2. A high index of suspicion of EAH should be

Table 2. Symptoms of mild symptomatic cases of exercise-associated hyponatremia (EAH) and treatment.

Symptoms	
Often non-specific and can vary between athletes	
– Nausea	– Bloatedness
– Vomiting	– Increase in body weight
– Dizziness	– Tremor
– Weakness	– Muscle cramps
– Light headiness	– Puffiness
– Adynamia	– Headache
– Fatigue	– Oliguria
Treatment	
– Restrict oral fluid intake until free-flowing urination	
– If athlete is alert and able to tolerate oral fluids provide oral hypertonic fluids	
– Oral hypertonic fluids may include 3% NaCl (100ml) or other hypertonic solutions with high sodium concentrations (e.g. concentrated bouillon)	
– If athlete is unable to tolerate oral fluids or symptoms are not improving or are progressing use intravenous bolus of 100 mL 3% NaCl (hypertonic saline) as per severe cases of EAH	

Table 3. Symptoms and treatment of severe cases of exercise-associated hyponatremia (EAH) and exercise associated hyponatraemic encephalopathy (EAHE). ABC (Airway, Breathing, Circulation).

Symptoms	
– Fatigue	– Somnolence
– Confusion	– Dyspnoea
– Agitation	– Gait disorders
– Lethargy	– Change of personality
– Altered mental state	– Seizures
– Disorientation	– Coma
Treatment	
– Emergency assessment (ABC) – Onsite serum sodium concentration [Na+] measurement if available – If measurement unavailable treat empirically – Intravenous access (i.v.) – I.v. bolus of 100 mL 3% NaCl (hypertonic saline), every 10 min at least twice or until clinical improvement – Alternatively, other comparable solution containing sodium can be used (e.g. 10 mL of 20% NaCl) – Arrange emergency transport to nearest medical facility	

warranted especially if there is a history of overhydration. Care must also be taken not to miss other medical conditions that may present in a similar way[12,70]. Onsite [Na^+] measurement can aid in the correct diagnosis but this is not always available or possible[70]. If symptoms progress or in cases of EAHE or rapid decrease in serum sodium levels symptoms may include confusion, agitation, altered mental state, dyspnoea or phantom running (Table 3). This may progress to seizure activities or coma, which constitutes a medical emergency and prompt recognition and treatment is warranted[13,15,16,19]. Deaths have also been reported from EAH[13].

Diagnosis

The correct diagnosis is made biochemically with serum sodium concentrations of < 135 mmol/L[13]. However, on-site sodium measurements during competitions are not always available or feasible in remote environments. Empirical treatment is recommended in the absence of biochemical results[13].

Treatment

Treatment strategies depend on clinical symptoms. Asymptomatic athletes generally do not require any active form of treatment but advice about proper fluid consumption is advisable (e.g. drink to thirst). Fluids can be restricted until onset of urination or oral hypertonic saline solutions may be given in order to reduce the risk of progression to symptomatic EAH[13,16].

Treatment strategies for mild symptomatic cases of EAH are summarized in Table 2[13]. If patients are not improving or are unable to tolerate oral fluids, intravenous administration of fluids is recommended, as in severe cases of EAH or EAHE (Table 3)[13]. If onsite [Na^+] measurement is not available, empirically lifesaving treatment with intravenous hypertonic saline solution should be given as this empirical treatment is unlikely to cause any harm even if the presumed diagnosis is wrong[13,15]. Emergency transfer to the nearest hospital should be arranged, especially if recovery is slow or delayed[13].

Prevention

As the main mechanism for the development of EAH is the overconsumption of fluids the most effective preventative measure is an adequate fluid intake. This can be achieved through drinking to thirst[13-15,37,66]. It is important to know that sports drinks are hypotonic when compared to plasma and overconsumption can also lead to EAH and do not offer any protection[13]. In the past the sports industry heavily promoted the consumption of sports drinks and overzealous fluid consumption[71]. Care needs to be taken when replacing sodium losses with salt tablets, although offering theoretical benefits and possibly slowing down the development or progression of EAH, salt tablets can increase thirst and thus lead to overconsumption of fluids thus aiding in the development of EAH[25,72]. Another contributing factor for the development of EAH is the use of NSAID[13], which is widely used among ultra-endurance athletes[73]. An important aspect of prevention is education and information about EAH is available on trusted websites in English and Spanish (www.ultrasportsscience.org).

Advice for athletes

It is important for athletes and coaches to be aware of proper hydration strategies during ultra-endurance events and that the current guidance of drinking to thirst are followed, which effectively can prevent the development of EAH without decrements in performance[13] (Table 4). Although sport drinks are often used with the belief that replacing lost electrolytes or sodium can prevent EAH this is however not correct,

Table 4. Practical advice on exercise associated hyponatraemia (EAH) for athletes and coaches. NSAID (non-steroidal anti-inflammatory drugs).

– Drink to thirst
– Overconsumption of fluids is the main risk factor
– Sports drinks cannot prevent EAH when overconsumption takes place
– Salt tablets do not offer protection so use with caution
– Do not use NSAID in training or competition
– Be well prepared for competition
– Acclimatize when competing in hot environments
– Educational material is available on trusted websites
– EAH can kill and knowledge about this condition and recognition is vital for everyone involved in endurance sports
– Alert and teach other athletes and coaches about EAH

Table 5. Practical advice of exercise associated hyponatraemia (EAH) for medical personnel.

– EAH can kill
– Knowledge about EAH and recognition of clinical signs is paramount for the medical team involved in endurance sports
– Consider availability of equipment for on-site serum sodium [Na^+] measurement during competition
– Consider providing pre-race briefing about proper hydration (drink to thirst) and advice on EAH to athletes and coaches
– Consider adequate fluid availability at event
– Pre-race planning of evacuation procedures and nearest medical facilities
– Consider preparing information leaflets on EAH for receiving medical team when transferring patient, as they may not be familiar with this condition
– Online learning resources and congress are available for further advice
– Hypertonic saline should be part of the mandatory medical equipment of health care professional providing care at endurance events

as sports drinks are hypotonic and when overconsuming can lead to EAH. This also applies to the ingestion of salt tablets that may slow down the development of EAH, but the high salt content can increase thirst which again leads to overhydration and EAH. Athletes also need to be aware of certain medications, especially NSAID, that can aid the development of EAH. EAH is a serious medical conditions and deaths have been reported so being aware of this condition, its symptoms and signs and risk factors is important for athletes. When talking to other athletes sharing the knowledge about this is paramount. This will be important in reducing the medical complications arising from EAH and help reducing the incidence of EAH.

Advice for medical personnel

Medical personnel should be aware of EAH, its symptoms, pathogenesis and treatment (Table 5). It may be difficult to recognise EAH in its early stages, but prompt recognition and appropriate treatment can reduce the disease burden. When planning for medical care it is therefore important to have all the necessary medical equipment (intravenous giving set, hypertonic saline solution etc.) within the medical facilities and depending on competition onsite blood analysers. Pre-race planning should include evacuation procedures and knowledge and contact details of the nearest hospitals. An information leaflet about EAH accompanying the patient to the hospital with pertinent treatment may be helpful as receiving staff at these facilities may not be aware of EAH and its treatment. Liberal fluid availability at some races has promoted the development of EAH, so careful planning when organising a race is important[13]. Educating other health care professionals or giving advice on proper hydration on race websites can also be an important factor in reducing the incidence of EAH. Leaflets, online teaching resources or congresses are available to train and update medical staff.

Conclusion

Endurance activities are popular, and participation is growing. Proper hydration is important for performance and avoiding medical problems. Overconsumption of fluids is the main mechanism, in combination with inadequate secretion of the hormone arginine vasopressin, in the development of exercise associated hyponatraemia (EAH). Most cases of EAH are mild but serious compilations and deaths have occurred. Intravenous administration of hypertonic saline solution can be lifesaving in severe cases. Prevention focuses on adopting a hydration strategy where fluids are consumed by drinking to thirst. Educating athletes, coaches and medical personnel about EAH is important.

Conflict of interest

The authors declare no conflict of interest.

Bibliography

1. Ahmadyar B, Rüst CA, Rosemann T, Knechtle B. Participation and performance trends in elderly marathoners in four of the world's largest marathons during 2004–2011. *Springerplus.* 2015;4:465.
2. Knechtle B, Scheer V, Nikolaidis PT, Sousa CV. Participation and performance trends in the oldest 100-km ultramarathon in the world. *Int J Environ Res Public Health.* 2020;17:1719.
3. Scheer V. Participation trends of ultra endurance events. *Sports Med Arthrosc Rev.* 2019;27:3–7.
4. Scheer V, Di Gangi S, Villiger E, Rosemann T, Nikolaidis PT, Knechtle B. Participation and performance analysis in children and adolescents competing in time-limited ultra-endurance running events. *Int J Environ Res Public Health*. 2020;17:1628.
5. Vitti A, Nikolaidis PT, Villiger E, Onywera V, Knechtle B. The "New York City Marathon": participation and performance trends of 1.2M runners during half-century. *Res Sports Med*. 2019;1–17.
6. Nikolaidis PT, Knechtle B. Pacing profiles in age group cross-country skiers in the Vasaloppet 2012-2016. *Chin J Physiol*. 2017;60:293–300.
7. Gloor RU, Knechtle B, Knechtle P, Rüst CA, Haupt S, Rosemann T, *et al.* Sex-related trends in participation and performance in the 'Swiss Bike Masters' from 1994–2012. *Percept Mot Skills.* 2013;116:640–54.
8. Knechtle B, Knechtle P, Lepers R. Participation and performance trends in ultra-triathlons from 1985 to 2009. *Scand J Med Sci Sports.* 2011;21:e82-90.
9. Knechtle B, Nikolaidis PT. Physiology and pathophysiology in ultra-marathon running. *Front Physiol.* 2018;9:634.
10. Scheer BV, Murray A. Al Andalus Ultra Trail: an observation of medical interventions during a 219-km, 5-day ultramarathon stage race. *Clin J Sport Med.* 2011;21:444–6.
11. Scheer BV, Reljic D, Murray A, Costa RJS. The enemy of the feet: blisters in ultraendurance runners. *J Am Podiatr Med Assoc*. 2014;104:473–8.
12. Scheer BV, Murray DA. Ultramarathon running injuries. In: Doral MN, Karlsson J, editors. *Sports Injuries.* Springer Berlin Heidelberg. 2015:2889–98.
13. Hew-Butler T, Rosner MH, Fowkes-Godek S, Dugas JP, Hoffman MD, Lewis DP, *et al.* Statement of the 3rd international exercise-associated hyponatremia consensus development conference, Carlsbad, California, 2015. *Br J Sports Med*. 2015;49:1432–46.
14. Knechtle B, Chlíbková D, Papadopoulou S, Mantzorou M, Rosemann T, Nikolaidis PT. Exercise-associated hyponatremia in endurance and ultra-endurance performance-aspects of sex, race location, ambient temperature, sports discipline, and length of performance: a narrative review. *Medicina (Kaunas)*. 2019;26:55.
15. Hew-Butler T, Loi V, Pani A, Rosner MH. Exercise-associated hyponatremia: 2017 update. *Front Med.* 2017;4:21.
16. Scheer V, Hoffman M. Exercise-associated hyponatremia: practical guide to its recognition, treatment and avoidance during prolonged exercise. *Dtsch Z Sportmed.* 2018;2018:311–8.
17. Noakes TD, Sharwood K, Collins M, Perkins DR. The dipsomania of great distance: water intoxication in an Ironman triathlete. *Br J Sports Med*. 2004;38:E16.
18. Bridges E, Altherwi T, Correa JA, Hew-Butler T. Oral hypertonic saline is effective in reversing acute mild-to-moderate symptomatic exercise -associated hyponatremia. *Clin J Sport Med*. 2018: 23.

