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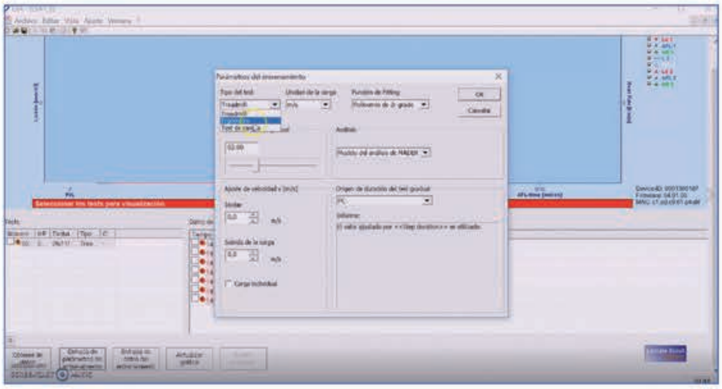

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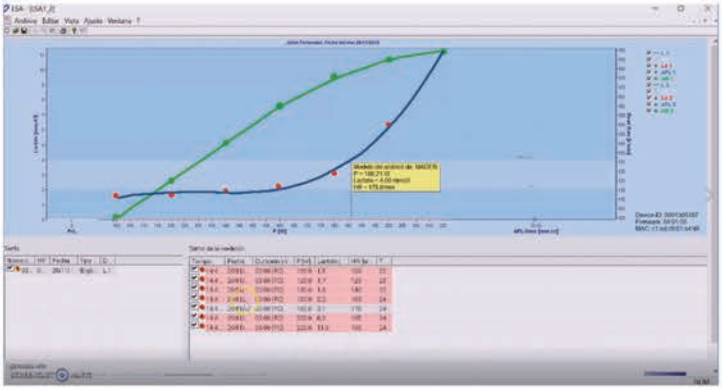

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Summary / Sumario

Science, practice and University

Ciencia, práctica y Universidad

Pedro J. Benito Peinado

Profesor Titular de Universidad de Fisiología del Ejercicio en la Facultad de Ciencias de la Actividad Física y del Deporte (INEF) de la Universidad Politécnica de Madrid.

In the field of Sports Science, there seems to be a considerable gap between science and practice, and an even greater one between university teaching and practice, for which the degree is supposed to prepare you. Sports science is an applied science, and not, therefore, a basic science, although it needs the latter to support many of its principles. It is a demonstrable fact that no government of our nation has supported with any kind of enthusiasm the development of science in general, particularly basic sciences, and much less applied sciences, like ours, where we are still fighting for a law regulating professional activity to clarify our competences.

But, even so, universities have always been a cradle of quality science at all levels, and although some of us feel like laughing or weeping when faced with the truth of the situation, it is right to say that they make a significant contribution when it comes to creating the breeding ground needed in order to generate the knowledge which the means available allow.

Although ours is a relatively young discipline, the basic sciences on which the generation of our applied knowledge rests have long histories behind them. Physics, chemistry, mathematics, medicine, history and many others have been providing solid knowledge to other fields for a long time, and now they feed ours.

We are in the information age, where all you need to access masses of information, often an unmanageable amount, is a connection to the Internet and a pinch of curiosity. The figure of the popular science writer is becoming increasingly relevant in society, as is only right, because new technology has a great part to play in our classrooms if we want to overcome the current state of obsolescence. But it should be stressed; science is written by scientists and is written in order to be understood by scientists. Although you don't need to be an Einstein to understand a scientific publication, you do need a basic grasp of statistics and the design of experiments unless you are prepared to place yourself at the mercy of the author and take his or her conclusions at face value. Such knowledge can be acquired in a number of ways, but the most frequent consists of taking a PhD, in Sports Science in our case. This does not give you the "power" to read science, but it does mean you are more likely to understand it. The problem with the vast majority of popularisers is that they do not have such an educational background and simply cull the information which interests them the most in order to arrive at the conclusions they have already reached. This is not unique to popular science writing. All simplifications in teaching tend to omit relevant information that makes the concepts and hypotheses put forward easier to understand, which can lead to misinterpretations or the original sense of the information being taken out of context.