19. Nolte HW, Hew-Butler T, Noakes TD, Duvenage CSJ. Exercise-associated hyponatremic encephalopathy and exertional heatstroke in a soldier: High rates of fluid intake during exercise caused rather than prevented a fatal outcome. *Phys Sportsmed.* 2015;43:93-8.

20. Hew-Butler T, Anley C, Schwartz P, Noakes T. The treatment of symptomatic hyponatremia with hypertonic saline in an Ironman triathlete. *Clin J Sport Med*. 2007;17:68–9.

21. Knechtle B, Chlíbková D, Nikolaidis PT. Exercise-associated hyponatremia in endurance performance. *Praxis* (Bern 1994). 2019;108:615–32.

22. O'Connor RE. Exercise-induced hyponatremia: causes, risks, prevention, and management. *Cleve Clin J Med*. 2006;73:S13-18.

23. Costa RJS, Teixeira A, Rama L, Swancott AJM, Hardy LD, Lee B, *et al*. Water and sodium intake habits and status of ultra-endurance runners during a multi-stage ultra-marathon conducted in a hot ambient environment: an observational field based study. *Nutr J*. 2013;12:13.

24. Hoffman MD, Hew-Butler T, Stuempfle KJ. Exercise-associated hyponatremia and hydration status in 161-km ultramarathoners. *Med Sci Sports Exerc*. 2013;45:784–91.

25. Hoffman MD, Stuempfle KJ, Sullivan K, Weiss RH. Exercise-associated hyponatremia with exertional rhabdomyolysis: importance of proper treatment. *Clin Nephrol*. 2015;83:235–42.

26. Noakes TD, Sharwood K, Speedy D, Hew T, Reid S, Dugas J, *et al*. Three independent biological mechanisms cause exercise-associated hyponatremia: evidence from 2,135 weighed competitive athletic performances. *Proc Natl Acad Sci USA*. 2005 20;102:18550–5.

27. Hew-Butler T, Hamilton R, Hamilton B, Colesa Z. Special Communication of a case of hypovolemic-associated EAH: lessons learned during recovery. *Curr Sports Med Rep*. 2017;16:289–93.

28. Hew-Butler T, Jordaan E, Stuempfle KJ, Speedy DB, Siegel AJ, Noakes TD, *et al*. Osmotic and nonosmotic regulation of arginine vasopressin during prolonged endurance exercise. *J Clin Endocrinol Metab*. 2008;93:2072–8.

29. Hew-Butler T. Arginine vasopressin, fluid balance and exercise: is exercise-associated hyponatraemia a disorder of arginine vasopressin secretion? *Sports Med*. 2010;40:459–79.

30. Wade CE. Response, regulation, and actions of vasopressin during exercise: a review. *Med Sci Sports Exerc*. 1984;16:506–11.

31. Hew-Butler T, Stuempfle KJ, Hoffman MD. Bone: an acute buffer of plasma sodium during exhaustive exercise? *Horm Metab Res.* 2013;45:697–700.

32. Harris G, Reid S, Sikaris K, McCrory P. Hyponatremia is associated with higher NT-proBNP than normonatremia after prolonged exercise. *Clin J Sport Med.* 2012;22:488–94.

33. Zelingher J, Putterman C, Ilan Y, Dann EJ, Zveibil F, Shvil Y, *et al.* Case series: hyponatremia associated with moderate exercise. *Am J Med Sci*. 1996;311:86–91.

34. Rosner MH, Kirven J. Exercise-associated hyponatremia. *Clin J Am Soc Nephrol*. 2007;2: 151–61.

35. Noakes TD, Goodwin N, Rayner BL, Branken T, Taylor RK. Water intoxication: a possible complication during endurance exercise. *Med Sci Sports Exerc*. 1985;17:370–5.

36. Frizzell RT, Lang GH, Lowance DC, Lathan SR. Hyponatremia and ultramarathon running. *JAMA*. 1986;255:772–4.

37. Noakes TD. Is drinking to thirst optimum? *Ann Nutr Metab.* 2010;57:9–17.

38. Cotter JD, Thornton SN, Lee JK, Laursen PB. Are we being drowned in hydration advice? Thirsty for more? *Extrem Physiol Med.* 2014;3:18.

39. Tam N, Nolte HW, Noakes TD. Changes in total body water content during running races of 21.1 km and 56 km in athletes drinking ad libitum. *Clin J Sport Med.* 2011;21:218–25.

40. Hoffman MD, Snipe RMJ, Costa RJS. Ad libitum drinking adequately supports hydration during 2 h of running in different ambient temperatures. *Eur J Appl Physiol.* 2018;118:2687–97.

41. Goulet EDB. Effect of exercise-induced dehydration on time-trial exercise performance: a meta-analysis. *Br J Sports Med.* 2011;45:1149–56.

42. Goulet EDB. Dehydration and endurance performance in competitive athletes. *Nutr Rev*. 2012;70:S132-136.

43. Mayer CU, Treff G, Fenske WK, Blouin K, Steinacker JM, Allolio B. High incidence of hyponatremia in rowers during a four-week training camp. *Am J Med*. 2015;128:1144–51.

44. Urso C, Brucculeri S, Caimi G. Physiopathological, epidemiological, clinical and therapeutic aspects of exercise-associated hyponatremia. *J Clin Med*. 2014;3:1258–75.

45. Rogers IR, Hook G, Stuempfle KJ, Hoffman MD, Hew-Butler T. An intervention study of oral versus intravenous hypertonic saline administration in ultramarathon runners with exercise-associated hyponatremia: a preliminary randomized trial. *Clin J Sport Med.* 2011;21:200–3.

46. Martinez-Cano JP, Cortes-Castillo V, Martinez-Villa J, Ramos JC, Uribe JP. Dysnatremia among runners in a half marathon performed under warm and humid conditions. *BMJ Open Sport Exerc Med.* 2018;4:e000351.

47. Speedy DB, Campbell R, Mulligan G, Robinson DJ, Walker C, Gallagher P, *et al.* Weight changes and serum sodium concentrations after an ultradistance multisport triathlon. *Clin J Sport Med*. 1997;7:100–3.

48. Rüst CA, Knechtle B, Knechtle P, Rosemann T. Higher prevalence of exercise-associated hyponatremia in triple iron ultra-triathletes than reported for ironman triathletes. *Chin J Physiol.* 2012;55:147–55.

49. Wagner S, Knechtle B, Knechtle P, Rüst CA, Rosemann T. Higher prevalence of exercise-associated hyponatremia in female than in male open-water ultra-endurance swimmers: the "Marathon-Swim" in Lake Zurich. *Eur J Appl Physiol.* 2012;112:1095–106.

50. Hew-Butler T, Dugas JP, Noakes TD, Verbalis JG. Changes in plasma arginine vasopressin concentrations in cyclists participating in a 109-km cycle race. *Br J Sports Med.* 2010;44:594–7.

51. Knechtle B, Knechtle P, Rosemann T. No case of exercise-associated hyponatremia in male ultra-endurance mountain bikers in the "Swiss Bike Masters." *Chin J Physiol.* 2011;54:379–84.

52. Chlíbková D, Rosemann T, Posch L, Matoušek R, Knechtle B. Pre- and post-race hydration status in hyponatremic and non-hyponatremic ultra-endurance athletes. *Chin J Physiol.* 2016;59:173–83.

53. Khodaee M, Luyten D, Hew-Butler T. Exercise-associated hyponatremia in an ultra-endurance mountain biker: a case report. *Sports Health*. 2013;5:334–6.

54. Myers TM, Hoffman MD. Hiker fatality from severe hyponatremia in Grand Canyon National Park. *Wilderness Environ Med.* 2015;26:371–4.

55. Weitkunat T, Knechtle B, Knechtle P, Rüst CA, Rosemann T. Body composition and hydration status changes in male and female open-water swimmers during an ultra-endurance event. *J Sports Sci.* 2012;30:1003–13.

56. Baker LB, Munce TA, Kenney WL. Sex differences in voluntary fluid intake by older adults during exercise. *Med Sci Sports Exerc*. 2005;37:789–96.

57. Stuempfle KJ, Lehmann DR, Case HS, Hughes SL, Evans D. Change in serum sodium concentration during a cold weather ultradistance race. *Clin J Sport Med*. 2003;13:171–5.

58. Stuempfle KJ, Lehmann DR, Case HS, Bailey S, Hughes SL, McKenzie J, *et al.* Hyponatremia in a cold weather ultraendurance race. *Alaska Med.* 2002;44:51–5.

59. Backer HD, Shopes E, Collins SL, Barkan H. Exertional heat illness and hyponatremia in hikers. *Am J Emerg Med*. 1999;17:532–9.

60. Oh RC, Malave B, Chaltry JD. Collapse in the heat - from overhydration to the emergency room - three cases of exercise-associated hyponatremia associated with exertional heat illness. *Mil Med.* 2018 01;183:e225–8.

61. Lebus DK, Casazza GA, Hoffman MD, Van Loan MD. Can changes in body mass and total body water accurately predict hyponatremia after a 161-km running race? *Clin J Sport Med.* 2010;20:193–9.

62. Tan DW, Yap SH, Wang M, Fan PW, Teo YS, Krishnasamy P, *et al.* Body mass changes across a variety of running race distances in the tropics. *Sports Med Open*. 2015;2:26.

63. Knechtle B, Knechtle P, Rüst CA, Gnädinger M, Imoberdorf R, Kohler G, *et al.* Regulation of electrolyte and fluid metabolism in multi-stage ultra-marathoners. *Horm Metab Res.* 2012;44:919–26.

64. Bürge J, Knechtle B, Knechtle P, Gnädinger M, Rüst CA, Rüst AC, *et al.* Maintained serum sodium in male ultra-marathoners--the role of fluid intake, vasopressin, and aldosterone in fluid and electrolyte regulation. *Horm Metab Res*. 2011;43:646–52.

65. Chorley J, Cianca J, Divine J. Risk factors for exercise-associated hyponatremia in non-elite marathon runners. *Clin J Sport Med.* 2007;17:471–7.

66. Hoffman MD, Stuempfle KJ, Rogers IR, Weschler LB, Hew-Butler T. Hyponatremia in the 2009 161-km Western States Endurance Run. *Int J Sports Physiol Perform*. 2012;7:6–10.

67. Rüst CA, Knechtle B, Joleska I, Knechtle P, Wirth A, Imoberdorf R, *et al*. Is the prevalence of exercise-associated hyponatremia higher in female than in male 100-km ultra-marathoners? *Hum Mov.* 2018;13:94–101.

68. Lee JKW, Nio AQX, Ang WH, Johnson C, Aziz AR, Lim CL, *et al*. First reported cases of exercise-associated hyponatremia in Asia. *Int J Sports Med.* 2011;32:297–302.

69. Scotney B, Reid S. Body Weight, Serum sodium levels, and renal function in an ultra-distance mountain run. *Clin J Sport Med.* 2015;25:341–6.

70. Hoffman MD, Pasternak A, Rogers IR, Khodaee M, Hill JC, Townes DA, *et al*. Medical services at ultra-endurance foot races in remote environments: medical issues and consensus guidelines. *Sports Med.* 2014;44:1055–69.

71. Beltrami FG, Hew-Butler T, Noakes TD. Drinking policies and exercise-associated hyponatraemia: is anyone still promoting overdrinking? *Br J Sports Med*. 2008;42:796–801.

72. Hoffman MD, Myers TM. Case study: symptomatic exercise-associated hyponatremia in an endurance runner despite sodium supplementation. *Int J Sport Nutr Exerc Metab.*;25:603–6.

73. Scheer BV, Burgos EV. The hidden danger of endurance races: analgesic use among ultramarathon runners. *Br J Sports Med*. 2013;47:e3.

Physical activity in oncology patients with breast cancer: non-pharmacological sports-based medical therapy? Systematic review

Diego Fernández-Lázaro*[1], Juan Mielgo-Ayuso[2], Alberto Caballero-García[3], Alfredo Córdova Martínez[2], María Paz Lázaro Asensio[5,6], César I. Fernández-Lázaro[1,2]

[1]Departamento de Biología Celular, Histología y Farmacología. Facultad de Ciencias de la Salud, Universidad de Valladolid. Campus de Soria, Soria. [2]Departamento de Bioquímica, Biología Molecular y Fisiología. Facultad de Ciencias de la Salud. Universidad de Valladolid. Campus de Soria, Soria. [3]Departamento de Anatomía y Radiología. Facultad de Ciencias de la Salud. Universidad de Valladolid. Campus de Soria. Soria. [4]Departamento de Fisioterapia. Facultad de Ciencias de la Salud. Universidad de Valladolid. Campus de Soria, Soria. [5]Centro de Salud "La Milagrosa" Salud Castilla y León (SACyL), Soria.[6]Preventiva y Salud Pública. Facultad de Medicina. Universidad de Navarra, IdiSNA. Pamplona.

Received: 24/10/2019
Accepted: 17/03/2020

Summary

Introduction: Breast cancer (BC) remains the leading cause of cancer in women with nearly 1.4 million new cases worldwide annually and 27.000 in Spain. Increasingly effective oncology therapies, however, have numerous adverse effects such as muscle degeneration, fatigue, decreased physical function and aerobic capacity, along with deteriorating quality of life. In this sense physical activity (PA) seems to be an interesting non-pharmacological strategy to alleviate these serious complications and with potential benefits for women with BC.
Objective: To examine whether PA interventions are effective on the physical and psychological fitness of patients with post-surgical BC in early stages of disease (I-III) and also to identify the most appropriate component of physical activity.
Methods: Systematic review, based on PRISMA guidelines, using a structured search of electronic databases: Medline (PubMed), SciELO and Cochrane Library Plus. Results relating PA and BC were included until 30 september 2019, while a search restriction was applied to publications to be in the last 10 years. The methodological quality of articles evaluated using the McMaster critical review form.
Results: We found 8 articles that have described the benefits of PA, highlighting physical, psychological and quality of life improvements, as well as decreased fatigue and lymphedema. The exercise routines used are aerobic component work and muscle strength.
Conclusion: The performance of AF, with aerobic and muscular strength routines, stimulate the improvement of the physical, psychological state and the quality of life of the patients of BC patients.

Key words:
Breast cancer. Physical activity. Women. Fatigue. Quality of life. Lymphedema.

Actividad física en pacientes oncológicos de cáncer de mama: ¿Terapia médica deportiva no farmacológica? Revisión sistemática

Resumen

Introducción: El cáncer de mama (CM) sigue siendo la causa principal de cáncer en las mujeres con casi 1,4 millones de casos nuevos en todo el mundo anualmente y 27.000 en España. Las terapias oncológicas, cada vez más eficaces, sin embargo, tienen numerosos efectos adversos como el degaste muscular, la fatiga, la disminución de la función física y la capacidad aeróbica, conjuntamente con el deterioro de la calidad de vida. En este sentido la actividad física (AF) parece ser una estrategia no farmacológica interesante para aliviar estas graves complicaciones y con potenciales beneficios para mujeres con CM.
Objetivo: Examinar si las intervenciones de AF son efectivas sobre estado físico y psicológico de los pacientes de CM postquirúrgicos en estadíos tempranos de enfermedad (I-III) y además identificar el componente de la AF más adecuado.
Material y método: Revisión sistemática, basada en las guías PRISMA, realizando una búsqueda estructurada en las bases de datos electrónicas: Medline (PubMed), SciELO y Cochrane Library Plus. Se incluyeron los resultados que relacionaran las AF y CM hasta el 30 de septiembre de 2019, mientras que se aplicó una restricción de búsqueda en las publicaciones para que fueran en los últimos 10 años. La calidad metodológica de los artículos se evaluó mediante el formulario de revisión crítica de McMaster.
Resultados: Se encontraron 8 artículos que han descrito los beneficios de la AF en los que destacan las mejoras físicas, psicológicas y en la calidad de vida, así como la disminución de la fatiga y linfedema. Las rutinas de ejercicio empleadas son de trabajo de componente aeróbico y de fuerza muscular.
Conclusión: La realización de AF, con rutinas de aeróbicas y de fuerza muscular, estimulan la mejora del estado físico, psicológico y la calidad de vida de los pacientes de CM.

Palabras clave:
Cáncer de mama. Actividad física. Mujeres. Fatiga. Calidad de vida. Linfedema.

SEMED-FEMEDE Award for Research of the Year 2019

Correspondence: Diego Fernández Lázaro
E-mail: diego.fernandez.lazaro@uva.es

Introduction

Cancer is a process in which cells grow and spread without control which can appear almost anywhere in the body and invade the surrounding tissue, causing metastases in distant parts of the body[1]. Cancer is a major epidemiological problem because it is one of the leading causes of death everywhere in the world[2]. Breast cancer (BC) is the most common type of cancer in women, with nearly 1.4 million new cases each year worldwide and 27,000 in Spain. Approximately 6-10% of these cases are stage IV cancer (de novo metastatic cancer) and the metastatic recurrence rate ranges from 20 to 30% of all existing cases of breast tumour[3].

BC is a systemic disease at the time of diagnosis. Consequently, hormone therapy, chemotherapy and/or radiotherapy are normally administered to eliminate any possible presence of hidden micrometastases following radical surgery, thereby reducing the risk of relapse and improving overall survival rates, as the clinically validated prognostic factors establish[4]. Despite the local, regional and systemic treatment applied, between 30% and 50% of patients with negative and positive axillary lymph nodes, respectively, relapse after five years of surgery[4].

Unfortunately, the disease itself, the adjuvant chemotherapy and the radiotherapy administered are associated with serious complications such as muscle wasting and weakness[5]. With BC, neoplastic cachexia causes great muscle mass and body weight loss, and neoplastic fatigue characterised by very extreme tiredness which does not improve with anything and gets worse with rest also appears[6]. These adverse effects are due not only to the therapy (chemotherapy and radiotherapy) but also to the physical inactivity of cancer patients[7], which exacerbates decline in their physical function and aerobic capacity, and further impairs their quality of life (QoL). Other potential side effects of treating BC include lymphedema, chronic inflammation, reduced bone mineral density, reduced cognitive function, vomiting, nausea, loss of appetite, insomnia, and peripheral neuropathy[8,9].

Physical activity (PA) plays an important role in alleviating many of the adverse effects of BC therapy. Clinic-based PA programmes have been shown to improve physical performance and reduce fatigue in BC patients. PA requires a set of intense and repetitive actions that give rise to a high level of metabolic and mechanical stress in the body that leads to adaptations of the different body systems of those who perform them[10]. PA stimulates a battery of intracellular processes which underlie these adaptations, including catabolic systems, such as autophagolysosome, the ubiquitin-proteasome and inflammation, and anabolic systems, such as protein synthesis. The activation and/or repression of specific signalling cascades which regulate these processes link the metabolic and mechanical stress to the regulation of cellular enzymes that lead to changes: myocellular changes in the mitochondria, the metabolic function, insulin-stimulated glucose uptake, intracellular signalling and transcriptional/translational regulation. PA also stimulates the proliferation and differentiation of muscle stem cells (satellite cells) as part of the adaptive response to training involving exercises to help patients recover from muscle wasting and weakness[11-14].

Moreover, some of the consequences of cancer or its adjuvant treatment cause states of chronic inflammation which play a crucial role in the development, progression and risk of cancer recurrence due to their effects on carcinogenesis and the development of the tumour microenvironment[1]. We know that a combination of aerobic and muscle resistance training stimulates the production and secretion of pro-inflammatory cytokines (IL-6, IL-2, IL-8, IL-10, TNF- α, IL-1 ß, IL-12, IFN-γ), which subsequently exert their effects locally in the skeletal muscle or their target organs. This initial pro-inflammatory response is controlled by anti-inflammatory molecules like the IL-1 receptor antagonist (IL-1ra), transforming growth factor beta (TGF-ß), interleukins 4, 6, 10, 11 and 13 and the specific IL-1, TNF α and interleukin 18 receptors. The immunomodulatory action of all these molecules limits the harmful effect of the inflammatory reaction in cancer[12,15]. Another neoplastic inflammatory process control mechanism could be established because the cytokine cascade induced by exercise differs from the cytokine cascade (TNF- α and IL-1) induced by cancer, which has been associated with a therapeutic action of PA by reducing the likelihood of tumour reactivation and progression. The ability of PA, therefore, to reduce chronic inflammation and favourably affect health makes it a crucial mechanism for BC survivors[15,16]. However, acute exposure to training only has a short-lived effect on the inflammatory profile and it is unlikely that a single exercise session will bring about adaptive changes. Repetition of the exercise would seem to be necessary for any long-term health benefits[15,16].