I was recently interested to learn the opinions of some of my students on the university education that they have received and, aware of the limitations of this education, I must say that I agree with some of their criticisms of our university system. I subscribe to the view that the degrees taught in many disciplines are divorced from the reality of the labour situation awaiting graduates. I also agree that a not inconsiderable number of professors, who, comfortable in the system, do not know how or do not wish to update themselves, lack motivation and are anchored in the past. I cannot argue against the idea that the ANECA quality assurance system and those of many universities are not worth the paper they are written on or simply constitute an infinite list of protocols which do not address the real demands of quality: such as the connection between contents by analysing the study programmes in

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depth, the study of graduates' needs and the renewal of curricula to make them relevant to the job market. That said, I think it only fair to defend the good work of many professors, who see their teaching work as the cornerstone of university quality and do their utmost in their scientific endeavours. Indeed, real, constructive criticism of a curriculum would require having studied several programmes and curricula for the same subject, defining a criteria of excellence and then criticising the different degrees. I think very few students have embarked on such a healthy exercise in order to practise objective, reasoned criticism.

Meanwhile, knowledge is not watertight and unalterable over time. Seneca is believed to have said that the "truth" lies in a dark pit and is no more than *a rough approximation to the option that a set of people have about what is happening at a specific moment* in our history. There is no absolute truth, because as soon as a human approaches it, it become subjective and interpretable, and, therefore, open to more or less objective debate. That is why when someone says that "the truth is this or that", I become a zealot of interpretation and get out my magnifying glass to scrutinise their arguments.

It is very important to regard the truth, as recognised in scientific or empirical documents, as perishable, because books, videos, notes and all the other hermetic ways in which we receive information tend to age very badly. Most of the information published in any scientific environment becomes obsolete in a short space of time. The small amount which does not fall obsolete will provide a basis of knowledge which, if it manages to survive, will be tested on many occasions to disprove its validity. This is the essence of knowledge, both empirical and scientific; the constant need to confirm our knowledge and put it to the test in practice to see if it still works or has become defunct. Scientific documents, good papers or books written with academic rigour, are testable in the future, because they owe part of their solidity to the very process behind them. And that, dear readers, can hardly be achieved in a tweet, a video or an infographic.

Speaking of obsolescence, one of the fiercest criticisms of university education is its scarce connection with the reality of the job world, as very little of what will be needed afterwards in a job is ever learned. We forget that universities are much more than agents for transmitting knowledge. Their objective, besides imparting skills to graduates, is to modify knowledge during the process. Going to university includes all the nerves of the first day, how terribly demanding that professor is, developing critical thinking, travelling to other cities and experiencing other environments, laboratories, experiences, libraries and countless moments which mean that were you to be introduced to the person you were when you started, you probably wouldn't even recognise yourself. So, to all those who criticise their degree, I ask you this question: would you be better professionals without the "scant" knowledge you acquired and the "experiences" you had at university? The most likely answer is no.

I do not wish to ignore the distance between science and practice in our professional field. In the sports world, science is believed not to be powerful enough to make important predictions which could influence the actual performance of athletes, understanding performance as winning or losing, which is the guiding principle of athletic performance. This denial of the applicability of science to the real environment is due to the great number of variables involved in the outcome and the suspicion that they cannot all be controlled at the same time. I do not deny this difficulty, particularly considering that at present we are far from making accurate predictions about competition results. But at a scientific conference last year, I asked the most eminent scientist in the world in the field of hypertrophy whether he thought we would ever be able to create an equation that predicted the behaviour of this variable. His response was an undisputable "NO", too many variables were involved to be able to model them in a single equation. In mid-2018, the first empirical equation attempting to capture the variable was published. Complex, indeed; unable to do it right now, maybe; but impossible, I do not agree.

This editorial is a reflection on the Spanish university system, its application to and link with professional practice, taking a neutral, objective and positive view of the road lying ahead of us. I think that work to improve as a society entails improving the various ways in which we acquire, process and apply information, without neglecting such essential pillars in personal formation as honesty, humility, prudence and respect, which should lead to a more balanced and mature society. I hope I have succeeded, at least, in encouraging reflection on the power of communication.