Another potential benefit of PA as a form of non-pharmacological intervention in cancer patients is the enhanced mental and social well-being resulting from taking part in PA programmes, leading to a reduction in the symptoms associated with the disease or its treatment[9].

The recommendation of moderate-intensity physical activity at least five days a week or 75 minutes of more vigorous exercise, together with two to three sessions per week of strength training, including exercises for the major muscle groups, has been approved by both the Canadian Cancer Society and the American Cancer Society to reduce the risk of breast cancer recurrence and lessen the symptoms associated with the disease or its treatment[17]. However, more hours of exercise and more exercise at a more vigorous intensity could potentially increase the benefits. In this sense, this study reviewed the articles published to date to examine whether PA interventions are effective in increasing physical fitness and improving other results (physical, psychological, muscular and biological) for postsurgical early-stage (I-III) BC patients and sought to identify the most suitable component of the physical activity carried out.

Materials and methods

Search strategy

This article is a systematic review focussing on the impact of performing physical activity on patients with BC. It was conducted following the specific methodological guidelines Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) and the PICOS question framework to define the inclusion criteria: P (population): "women with breast cancer," I (intervention): "impact of physical activity on patients with breast cancer", C (comparison): "same conditions with/without physical activity", O (outcomes): "Physical, biological, psychological, muscle and quality of life modifications induced following physical activity programmes", S (study type): "randomised design without placebo"[18].

A structured search was conducted in the following electronic databases: Medline (PubMed), SciELO and Cochrane Library Plus. Results until 30 August 2019 were included, while a search restriction was applied to publications so they were from the last 10 years due to constant developments in oncology. The search terms included a mix of medical subject headings (MeSH) and free text words for key concepts related to BC and physical activity: physical activity, neoplasms, breast cancer, exercise, benefits, prescription, physiotherapy and rehabilitation (Table 1). Through this search, relevant articles in the field of physical activity in patients with BC were obtained applying the snowball method. All the titles and abstracts from the search were crossed-checked to identify duplicates and studies which were potentially missing. The titles and abstracts were then examined for later review of the full text. Two authors (DFL and CIFL) independently performed the search for published studies and disagreements regarding the physical parameters were resolved by discussion.

Table 1. Databases, search terms, articles selected.

Search number	Database used	Search term	Number of articles after removing duplicates	Number of articles evaluated with full text
1	Medline (PubMed)	Physical activity AND cancer	77	8
2	Medline (PubMed)	Physical activity AND breast cancer	63	10
3	Medline (PubMed)	Physical activity AND breast cancer AND benefits	57	4
4	Medline (PubMed)	Physical activity AND breast cancer AND physiotherapy	20	4
5	Medline (PubMed)	Physical activity AND breast cancer AND prescription	23	4
6	Cochrane library plus	Cancer and physical activity	11	3
7	Cochrane library plus	Breast cancer AND physical activity	25	4
8	Cochrane library plus	Breast cancer AND physiotherapy	30	2
9	SciELO	Cáncer AND actividad física	6	1
10	SciELO	Cáncer de mama AND actividad física	27	0

Inclusion and exclusion criteria

The following inclusion criteria were applied to select the studies from the papers obtained in the search: 1) A well designed experiment involving physical activity in postsurgical early-stage (I-III) BC patients; 2) Not receiving chemotherapy or radiotherapy; 3) An identical situation of BC patients not doing physical activity; 4) Articles published in the last 10 years; 5) Publications on human female study subjects aged over 18; 6) Languages restricted to English, German, French, Italian, Spanish and Portuguese. The exclusion criteria applied were: 1) Publications not related to BC and physical activity; 2) Duplicated papers; 3) Studies more than 10 years old; 4) Not conducted on female humans; 5) No previous filters on fitness level or capacity to do physical activity; 6) Papers of poor methodological quality, ≤8 points according to the McMaster University critical review form[19] for quantitative studies; 7) Narrative or systematic reviews.

Data extraction and synthesis

After applying the inclusion/exclusion criteria to each study, the data on the source of the study (including authors and year of publication), BC patient status, study design, participant characteristics, PA protocol used with the patients, and the results and conclusions of the interventions were extracted independently by two authors (DFL and CFL) using a spreadsheet (Microsoft Inc., Seattle, WA, USA). Any disagreements were then resolved by discussion until consensus was reached..

Methodological quality assessment

The methodological quality of the articles assessed using the McMaster University critical review form19 attained scores ranging from 11 to 15 points, representing a minimum methodological quality of 68.8% and a maximum of 93.8% (Table 2). Of the 8 papers, 3 were considered to be of "very good" quality, 4 of "good" quality and 1 of "excellent" quality. No study was excluded for failing to meet the minimum quality threshold. Table 2 details the results of the criteria evaluated, where the main shortcomings found in terms of methodological quality were associated with items 5, 12 and 13 of the questionnaire, which cover detailed

Table 2. Methodological quality assessment

Reference	Ítems																T	%	MQ
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16			
Moros *el al.*[28] 2010	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	14	87.5	VG
Patsou *et al.*[24] 2018	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	14	87.5	VG
Dieli-Conwright *et al.*[20] 2018	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	15	93.8	E
Di Blasio *et al.*[22] 2016	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	0	13	81.3	VG
Musanti *et al.*[23] 2012	1	1	1	1	0	1	1	1	1	1	0	0	0	1	0	1	11	68.8	G
Speck, Gross, *et al.*[27] 2010	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1	0	12	75	G
Rogers *et al.*[25] 2014	1	1	1	1	1	0	1	1	1	1	0	0	0	1	0	1	11	68.8	G
Saarto *et al.*[26] 2012	1	1	1	1	0	1	1	1	1	1	0	0	0	1	1	0	11	68.8	G
T	10	10	10	10	4	7	10	10	10	9	6	3	4	10	8	6			

T: total items met; MQ: Methodological quality (poor ≤8 points; acceptable 9-10 points; good 11-12 points; very good 13-14 points; excellent ≥15.
(1) Criterion met; (0) Criterion not met.

justification of the sample size, discussion of the clinical importance of the results and reporting drop-outs, respectively.

Results

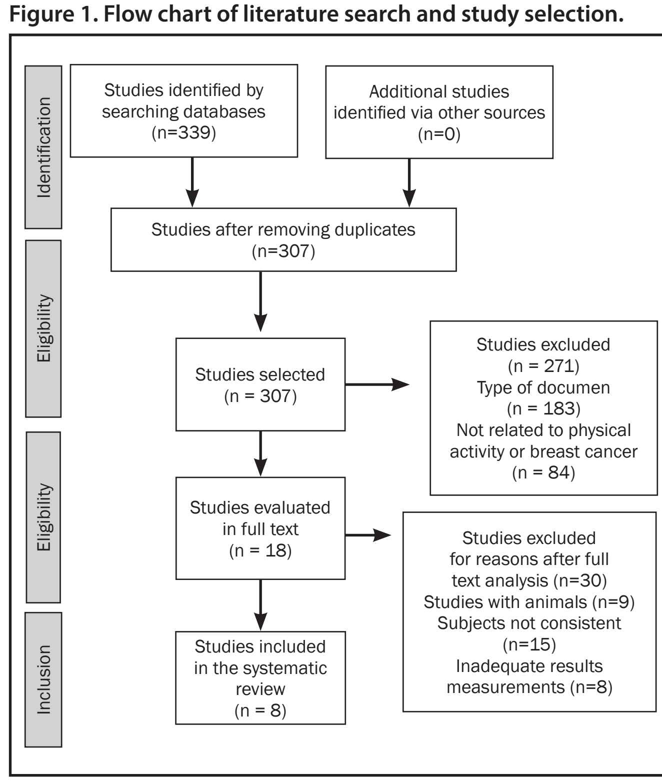
Selection of studies

The search yielded 389 articles, of which 339 were published after 2010. After removing the duplicate articles (n = 32), 307 articles were selected for examination by title and abstract, of which 183 were excluded because they did not involve any intervention and 84 because they were not related to the search subject. The full texts of the remaining 40 publications were evaluated according to the inclusion criteria, of which 9 studies were removed because they were conducted with animals, 15 because they involved subjects with comorbidities and 8 because they did not measure any of the variables included in this study. And so the eight articles included in this systematic review (Figure 1) were obtained.

Results measured

Table 3 includes data on the source of the study (including authors and year of publication), BC patient status, study design, participant characteristics, PA intervention protocol used with the BC patients and results and conclusions.

Figure 1. Flow chart of literature search and study selection.



Discussion

The health problems caused by BC are due both to the disease itself and to the action taken, such as: surgical resection and different treatments (hormonal therapy, adjuvant chemotherapy and radiotherapy). Additionally, these effects are exacerbated when the lifestyle of the BC patient is unsuitable because he/she is physically inactive, obese, has abnormal eating patterns (malnutrition or overeating) and has lost muscle mass. For these reasons, prescribing and performing PA could be an effective non-pharmacological strategy to mitigate all the effects of BC through which to modify the patient's lifestyle, stimulating potential physical, biological, psychological and muscle modifications leading to an improvement in the patient's quality of life[9,20].

This study aims to systematically review PA interventions for women with early stage BC who are not undergoing chemotherapy or radiation therapy to determine their effectiveness as a recovery strategy for patients and to provide some basic guidelines for the correct prescription of exercise in this population. The results provided could be considered

Table 3. Summary of the studies included in the review which investigate the impact of physical activity on patients with breast cancer.

Authors	Patient situation	Study	Intervention	Results	Conclusions
Moros *et al.*[28] 2010	22 ♀, 49±7 y.o. (40.9% were working prior to diagnosis) BC Post-SP Before chemotherapy	Randomised Controlled Trial Exclusion: condition preventing physical activity (heart disease, hypertension, anaemia, fracture risk, diabetes). Inclusion: DOES NOT exercise ♀> 65 y.o.	18-22 weeks of treatment, 3 sessions per week → 60 minutes per session. Warm-up (10´) Main part (45′) – Exercise bike – Breathing exercises – Upper limb strength work, non-operated arm – Treadmill walking – Pelvic girdle and abdominal work Stretching / Relaxation (5′)	↑*Quality of life (EORTC QLQ-C30). ↑ fatigue ↓ Functional capacity (Karnofsky performance status) ↓ Overall psychological well-being (General Health Questionnaire) ↓* Somatic / psychological ↓* Overall score	An exercise programme improves the quality of life of women with breast cancer undergoing chemotherapy.
Patsou *et al.*[24] 2018	171♀, 51.74±7.26 y.o. BC Post-SP Stage I-III: I: 31.5% II: 50.4% III: 28.1% 12-18 months after chemotherapy and/or radiotherapy ♀ 18-65 y.o	Randomised Controlled Trial G1 physically active group (n=82) G2 physically active group (n=89) The groups were established based on the IPAQ criteria: Types of PA, intensity, frequency and duration. Exclusion criteria: comorbidities or oncological processes which inhibit effects of physical activity	Exercise Vigorous: High-intensity aerobic exercises (running or cycling), lifting heavy weights Moderate: swimming, cycling at normal speed and walking quickly Mild: gentle walks Data on frequency (measured in days/week) and duration (time/day) were collected separately for each specific type of activity according to IPAQ Overall health assessed with EORTC QLQ-C30.	↑ Mood ↓* Anxiety ↑ * Self-esteem ↑ Psychological profile. ↑* Health ↑* Fitness ↑* Quality of life G1 significant positive correlations with self-esteem, overall health and quality of life (physical, role, emotional, cognitive and social).	Start carrying out physical activity as soon as possible after diagnosis, treatment to achieve greater self-esteem, better quality of life, lower anxiety, less symptoms of depression and better physical condition to achieve higher survival rate of BC patients.
Dieli-Conwright *et al.*[20] 2018	BC Post-SP Stage I-III: Stage I (40%) Stage II (38%) < 6 months after chemotherapy and/or radiotherapy	418 ♀ 56.3±10.4 y.o. Randomised Controlled Trial Assessment at start of the study, after the intervention (month 4) and 3-month follow-up period (exercise group only).	Intervention: 16 weeks, (3 per week) Aerobic 150 minutes Days 1-3: aerobic exercise + resistance (~ 80 minutes). Day 2: aerobic exercise (~ 50 minutes). Strength: * Circuit without rest periods between exercises 2-3 per week. Follow-up: The exercise group spent 12 weeks doing exercise on their own without intervention.	Intervention ↑* Quality of life (FACT; SF-36) ↑* Muscular strength ↑* VO_2max ↑* Bone formation (phosphatase and osteocalcin) ↓* fatigue ↓* depression Follow-up ↑* Physical fitness vs. start of study.	Intervention based on aerobic and resistance exercise designed to improve metabolic syndrome led to improvements in quality of life, depression, fatigue and physical fitness which were maintained after 3 months of follow-up. The first study to improve these outcomes significantly. Combined physical activity should be incorporated into the treatment and care plans for BC.
Di Blasio *et al.*[22] 2016	BC Post-SP with lymphedema type II Currently with hormonal treatment Without prior chemotherapy or radiotherapy	20 ♀, 50.6±3.6 Randomised Inclusion:>40 ≤55 y.o. No specific diet, no exercise <6 months at the start of study Randomly assigned to 4 groups	10 weeks, three sessions of 70 minutes at moderate intensity. Warm-up 15´ Central part 45′ G1: Nordic walking (NW) G2: Walking (W) G3: ISA method (specific for BC survivors) +NW G4: ISA +W Cool-down 10′	*Group: 1, 3 and 4* ↓*Diameter arm/forearm homolateral SP ↑ Upper limb strength ↑ Lymphedema prevention Group: 1 and 4 ↓* Extracellular H2O; extracellular H2O/ Total H_2O ratio; wrist diameter, homolateral SP *Group:* 2 = Limb diameter and body H_2O	NW, NW+ISA, W+ISA are beneficial for reducing the arm and forearm circumference on the operated side and increasing upper limb muscular strength. However, just W does not produce any change in the upper limbs.

♀: Female; BC: Breast cancer: SP: Surgical procedure; ↑: Increase; ↑*: Statistically significant increase; ↓: Decrease; ↓*: Statistically significant decrease; ´: Minutes; VO_2max: Maximum oxygen uptake.

(continúa)

Authors	Patient situation	Study	Intervention	Results	Conclusions
Musanti *et al.*[23] 2012	BC Post-SP Stage I-III: ♀ 18+ y.o. Receiving hormonal therapy Post-chemotherapy 3 months + or Post-radiotherapy 6 weeks + before the start of the study and no more than 24 months beyond their last treatment.	42 ♀ in three randomly assigned groups: - Aerobic group (A): 13 women - Flexibility group (F): 12 women - Resistance group (R): 17 women - Aerobic and resistance group (AR): 18 women Exclusion criteria: comorbidities or oncological processes which inhibit effects of physical activity	Individualised home-based exercise programme *Aerobic exercise* Frequency: 3/5 per week. 15-30 min. per session. Progressive intensity: 40–85% *Resistance exercise.* Frequency: 2/3 per week Repeats per session: 10-12. Sets of exercises for major muscle groups with resistance band Intensity: 3-8 perceived exertion rating on a scale of 1 to 10. Aerobic + resistance exercise. Combination of the 2 protocols	R ↑ strength A ↑* VO_2max A-R ↑ physical and overall self-esteem. F ↑ body fat A-R ↑ overall self-esteem Long-term improvements ↑ physical fitness	The exercise model based on improving physical and overall self-esteem was beneficial for female survivors of breast cancer, especially for those who followed a protocol based on flexibility and resistance exercises followed by aerobic exercises, because they showed greater long-term adherence and maintenance. They all also improved their physical fitness and overall self-esteem.
Speck *et al.*[27] 2010	BC Post-SP Stage I-II: ♀ 18+ y.o. With or without lymphedema	234 [112 lymphedema] Two randomly assigned groups: Intervention Group (IG): physical activity 56±9 y.o. Control group (CG): no physical activity 58±9 y.o. Inclusion: 12 months of physical activity intervention Exclusion: comorbidities or oncological processes which inhibit effects of physical activity	IG: Strength training, upper and lower limbs, and core. 2 90-minute sessions per week. CG: Training without loads or with light weights. Warm-up and stretching added.	IG: ↓ incidence, ↓ severity ↓ exacerbation of lymphedema in the upper limbs. . ↑*Muscular strength ↑ Quality of life (SF-36) ↑ Self-perception appearance	Interventions with the potential to increase strength can improve body image in BC survivors Strength training positively influenced the self-perceptions of appearance, health, physical strength, sexuality, relationships, and social functioning.
Rogers *et al.*[25] 2014	Ductal BC *in situ* Post-SP Stage I-III: ♀ 118-70 y.o. Not receiving chemotherapy or radiotherapy ≥ 8 weeks post SP	222 women randomised into two groups: Intervention Group (IG): physical activity 54 y.o. Control Group (CG): no physical activity 55 y.o. Inclusion: 6 months of physical activity intervention Exclusion: comorbidities that prevent physical activity or its evaluation	IG: 3 months 12 sessions of supervised aerobic training + individual exercise at home and group physical activities. CG: received written information on physical activity	GI adherence to the treatment was 98% and ↑* CG ↑ Aerobic fitness ↑ 6-minute walk post-intervention. ↑*Physical activity in time and intensity ↑* Physical fitness ↑*Quality of life (FACT)	The intervention led to improved physical activity and aerobic capacity. In the short term, it was able to significantly improve quality of life several months after completion, representing an important and worthwhile finding.
Saarto *et al.*[26] 2012	BC Post-SP Stage I-II: ♀ 35-68 y.o. Treated with chemotherapy and/or adiotherapy ≥ 4 months Hormonal treatment no less than three months before.	500 women, mean age 52.3 randomised into two groups: *Intervention Group* (IG): activity n= 237 *Control Group* (CG): no activity n= 263 Exclusion: comorbidities that prevent physical activity or its evaluation	12 months of intervention. IG: Aerobic exercise Time = 48 weeks Duration = 60 min/session Frequency = 1 session/week Intensity = 86%-92%. CG: Encouraged to maintain their previous level of physical activity and exercise habits	Training group ↑ neuromuscular performance ↑ walking time ↑ physical fitness ↑* quality of life (EORTC QLQ-C30). ↑* time performing physical activity ↑ physical performance	Any increase in physical activity, whether triggered by the intervention or spontaneous, was related to improved quality of life in BC patients. Thus, even a motivation of BC survivors to exercise post-treatment could be sufficient to improve their physical activity and quality of life, at least among those who are inclined to be physically active.

♀: Female; BC: Breast cancer: SP: Surgical procedure; ↑: Increase; ↑*: Statistically significant increase; ↓: Decrease; ↓*: Statistically significant decrease; ´: Minutes; VO_2max: Maximum oxygen uptake.

of interest by professionals responsible for prescribing physical exercise as part of the treatment or rehabilitation process for this population. The studies included in this study are randomised controlled trials, considered the "gold standard" to examine whether there is a cause-and-effect relationship between PA and potential benefits for BR patients[21].

The most relevant results of this systematic review indicate that women who have received chemotherapy and/or radiotherapy for BR and do various forms of physical activity and exercise have improved in terms of physical health[20,22-27], psychological health[20,23,24,27], QoL[20,24-28] and fatigue[20]. Some studies have shown improvements in the specific physical capacity functions such as maximum oxygen uptake (VO_2max)[20,23], muscle strength[20,22,23,27] and muscular performance[26]. Other metabolic findings include possible positive effects on bone mineral density[20]. Two studies also report a decrease in upper-limb lymphedema[22,27].

The prescription of PA following the post-surgical procedure stage and chemotherapy and/or radiotherapy treatments took into account the limitations of these women. However, those women with BC-associated comorbidities (cardiovascular problems, respiratory problems, hypertension, anaemia, fracture risk, diabetes), in metastatic stage IV and with some kind of intrinsic impediment preventing them from performing PA were excluded. Primary breast tumours do not normally cause death; death in these cases is the result of the spread/metastasis of the cancer to secondary sites in the body. The 5-year survival rate stands at 99% for localised breast cancer, 84% for regional stage breast cancer (nearby lymph nodes) and 23% for metastases (distant organs) and lymph nodes[3,5]. For this reason, PA after surgery and chemotherapy and/or radiotherapy is justified because it reduces the levels of circulating oestrogen[29], which potentially slows down or halts the growth of hormone-sensitive tumours by blocking the body's ability to produce hormones or by interfering with the effects of hormones on breast cancer cells, which would reduce the risk of developing metastases[30]. It is also suggested[31] that regular PA so the women can reach an optimal physical condition helps keep oestrogen levels so low that they do not interact with the receptors in the breast cancer cells sensitive to the hormones, thus preventing changes in the expression of specific genes which can stimulate cell growth.