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Original article

Does high intensity interval training (HIIT) affect strength training performance?

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Summary

Objective: To assess the effect of high intensity interval training (HIIT) on the subsequent performance of strength training (ST) in lower limbs.
Methods: 10 men (23.4 ± 2.4 years, 78.9 ± 8.0 kg, height 1.78 ± 0.08 m, BMI 24.80 ± 1.16, % G 12.3 ± 2, 5; $VO_{2máx}$ 50.9 ± 3.6 ml / kg / min) were subjected to anthropometric, cardiorespiratory and 10 maximum repetition (10RM) tests. At time 1 (M1) the ST was made up of 3 sets of repetitions until the concentric failure for 100% of 10RM, with intervals of 3 minutes between sets in the exercise leg press 45º (LP). Three minutes later the sitting femoral exercise (FS) was started, with the same procedures as before. At time 2 (M2) a HIIT session composed of 10 1 'stimuli with intensity between 90 and 95% HR_{max} (Borg 9 - 10) was performed, interspersed with 10 1' recoveries with intensity between 70 and 75% FC_{max} (Borg 6 - 7). Immediately after, the ST was performed with the same M1 procedures. The strength performance of the lower limbs was determined by the number of repetitions performed in M1 and M2.
Results: There was a reduction in the total of repetitions in the M2 both in the LP (Δ% = -22.97, p-value = 0.0001) and in the FS (Δ% = -17.56%; value = 0.0001) compared to M1. In M2 there was a reduction only in the 3rd series of LP in the intra-group analysis, and intergroup reduction in the three series of M2 compared to M1. For FS, intragroup reduction was observed in the 3rd series of M1 and M2, in addition to intergroup reduction in the 1st and 3rd series of M2 compared to M1.
Conclusion: HIIT, with the characteristics of volume and intensity prescribed in the present study, was able to exert negative interference on the subsequent performance in ST in lower limbs.

Key words:
Physical exercise. Interval training. Strength training. Concurrent training.

¿Afecta el entrenamiento intervalado de alta intensidad (HIIT) al desempeño en el entrenamiento de la fuerza?

Resumen

Objetivo: Valorar el efecto del entrenamiento intervalado de alta intensidad de (HIIT) sobre el subsiguiente desempeño del entrenamiento de la fuerza (EF) en miembros inferiores.
Métodos: 10 hombres (23,4 ± 2,4 años; 78,9 ± 8,0 kg; Estatura 1,78 ± 0,08 m; IMC 24,80 ± 1,16; %G 12,3 ± 2,5; $VO_{2máx}$ 50,9 ± 3,6 ml/kg/min) fueron sometidos a mediciones antropométricas, cardiorrespiratorias y prueba de 10 repeticiones máximas (10RM). En el momento 1 (M1) se realizó el EF compuesto por 3 series de repeticiones hasta el fallo concéntrico para el 100% de 10RM, con intervalos de 3 minutos entre series en el ejercicio leg press 45º (LP). Tres minutos después se inició el ejercicio de femoral sentado (FS), con los mismos procedimientos anteriores. En el momento 2 (M2) se realizó una sesión de HIIT compuesta por 10 estímulos de 1' con intensidad entre el 90 y 95% $FC_{máx}$ (Borg 9 - 10), intercalados con 10 recuperaciones de 1' con intensidad entre 70 al 75% $FC_{máx}$ (Borg 6 - 7). Inmediatamente después, se realizó el EF con los mismos procedimientos del M1. El rendimiento de la fuerza de los miembros inferiores fue determinado por el número de repeticiones ejecutadas en M1 y M2.
Resultados: Hubo una reducción en el total de repeticiones en el M2 tanto en el LP (Δ%= -22,97; p-valor=0,0001) como en el FS (Δ%= -17,56%; p-valor=0,0001) en comparación con el M1. En M2 hubo una reducción sólo en la 3ª serie del LP en el análisis intragrupo, y reducción intergrupos en las tres series del M2 en comparación con M1. Para el FS, se observó reducción intragrupo en la 3ª serie de M1 y M2, además de reducción intergrupos en la 1ª y 3ª serie de M2 en comparación con M1.
Conclusión: El HIIT, con las características de volumen e intensidad prescritas en el presente estudio, fue capaz de ejercer interferencia negativa sobre el subsiguiente desempeño en el EF en miembros inferiores.

Palabras clave:
Ejercicio físico. Entrenamiento intervalado. Entrenamiento de fuerza. Entrenamiento concurrente.

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Introduction

The benefits of regular physical exercise to the health and the importance of including aerobic and muscle-strengthening activities in such exercise are well documented[1]. Regular physical exercise brings health improvements, such as increased maximal oxygen uptake, an increase in lean body mass, a reduction in systolic (SBP) and diastolic blood pressure (DBP) in repose, increased HDL cholesterol levels, reduced LDL cholesterol levels and greater glucose tolerance[2].

The types of physical exercise available include strength training and aerobic endurance training. High-intensity interval training (HIIT) is one of the ways in which aerobic exercise can be performed to promote positive physiological adaptations as a result of metabolic alterations and ionic homeostasis[3]. HIIT is part of training for such sports as football, handball, basketball, cycling and running[4]. Athletes and specialists are interested in perfecting and including this method in their training programmes[5] with an eye to improving performance[6].

Another type of training considered important to improve performance is strength training (ST). It is used both to maintain health in the general population and to improve the performance of athletes[7]. ST is recommended in order to increase muscle mass and enhance strength, fitness and the health[8,9]. In practice, different physiological responses, such as improved integrated operation of the nervous and muscular systems (neural adaptations), and the hypertrophic effects of training, can be obtained by manipulating the variables involved (exercise order, time interval between sets and exercises, number of sets and repetitions, fractioning training, etc.).

A combination of aerobic exercise and strength training in a single session is called concurrent training (CT)[10]. Athletes and physically active individuals often use this type of training[11] because the benefits of both systems can be accrued at the same time[12]. In CT, aerobic exercise is used to reduce body fat stores and strength training is used to try to preserve or increase lean mass[13].

However, certain considerations should be taken into account regarding this method, since it would appear that a combination of different training systems in a single training session may negatively affect performance[14-16].

The aim of this study was to evaluate the effect of high intensity interval training on subsequent performance during strength training involving the lower limbs.

Material and method

Sample

The sample consisted of 10 male volunteers who had at least six months' experience of strength training sessions lasting over 60 minutes more than four times a week. According to the risk stratification criteria of the *American Heart Association* (AHA)[17], the individuals did not exhibit any apparent risk factors preventing them from taking part in the research.

The study adopted the following criteria for exclusion: a) the existence of degenerative or metabolic diseases, injuries or musculoskeletal limitations which might prevent performance of the exercises programmed, or cardiovascular disorders; b) the use of ergogenic/nutritional substances.

The study respected the standards for research involving human beings set out in Resolution 466/2012 of the Brazilian National Health Council and the Declaration of Helsinki[18]. The study project was approved by the Research Ethics Committee of the Federal University of Rio de Janeiro (number 983.976 / 2015).

Data collection procedures

Each volunteer paid five non-consecutive visits, always at the same time and with intervals of 48 to 72 hours, depending on their availability. On their first visit, the participants were informed about all the study procedures and responded to the AHA questionnaire. Their anthropometric measurements were taken and they performed the 10 repetition maximum test (10RM). On their second visit, they did a 10RM re-test. On their third visit, an ergometer test was performed to estimate relative maximal oxygen uptake (mlO_2/kg/min) and their HR_{Rest} (after 10 minutes of rest) and HR_{max} variables were measured. The study sessions were held on the fourth and fifth visits.

Anthropometric measurements

Height was measured using a Sanny® ES2020 professional stadiometer (Brazil). Body composition was evaluated by bioelectrical impedance analysis (BIA) using a Biospace InBody® 230 (South Korea) with a capacity of 250 kg and an accuracy of 100 g. The body mass index (BMI) was calculated by dividing total body mass (TBM) by height (m) squared. All the anthropometric measurements were taken following the specific protocols recommended in the *International Standards for Anthropometric Assessment* (ISAK)[19].