Physical activity

CWhen prescribing PA for BC patients, there are several ways of planning the type of training, seeking what is potentially the most beneficial type for the patient and adapting it to their condition[31]. In this review, seven studies included aerobic training (AT)[20,22-26,28] and in some[22,24-26] it was the only type of PA used. Doing PA which only involves AT[22,24-26] could be due to possible complications associated with the appearance of secondary lymphoedema caused by strength training (ST) of the upper limbs of these patients. However, Speck *et al.*[27] only used ST and observed that the symptoms and exacerbation of lymphoedema disappeared. Other studies performed work in which ST was combined with AT[20,23,28]. Musanti *et al.*[23] and Moros *et al.*[28] also included flexibility work at the end of the training sessions.

Aerobic training

Many varieties of AT establish specific routines: a) Impact activities, which besides serving as a warm-up to training, are widely used because they favour bone regeneration and prevent osteoporosis[28]. When performing exercise of this kind, the intensity is increased gradually over the session[20,22-24,28]; b) Exercises bikes can be combined with breathing exercises and even exercises to strengthen the upper limbs[28]; c) Nordic walking (NW) is a form of walking using walking poles to help you move along, thereby involving the trunk and upper limbs in the exercise[22]; d) Running or walking: this was the basic AT for the patients in the studies[20,23-26].

AT is prescribed in order to increase aerobic and functional capacity, which has diminished in patients with BC, generally after receiving cancer treatment[31]. Fitness assesses the level of physiological readiness or capacity for exercise. From this perspective, direct assessment by VO_2max[20,23] and the International Physical Activity Questionnaire (IPAQ)[24] or indirect methods which measure the time and intensity of the PA[25,26] performed have shown significant improvements in the specific physical capacity functions of patients with BC after following PA protocols.

Strength training

The aim of ST is to prevent the loss of muscle mass and strength produced by BC and oncological medical treatment. The most aggressive therapies are even associated with problems of malnutrition, resulting in anorexia or cachexia, which exacerbates muscle degeneration[31]. Increases have been observed[22,23] in muscle strength, some of which are significant[20,27], and also imply a better body image, thereby bringing in the psychological aspect, of particular importance when it comes to overcoming BC. These improvements in skeletal muscle associated with ST could result from the transcriptional deregulation of the MuRF-1 and atrogin-1 proteins which increase during BC and chemotherapy and/or radiotherapy[12]. MuRF-1 and atrogin-1 have been identified as ligases which participate in E3 ubiquitin-mediated muscle proteolysis, one of the chief pathways which regulates muscle protein breakdown, and this system plays a central role in controlling muscle size[32].

Doing PA also leads to the recovery of type II fibre, lost after chemotherapy and/or radiotherapy or due to neoplastic cachexia processes[31], producing an improvement in the contractile activity and speed of skeletal muscle, leading to improvements in strength[20,22,23,27].

Flexibility training

Flexibility training (FT) is prescribed together with other types of training[23,27,28] to increase joint mobility, especially in those patients who have undergone surgery and the area is quite retracted, the muscles improving the mobility and functional capacity of the affected area.

Control of lymphedema

The BC patients who engaged in an exclusive upper and lower limb ST programme[27] not only significantly increased their strength but also had a lower incidence and severity of lymphedema. Di Blasio et al's study[22] reports that NW is effective in reducing lymphedema, significantly decreasing the diameter of the homolateral arm and forearm, as well as establishing a preventive mechanism against exacerbations. Probably the method of doing NW, which involves a cycle of opening and closing the hands, creating a pumping effect, promotes blood and lymphatic circulation by contraction of the upper limbs. NW is combined with the ISA method (specifically designed for breast cancer survivors), used to warm up the joints gently, lessen tensions and help reduce lymphedema. Reducing lymphedema leads to an increase in the effective contractile space which increases the strength of the upper limbs and improves MMSS and improves body image.

Improvement of fatigue

Interleukin 6 (IL-6) has been associated with symptoms of fatigue, which are the most common symptoms and their action among patients with BC is devastating because they are associated with chronic inflammatory processes. Besides being associated with fatigue, IL-6 is a predictive biomarker of survival in people with metastatic BC[12] because it plays a key role in the development, progression and risk of BC. Lahart *et al*.[31] claim that PA specifically reduces fatigue in people with BC and that this improvement could be associated with the reduction in IL-6 and other cytokines (IL-2, IL-8 and TNFα)[12,15]. This finding could contribute to the incorporation of PA routines which have been associated with a favourable tendency in survival through exercise in several populations with cancer[15]. In this regard, the direct measurement of fatigue by Dieli-Conwright *et al*.[20] saw a significant decrease which led to a significant improvement in the physical condition of BC patients compared to the start of the study. This decrease in fatigue is revealed indirectly[25,26] because these patients are able to significantly increase the time and intensity of PA, which supposes an improvement in physical fitness without the onset of fatigue.

Psychological aspects

At some point in the course of the disease, most BC survivors suffer psychological side effects related to the disease itself or the medical treatment received. Depression and low self-esteem are associated in part with the physical changes that the women experience and in part with loneliness[31]. To try to combat these psychological consequences, studies on PA in patients with BC[20,23,24,27] have reported improvements of such psychological factors as mood, anxiety and depression, self-esteem and self-perception of the appearance. In addition to the actual patients, these changes also benefit their families. These improvements in psychological profile affect QoL very favourably.

Quality of life of the patients

QoL can be related to all aspects of a person's life, but in the field of oncology the term focuses on the health of the patient[33]. At present, attention has been focused on the quality and not just the quantity of life. Non-pharmacological PA therapy should be assessed on whether it is more likely to provide a life worth living in social, psychological and physical terms, evaluating the health of the individual and the potential benefits and risks that may arise from PA[34].

Quality of life was assessed using validated questionnaires: the European Organisation for Research and Treatment of Cancer (EORTC) questionnaire (EORTC QLQC30)[24,26,28], the Functional Assessment of Cancer Therapy (FACT)[20,25] and the Short Form-36 Health Survey (SF-36)[20,27]. All the studies[20,24-28] showed a significant improvement in QoL compared with the control group. These results are consistent with others published[9,16,31,34]. Generally, QoL is influenced by the beneficial evolution obtained in perceptions of body image, self-esteem and mood after doing PA programmes. Additionally, adherence to PA therapy is favoured by improvements in QoL, which should encourage the implementation of PA as a continuous habit in patients with BC, resulting in all the long-term health benefits described[15,16].

Conclusion

Doing PA with AT and ST routines stimulates improvements of the physical and psychological condition of patients with BC. Doing PA gives rise to increases in muscle strength and VO_2max, decreases in fatigue and lymphedema, and improvements in self-esteem and body image which have a direct beneficial effect on the QoL of BC patients.

Our thanks to:

The authors would like to thank the Department of Medical Oncology at the University Clinical Hospital of Salamanca and the Institute of Health Science Studies of Castile and León (ICSCYL) for their support and cooperation throughout the process of conducting this study.

Conflict of interest

The authors declare that they are not subject to any type of conflict of interest.

Bibliography

1. Hanahan D, Weinberg RA. Hallmarks of cancer: the next generation. *Cell*. 2011;144:646-74.
2. Naghavi M, Abajobir AA, Abbafati C, Abbas KM, Abd-Allah F, Abera SF, *et al*. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2017;390:1151-210.
3. O'Shaughnessy J. Extending survival with chemotherapy in metastatic breast cancer. *Oncologist*. 2005;10:20-9.
4. Wang J, Chang S, Li G, Sun Y. Application of liquid biopsy in precision medicine: opportunities and challenges. *Front Med*. 2017;11:522-7.
5. Senkus E, Kyriakides S, Ohno S, Penault-Llorca F, Poortmans P, Rutgers E, *et al*. Primary breast cancer: ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up. *Ann Oncol*. 2015;26:v8-30.
6. Berger AM, Gerber LH, Mayer DK. Cancer-related fatigue: implications for breast cancer survivors. *Cancer*. 2012;118:2261-9.
7. Gilliam LA, St. Clair DK. Chemotherapy-induced weakness and fatigue in skeletal muscle: the role of oxidative stress. *Antioxid Redox Signaling*. 2011;15:2543-63.

8. Coughlin SS, Caplan LS, Williams V. Home-based physical activity interventions for breast cancer patients receiving primary therapy: a systematic review. *Breast Cancer Res Treat.* 2019;1788:513-22.
9. Gebruers N, Camberlin M, Theunissen F, Tjalma W, Verbelen H, Van Soom T, *et al*. The effect of training interventions on physical performance, quality of life, and fatigue in patients receiving breast cancer treatment: a systematic review. *Support Care Cancer.* 2019;27:109-22.
10. Coffey VG, Hawley JA. The molecular bases of training adaptation. *Sports Med.* 2007;37:737-63.
11. Egan B, Zierath JR. Exercise metabolism and the molecular regulation of skeletal muscle adaptation. *Cell Metab.* 2013;17:162-84.
12. Møller AB, Lønbro S, Farup J, Voss TS, Rittig N, Wang J, *et al.* Molecular and cellular adaptations to exercise training in skeletal muscle from cancer patients treated with chemotherapy. *J Cancer Res Clinical Oncol.* 2019;145:1449-60.
13. Møller AB, Voss TS, Vendelbo MH, Pedersen SB, Møller N, Jessen N. Insulin inhibits autophagy signaling independent of counterregulatory hormone levels but does not affect the effects of exercise. *J Applied Physiol.* 2018;125:1204-9.
14. Stefanetti RJ, Lamon S, Wallace M, Vendelbo MH, Russell AP, Vissing K. Regulation of ubiquitin proteasome pathway molecular markers in response to endurance and resistance exercise and training. *Pflügers Arch*. 2015;467:1523-37.
15. Meneses-Echávez JF, Correa-Bautista JE, González-Jiménez E, Río-Valle JS, Elkins MR, Lobelo F, *et al.* The effect of exercise training on mediators of inflammation in breast cancer survivors: a systematic review with meta-analysis. *Cancer Epidemiol Biomarkers Prev.* 2016;25:1009-17.
16. Buffart L, Galvão DA, Brug J, Chinapaw M, Newton RU. Evidence-based physical activity guidelines for cancer survivors: current guidelines, knowledge gaps and future research directions. *Cancer Treat Rev.* 2014;40:327-40.
17. Hamer J, Warner E. Lifestyle modifications for patients with breast cancer to improve prognosis and optimize overall health. *CMJA*. 2017;189:E268-E274.
18. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, *et al.* The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med.* 2009;6:e1000100.
19. Law M, Stewart C, Pollock N, Letts L, Bosch J, Westmorland M. *McMaster Critical Review Form-Quantitative Studies.* Hamilton, Ontario: McMaster University Occupational Therapy Evidence-Based Practice Research Group. 1998.
20. Dieli-Conwright CM, Courneya KS, Demark-Wahnefried W, Sami N, Lee K, Sweeney FC, *et al.* Aerobic and resistance exercise improves physical fitness, bone health, and quality of life in overweight and obese breast cancer survivors: a randomized controlled trial. *Breast Cancer Res.* 2018;20:124.
21. Barton S. Which clinical studies provide the best evidence?: The best RCT still trumps the best observational study. *BMJ.* 29;321:255-6.
22. Di Blasio A, Morano T, Bucci I, Di Santo S, D'Arielli A, Castro CG, *et al.* Physical exercises for breast cancer survivors: effects of 10 weeks of training on upper limb circumferences. *Journal Phys Ther Sci.* 2016;28:2778-84.
23. Musanti R. A study of exercise modality and physical self-esteem in breast cancer survivors. *Med Sci Sports Exerc.* 2012;44:352-61.
24. Patsou ED, Alexias GT, Anagnostopoulos FG, Karamouzis MV. Physical activity and sociodemographic variables related to global health, quality of life, and psychological factors in breast cancer survivors. *Psychol Res Manag.* 2018;11:371-81.
25. Rogers LQ, Courneya KS, Anton PM, Hopkins-Price P, Verhulst S, Vicari SK, *et al.* Effects of the BEAT Cancer physical activity behavior change intervention on physical activity, aerobic fitness, and quality of life in breast cancer survivors: a multicenter randomized controlled trial. *Breast Cancer Res Treat.* 2015;149:109-19.
26. Saarto T, Penttinen HM, Sievänen H, Kellokumpu-Lehtinen P-L, Hakamies-Blomqvist L, Nikander R, *et al.* Effectiveness of a 12-month exercise program on physical performance and quality of life of breast cancer survivors. *Anticancer Res.* 2012;32:3875-84.
27. Speck RM, Gross CR, Hormes JM, Ahmed RL, Lytle LA, Hwang W-T, *et al.* Changes in the body image and relationship scale following a one-year strength training trial for breast cancer survivors with or at risk for lymphedema. *Breast Cancer Res Treat.* 2010;121:421-30.
28. Moros MT, Ruidiaz M, Caballero A, Serrano E, Martínez V, Tres A. Ejercicio físico en mujeres con cáncer de mama. *Rev Med Chil.* 2010;138:715-22.
29. Sokoloff NC, Misra M, Ackerman KE. Exercise, training, and the hypothalamic-pituitary-gonadal axis in men and women. *Front Horm Res*. 2016;47:27-43.
30. Pizot C, Boniol M, Mullie P, Koechlin A, Boniol M, Boyle P, *et al.* Physical activity, hormone replacement therapy and breast cancer risk: A meta-analysis of prospective studies. *Eur J Cancer.* 2016;52:138-54.
31. Lahart IM, Metsios GS, Nevill AM, Carmichael AR. Physical activity for women with breast cancer after adjuvant therapy. *Cochrane Database Syst Rev.* 2018;1:CD011292
32. Gumucio JP, Mendias CL. Atrogin-1, MuRF-1, and sarcopenia. *Endocrine*. 2013;43:12-21.
33. Recalde M, Samudio M. Calidad de vida en pacientes con cáncer de mama en tratamiento oncológico ambulatorio en el Instituto de Previsión Social en el año 2010. *Mem Inst Investig Cienc Salud.* 2012;10:13-29.
34. Arraras JI, Martínez M, Manterota A, Laínez N. La evaluación de la calidad de vida del paciente oncológico. El grupo de calidad de vida de la EORTC. *Psicooncología.* 2004;1:87-98.

XVIII Congreso Internacional de la Sociedad Española de Medicina del Deporte

Fecha

25-27 de Noviembre de 2021

Lugar

Universidad Católica San Antonio de Murcia (UCAM)
Campus de los Jerónimos
30107 Guadalupe (Murcia)
Página web: https://www.ucam.edu/

Secretaría Científica

Sociedad Española de Medicina del Deporte
Dirección: C/ Cánovas nº 7, bajo
50004 Zaragoza
Teléfono: +34 976 02 45 09
Correo electrónico: congresos@femede.es
Página web: http://www.femede.es/congresomurcia2020

Secretaría Técnica

Viajes El Corte Inglés S.A.
División Eventos Deportivos
C/ Tarifa, nº 8. 41002 Sevilla
Teléfono: + 34 954 50 66 23
Correo electrónico: areaeventos@viajeseci.es
Personas de contacto: Marisa Sirodey y Silvia Herreros

SESIONES PLENARIAS Y PONENCIAS OFICIALES

- Síndrome compartimental en el deporte.
- Síndrome compartimental en el deporte.
- Aplicación de la variabilidad de la frecuencia cardiaca al entrenamiento deportivo.
- Sistemas complejos y deportes de equipo.
- Respuestas fisiológicas y patológicas de la frecuencia cardiaca y de la tensión arterial en la ergometría.
- Sistemas de esponsorización deportiva
- Medicina biológica. Células madre.
- Entrenamiento en deportistas de superélite.

Idioma oficial

El lenguaje oficial del Congreso es el español.
Traducción simultánea de sesiones plenarias y ponencias.

2020		
32nd FIEP World Congress / 12th International Seminar for Physical Education Teachers /15th FIEP European Congress	2-8 Agosto Jyväskylä (Finlandia)	Información: Branislav Antala E-mail: antala@fsport.uniba.sk
2020 Yokohama Sport Conference	8-12 Septiembre Yokohama (Japón)	web http://yokohama2020.jp/overview.html
International Congress of Dietetics	15-18 Septiembre Cape Town (Sudáfrica)	web: http://www.icda2020.com/
XXXVI Congreso Mundial de Medicina del Deporte	24-27 Septiembre Atenas (Grecia)	www.globalevents.gr
VIII Congreso HISPAMEF	15-17 Octubre Cartagena de Indias (Colombia)	web: http://hispamef.com/viii-congreso-hispamef-15-17-de-2020/
XXIX Isokinetic Medical Group Conference: Football Medicine	24-26 Octubre Lyon (Francia)	web: www.footballmedicinestrategies.com
26th TAFISA World Congress	13-17 Noviembre Tokyo (Japón)	web: www.icsspe.org/sites/default/files/e9_TAFISA%20World%20Congress%202019_Flyer.pdf
2021		
Congreso Mundial de Psicología del Deporte	1-5 Julio Taipei (Taiwan)	web: https://www.issponline.org/index.php/events/next-world-congress
26th Annual Congress of the European College of Sport Science	7-10 Julio Glasgow (Reino Unido)	E-mail: office@sport-science.org
22nd International Congress of Nutrition (ICN)	14-19 Septiembre Tokyo (Japón)	web: http://icn2021.org/
European Federation of Sports Medicine Associations (EFSMA) Conference 2021	28-30 Octubre Budapest (Hungría)	web: http://efsma.eu/
Congreso Mundial de Podología	Barcelona	web: www.fip-ifp.org
XVIII Congreso Internacional SEMED-FEMEDE	25-27 Noviembre Murcia	web: www.femede.es
2022		
8th IWG World Conference on Women and Sport	5-8 Mayo Auckland (N. Zelanda)	web: http://iwgwomenandsport.org/world-conference/
XXXVII Congreso Mundial de Medicina del Deporte FIMS	Septiembre Guadalajara (México)	web: www.femmede.com.mx

Cursos *on-line* SEMED-FEMEDE

Curso "ANTROPOMETRÍA PARA TITULADOS EN CIENCIAS DEL DEPORTE. ASPECTOS TEÓRICOS"
Curso dirigido a los titulados en Ciencias del Deporte destinado a facilitar a los alumnos del curso los conocimientos necesarios para conocer los fundamentos de la antropometría (puntos anatómicos de referencia, material antropométrico, protocolo de medición, error de medición, composición corporal, somatotipo, proporcionalidad) y la relación entre la antropometría, la salud y el rendimiento deportivo.

Curso "ANTROPOMETRÍA PARA SANITARIOS. ASPECTOS TEÓRICOS"
Curso dirigido a sanitarios destinado a facilitar los conocimientos necesarios para conocer los fundamentos de la antropometría (puntos anatómicos de referencia, material antropométrico, protocolo de medición, error de medición, composición corporal, somatotipo, proporcionalidad) y la relación entre la antropometría y la salud.

Curso "PREVENCIÓN DEL DOPAJE PARA MÉDICOS"
Curso dirigido a médicos destinado a proporcionar os conocimientos específicos sobre el dopaje, sobre las sustancias y métodos de dopaje, sus efectos, sus consecuencias, saber el riesgo que corren los deportistas en caso de que se les detecten esas sustancias, cómo pueden utilizar la medicación que está prohibida y conocer las estrategias de prevención del dopaje.

Curso "PRESCRIPCIÓN DE EJERCICIO FÍSICO PARA PACIENTES CRÓNICOS"
Curso dirigido a médicos destinado a proporcionar los conocimientos específicos sobre los riesgos ligados al sedentarismo y las patologías crónicas que se benefician del ejercicio físico, los conceptos básicos sobre el ejercicio físico relacionado con la salud, el diagnóstico y evaluación como base para la prescripción del ejercicio físico, los principios de la prescripción del ejercicio físico, además de describir las evidencias científicas sobre los efectos beneficiosos y útiles del ejercicio físico.

Curso "ENTRENAMIENTO, RENDIMIENTO, PREVENCIÓN Y PATOLOGÍA DEL CICLISMO"
Curso dirigido a los titulados de las diferentes profesiones sanitarias y a los titulados en ciencias de la actividad física y el deporte, destinado al conocimiento de las prestaciones y rendimiento del deportista, para que cumpla con sus expectativas competitivas y de prolongación de su práctica deportiva, y para que la práctica deportiva minimice las consecuencias que puede tener para su salud, tanto desde el punto de vista médico como lesional.

Curso "FISIOLOGÍA Y VALORACIÓN FUNCIONAL EN EL CICLISMO"
Curso dirigido a los titulados de las diferentes profesiones sanitarias y a los titulados en ciencias de la actividad física y el deporte, destinado al conocimiento profundo de los aspectos fisiológicos y de valoración funcional del ciclismo.

Curso "CARDIOLOGÍA DEL DEPORTE"
Curso dirigido a médicos destinado a proporcionar los conocimientos específicos para el estudio del sistema cardiocirculatorio desde el punto de vista de la actividad física y deportiva, para diagnosticar los problemas cardiovasculares que pueden afectar al deportista, conocer la aptitud cardiológica para la práctica deportiva, realizar la prescripción de ejercicio y conocer y diagnosticar las enfermedades cardiovasculares susceptibles de provocar la muerte súbita del deportista y prevenir su aparición.