10 repetition maximum test (10RM)

10 repetition maximum testing and re-testing (10RM) took place in a single day on 45º leg press (LP) and seated leg curl (SLC) equipment, following the recommendations of Baechle and Earle[20]. The 10RM test was chosen due to its high correlation with the muscle strength registered with 1 repetition maximum (1RM) and a lower injury rate[21].

Testing and re-testing were halted when the individuals could not complete the movement, with voluntary concentric interruption at 10RM[22]. The movement execution speed was approximately 2 seconds for each movement phase.

If the load for 10RM was not obtained after three attempts, the test was called off and carried out the next non-consecutive day previously scheduled. The intervals between attempts at each exercise during 10RM testing and/or re-testing were set at 5 minutes. 10RM was considered to be the highest load achieved in the two days with a difference of less than 5% and if the difference in the loads moved was equal to or greater than 5%, a new re-test was arranged to check the reproducibility of the load[23]. After obtaining the load in the particular exercise, there were recovery intervals of no less than 10 minutes before moving on to testing with the next strength exercise[24].

All the tests and re-tests took place at times similar to those at which the individuals usually trained, were carried out at a controlled temperature of between 18 ºC to 22 ºC and were monitored by an experienced evaluator. There was an intraclass correlation coefficient (ICC) of 0.95. The study participants were instructed not to perform physical exercises of any kind and not to take stimulants in the 24 hours prior to both data collection and the study itself.

Maximum Heart Rate (HR_{max})

In order to prescribe and control the intensity of HIIT, the volunteers' HR_{max} was measured using an incremental treadmill test (Inbramed® Master ATL, Brazil) according to the protocol proposed by Bruce[25]. The individuals' heart rates were monitored with a Polar® S210 (Finland) heart rate monitor. In order to characterise the sample group, maximal oxygen uptake (VO_{2max}) was estimated in the same test.

Study

In the first study session (S1), the participants were subjected to ST on the LP and SLC equipment. The specific warm-up consisted of 1 set of 15 repetitions on the LP at 50% of the maximum load obtained in 10RM testing and/or re-testing. Three minutes after the warm-up, 3 sets of repetition to voluntary concentric failure were performed at an intensity of 100% 10RM, with intervals of 3' between sets. Three minutes after the 3rd LP set, the 3 sets on the SLC equipment began, following the same procedures in terms of volume and intensity.

In the second study session (S2), the subjects, monitored by a heart rate monitor, were subjected to HIIT, according to the protocol adapted by Gibala *et al.*[26], which consisted of 30 minutes on the treadmill (Life Fitness 95T with Flex Deck Shock Absorption System, USA) without incline, divided into: a) 5' warm-up at an intensity of 50 to 55% HR_{max}; b) specific phase lasting 20' divided into 10 stimuli of 1' at an intensity of 90 to 95% HR_{max} and perceived exertion between 9 and 10 on the Borg scale (CR10)27, interspersed with 10 active intervals lasting 1' at an intensity of 70 to 75% HR_{max} and perceived exertion between 6 and 7; c) 5' cool-down at an intensity of 50% HR_{max}. Immediately after HIIT, the participants performed the ST, following the same procedures as those in S1. However, in this stage the ST was not preceded by the specific LP and SLC warm-up.

Lower limb strength performance was determined by the number of repetitions completed in each of the ST sets carried out in the different study sessions.

Data analysis

The data were processed using the *Statistical Package for Social Sciences* (SPSS statistics 20 - Chicago, USA) and were presented as mean, standard deviation and minimum and maximum values. The normality and homogeneity of the sample data were verified with the Shapiro-Wilk test and Levene's test, respectively. On the basis of the results, it was decided that a paired Student's t-test should be used to analyse the total number of repetitions completed between the study sessions. Repeated measures ANOVA, followed by Tukey's Post-hoc test, was used for intra- and inter-study protocol analysis. The level of significance was set at $p < 0.05$.

Results

Table 1 shows the data relevant to the body composition and cardiorespiratory fitness of the volunteers. The results of the Shapiro-Wilk test for the variables mentioned showed a near normal distribution curve.

Figure 1 depicts analysis of the number of repetitions completed in each series carried out on the LP apparatus in the two study sessions (S1 and S2).