Curso "ELECTROCARDIOGRAFÍA PARA MEDICINA DEL DEPORTE"
Curso dirigido a médicos destinado a proporcionar los conocimientos específicos para el estudio del sistema cardiocirculatorio desde el punto de vista del electrocardiograma (ECG).

Curso "AYUDAS ERGOGÉNICAS"
Curso abierto a todos los interesados en el tema que quieren conocer las ayudas ergogénicas y su utilización en el deporte.

Curso "ALIMENTACIÓN, NUTRICIÓN E HIDRATACIÓN EN EL DEPORTE"
Curso dirigido a médicos destinado a facilitar al médico relacionado con la actividad física y el deporte la formación precisa para conocer los elementos necesarios para la obtención de los elementos energéticos necesarios para el esfuerzo físico y para prescribir una adecuada alimentación del deportista.

Curso "ALIMENTACIÓN Y NUTRICIÓN EN EL DEPORTE"
Curso dirigido a los titulados de las diferentes profesiones sanitarias (existe un curso específico para médicos) y para los titulados en ciencias de la actividad física y el deporte, dirigido a facilitar a los profesionales relacionados con la actividad física y el deporte la formación precisa para conocer los elementos necesarios para la obtención de los elementos energéticos necesarios para el esfuerzo físico y para conocer la adecuada alimentación del deportista.

Curso "ALIMENTACIÓN Y NUTRICIÓN EN EL DEPORTE" Para Diplomados y Graduados en Enfermería.
Curso dirigido a facilitar a los Diplomados y Graduados en Enfermería la formación precisa para conocer los elementos necesarios para la obtención de los elementos energéticos necesarios para el esfuerzo físico y para conocer la adecuada alimentación del deportista.

Más información:
www.femede.es

Guidelines of publication Archives of Sports Medicine

The ARCHIVES OF SPORTS MEDICINE Journal (Arch Med Deporte) with ISSN 0212-8799 is the official publication of the Spanish Federation of Sports Medicine. This journal publishes original works about all the features related to Medicine and Sports Sciences from 1984. This title has been working uninterruptedly with a frequency of three months until 1995 and two months after this date. Arch Med Deporte works fundamentally with the system of external review carried out by two experts (peer review). It includes regularly articles about clinical or basic research, reviews, articles or publishing commentaries, brief communications and letters to the publisher. The articles may be published in both SPANISH and ENGLISH. The submission of papers in English writing will be particularly valued.

Occasionally oral communications accepted for presentation in the Federation's Congresses will be published.

The Editorial papers will only be published after an Editor requirement.

The manuscripts accepted for publication will become FEMEDE property and their reproduction, total or partial, must be properly authorized. All the authors will have to send a written letter conceding these rights as soon as the article is accepted for publication.

Submit of manuscripts

1. The papers must be submitted at the Editor in Chief's attention, written in double space in a DIN A4 sheet and numbered in the top right corner. It is recommended to use Word format, Times New Roman and font size 12. They must be sent by e-mail to FEMEDE's e-mail address: femede@femede.es.
2. On the first page exclusively it should include: title (Spanish and English), authors' first name, initial of the second name (if applicable), surname and optionally the second one; Main official and academic qualifications, workplace, full address and corresponding author e-mail. Supports received in order to accomplish the study – such as grants, equipments, medicaments, etc- have to be included.
   A letter in which the first author on behalf of all signatories of the study, the assignment of the rights for total or partial reproduction of the article, once accepted for publication shall be attached.
   Furthermore, the main author will propose up to four reviewers to the editor. According to the reviewers, at least one must be from a different nationality than the main author. Reviewers from the same institutions as the authors, will not be accepted.
3. On the second page the abstract of the work will appear both in Spanish and English, and will have an extension of 250-300 words. It will include the intention of the work (aims of the research), methodology, the most out-standing results and the main conclusions. It must be written in such a way to allow the understanding of the essence of the article without reading it completely or partially. After the abstract, from three to ten key words will be specified in Spanish and English, derived from the Medical Subject Headings (MeSH) of the National Library of Medicine (available in: http://www.nlm.nih. gov/mesh/MBrowser.html).
4. The extension of the text will change according to the section applicable:
   a. Original research: maximum 5.000 words, 6 figures and 6 tables.
   b. Review articles: maximum 5.000 words, 5 figures and 4 tables. In case of needing a wider extension it is recommended to contact the journal Editor.
   c. Editorials: they will be written by Editorial Board request.
   d. Letters to the Editor: maximum 1.000 words.
5. Structure of the text: it will change according to the section applicable:
   a. **ORIGINALS RESEARCH**: It will contain an introduction, which must be brief and will contain the aim of the work, written in such a way that the reader can understand the following text.
   Material and method: the material used in the work will be exposed, as well as its characte¬ristics, selection criteria and used techniques, facilitating the necessary data in order to allow the reader to repeat the experience shown. The statistical methods will be detailed described.
   Results: Results must report and not describe the observations made with the material and method used. This information can be published in detail in the text or using tables and figures. Information given in the tables or figures must not be repeated in the text.
   Discussion: The authors will expose their opinions about the results, their possible interpretation, relating the observations to the results obtained by other authors in similar publications, suggestions for future works on the topic, etc. Connect the conclusions with the aims of the study, avoiding free affirmations and conclusions not supported by the information of the work.
   The acknowledgments will appear at the end of the text.

b. **REVIEWS ARTICLES:** The text will be divided in as much paragraphs as the author considers necessary for a perfect compre-hension of the topic treated.

c. **LETTERS TO THE EDITOR:** Discussion about published papers in the last two issues, with the contribution of opinions and experiences briefed in 3 pages, will have preference in this Section.

d. **OTHERS:** Specific sections commissioned by the Journal's Editorial Board.

6. **Bibliography:** it will be presented on pages apart and will be ordered following their appearance in the text, with a correlative numeration. In the text the quote's number will be presented between parentheses, followed or not by the authors' name; if they are mentioned, in case the work was made by two authors both of them will figure, and if there are more than two authors only the first will figure, followed by "et al".

   There will not be personal communication, manuscripts or any unpublished information included in the bibliographical appointments.

   The official citation for the journal Archives of Sports Medicine is Arch Med Sport.

   References will be exposed in the following way:

   - **Journal: order number;** surnames and name's initial of the article authors with no punctuation and separated with a comma (if the number of authors is higher than six, only the six first will figure, followed by "et al"); work's title in its original language; abbreviated journal name, according to the World Medical Periodical; year of publication; volume number; first and last page of the quoted extract. Example: Calbet JA, Radegran G, Boushel R and Saltin B. On the mechanisms that limit oxygen uptake during exercise in acute and chronic hypoxia: role of muscle mass. *J Physiol.* 2009;587:477-90.
   - **Book chapter**: Authors, chapter title, editors, book title, city, publishing house, year and number of pages. Example: Iselin E. Maladie de Kienbock et Syndrome du canal carpien. En : Simon L, Alieu Y. Poignet et Medecine de Reeducation. Londres : Collection de Pathologie Locomotrice Masson; 1981. p162-6.
   - **Book**. Authors, title, city, publishing house, year of publication, page of the quote. Example: Balius R. Ecografía muscular de la extremidad inferior. Sistemática de exploración y lesiones en el deporte. Barcelona. Editorial Masson; 2005. p 34.
   - **World Wide Web**, online journal. Example: Morse SS. Factors in the emergence of infectious diseases. Emerg Infect Dis (revista electrónica) 1995 JanMar (consultado 0501/2004). Available in: http://www.cdc.gov/ncidod/EID/ eid.htm

7. **Tables and figures.** Tables and figures will be sent on separate files in JPEG format. Tables must be sent in word format.

   Tables shall be numbered according to the order of appearance in the text, with the title on the top and the abbreviations described on the bottom. All nonstandard abbreviations which may be used in the tables shall be explained in footnotes.

   Any kind of graphics, pictures and photographies will be denominated figures. They must be numbered correlatively by order of appearance in the text and will be sent in black and white (except in those works in which colour is justified). Color printing is an economic cost that has to be consulted with the editor.

   All tables as well as figures will be numbered with Arabic numbers following the order of appearance in the text.

   At the end of the text document the tables and figures captions will be included on individual pages.

8. The Journal's Editorial Staff will communicate the reception of submitted articles and will inform about its acceptance and possible date of publication.

9. After hearing the reviewers' suggestions (journal uses peer correction system), may reject the works which are not suitable, or indicate the author the modifications which are thought to be necessary for its acceptance.

10. The Editorial Board is not responsible for the concepts, opinions or affirmations supported by the authors.

11. Submissions of the papers: Archives of Sports Medicine. By e-mail to FEMEDE'S e-mail address: femede@femede.es. The submission will come with a cover letter on which the work's examination for its publication in the Journal will be requested, article type will be specified, and it will be certified by all authors that the work is original and has not been partially or totally published before.

Conflicts of interests

If there should be any relation between the work's authors and any public or private entity, from which a conflict of interests could appear, it must be communicated to the Editor. Authors must fulfil a specific document.

Ethics

All authors that sign the articles accept the responsibility defined by the World Association of Medical Editors.

The papers sent to the journal for evaluation must have been elaborated respecting the international recommendations about clinical and laboratory animals' researches, ratified in Helsinki and updated in 2008 by the American Physiology.

For the performance of controlled clinic essays the CONSORT normative shall be followed, available at http://www.consort-statement.org/

Campaña de aptitud física, deporte y salud

La **Sociedad Española de Medicina del Deporte**, en su incesante labor de expansión y consolidación de la Medicina del Deporte y, consciente de su vocación médica de preservar la salud de todas las personas, viene realizando diversas actuaciones en este ámbito desde los últimos años.

Se ha considerado el momento oportuno de lanzar la campaña de gran alcance, denominada **CAMPAÑA DE APTITUD FÍSICA, DEPORTE Y SALUD** relacionada con la promoción de la actividad física y deportiva para toda la población y que tendrá como lema **SALUD – DEPORTE – DISFRÚTALOS**, que aúna de la forma más clara y directa los tres pilares que se promueven desde la Medicina del Deporte que son el practicar deporte, con objetivos de salud y para la mejora de la aptitud física y de tal forma que se incorpore como un hábito permanente, y disfrutando, es la mejor manera de conseguirlo.

UCAM Universidad Católica San Antonio de Murcia

Campus de los Jerónimos,
Nº 135 Guadalupe 30107

(Murcia) - España

Tlf: (+34)968 27 88 01 · info@ucam.edu

UCAM
UNIVERSIDAD
CATÓLICA DE MURCIA