After intragroup analysis, a significant difference was observed only in the third ($F = 3.269$; $p = 0.04$) set of S2. No differences were observed in S1. Intergroup analysis revealed a significant reduction in the number of repetitions in the first ($F = 5.828$; $p = 0.02$), second ($F = 7.531$; $p = 0.01$) and third ($F = 15.818$; $p = 0.001$) sets of S2 compared to S1.

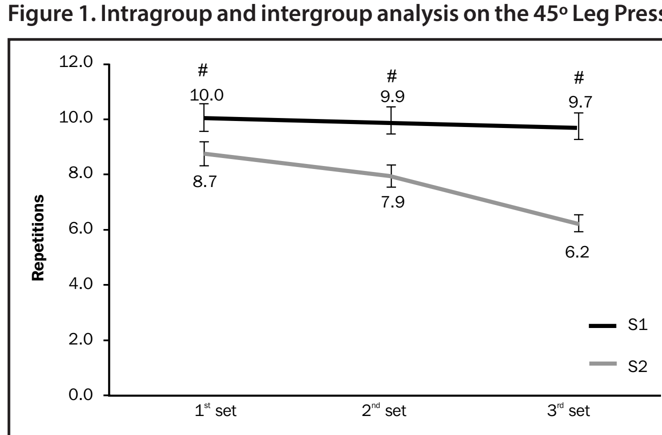
Figure 2 depicts analysis of the number of repetitions completed in each series carried out on the SLC apparatus in the two study sessions (S1 and S2).

Table 1. Body composition and cardiorespiratory fitness.

	Age (years)	TBM (kg)	H (m)	BMI (kg/m^2)	%F	VO_{2max} (ml/kg/min)
Mean	23.4	78.9	1.78	24.8	12.3	50.9
SD	2.4	8.0	0.08	1.16	2.5	3.6
SW (p-value)	0.32	0.71	0.72	0.94	0.78	0.39

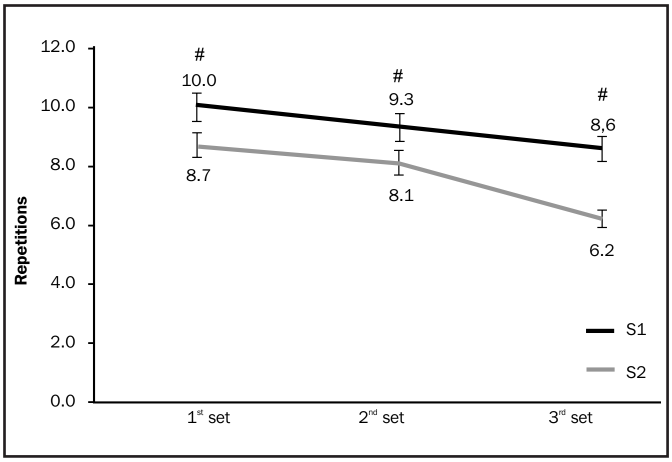
TBM: total body mass; H: height; BMI: body mass index; %F: percentage of fat mass; SD: standard deviation; SW (p-value): Shapiro-Wilk normality test.

Figure 1. Intragroup and intergroup analysis on the 45º Leg Press.



#Significant intergroup difference; *Significant intragroup difference.

Figure 2. Intragroup and intergroup analysis on the Seated leg curl machine.



#Significant intergroup difference; *Significant intragroup difference.

Table 2. Total number of repetitions.

Equipment	S1	S2	Δ%	p-value
45º Leg Press	29.6	22.8	-22.97	<0.001
Seated leg curl	27.9	23.0	-17.56	<0.001

After intragroup analysis, a reduction was observed in the third series of both S1 ($F = 7.151$, $p = 0.003$) and S2 ($F = 3.691$, $p = 0.04$) compared to the others. Intergroup analysis showed a significant reduction in the number of repetitions in the first ($F = 5.053$; $p = 0.03$) and third ($F = 7.005$; $p = 0.01$) sets of S2 compared to S1. There were no intergroup differences in the second set ($F = 3.323$, $p = 0.08$).

Table 2 compares and shows the percentage change (Δ%) between the total number of repetitions completed in the three sets of the exercises used in the two study sessions (S1 and S2).

There was a significant reduction ($p < 0.05$) between the total number of repetitions completed by the participants in the three sets on both the LP and SLC machines.

Discussion

The aim of the study was to evaluate the effect of HIIT on lower limb strength performance. When HIIT was performed before ST, the muscle strength of the lower limbs dropped significantly. Aerobic exercise may lead to residual fatigue which affects the ability to perform strength training repetition maximums and one of the possible causes of this fatigue is related to the depletion of creatine phosphate reserves[28,29].

High intensity aerobic training (> 90% VO_{2max}) leads to greater recruitment of motor units consisting of type II fibres, as does strength training involving protocols above 70% 1RM[30]. On analysing the influence of the different methods and intensities of cardiorespiratory exercise on strength performance, only the intermittent method (1 'stimulus with 1' recovery) at a high intensity (90% VO_{2max}) managed to negatively influence strength performance[31]. These intensities were used in this study, corroborating the results presented.

For Simão *et al.*[32], the performance of both large and small muscle groups in exercises carried out last in the sequence of a training programme leads to a lower number of repetitions, especially in the last sets of each exercise. Performance is better in the exercises at the start of a training session, regardless of the size of muscle mass and the number of joints involved. As in the present study, the reduction in the total number of LP repetitions was greater than it was in SLC; this was probably due to the interference of HIIT associated with the neuromuscular exercise performed on the LP.

The findings of Raddi *et al.*[33] suggest that the negative interference of cardiorespiratory training on strength performance depends on the body segment used, because, in their research, no significant differences were observed in dynamic and isometric strength with or without previous cardiorespiratory exercise consisting of running on a treadmill.

Leveritt *et al.*[34] investigated the effects of a session of high intensity cardiorespiratory exercise on lower limb strength, concluding that muscle performance can be inhibited if the strength training session is preceded by incremental exercise on a cycle ergometer at intensities varying between 40% and 100%. These results confirm the results obtained in this study, in which a reduction in muscle performance was observed in the two exercises tested when they were performed after a session of high intensity cardiorespiratory exercise.

Jones *et al.*[35] evaluated the effects of exercise in concurrent training on endocrine responses and strength. The results for strength production suggest that doing cardiorespiratory exercise prior to strength training may lead to acute adaptations which are unfavourable for the development of this variable, particularly at high intensities.

It was found that performance in strength training when preceded by cardiorespiratory training fell by 37.4% compared to strength training in isolation, providing results similar to those of this study. After cardiorespiratory training at an intensity of 70% HRR, the capacity to do 45º leg press strength training at 85% 1RM was significantly lower. The same was observed in the present study.

In the results of this study, the findings of Costa *et al.*[2] showed that cardiorespiratory exercise performed before strength training was not able to negatively influence muscle performance. However, the cardiorespiratory exercise lasted 25' and was carried out at an intensity of 70% HRR using the continuous method. Muscle performance was evaluated with seated knee extension exercise at an intensity of 70% 1RM.

On the basis of the data obtained in this research, it is possible to conclude that muscle performance in both LP and SLC exercise, measured by the number of repetitions completed, fell significantly when carried out after high intensity interval training. It is, therefore, possible to infer that aerobic training, with volume and intensity characteristics as prescribed in this study, can negatively influence lower limb strength performance.

We suggest that future studies use larger samples and longer study times to enable research into the chronic effect of concurrent training on strength performance when performing exercises for the same muscle groups.

Conflict of interest

The authors do not declare a conflict of interest.

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Original article

Kinematics and thermal sex-related responses during an official beach handball game in Costa Rica: a pilot study

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Summary

Beach handball is a sport characterized by being a complex, dynamic, fluid of constant exchange of offensive and defensive plays. The objectives of this study was describe and analyzing the kinematics and thermal responses in male and female beach handball players during an official game in Costa Rica. Sixteen beach handball players participated, eight women and eight men. All participants were grouped by sex in two teams, male team and female team and every team played against the same adversary. Every game had two periods, 10 min each, 5 min rest, were made. GPS devices were used to quantify the kinematics responses, heart rate was obtained through cardiac monitors, internal temperature was measured using CorTemp pills and body weight loss, sweating rate and fluid intake were calculated. The main results shown significant differences between men and women in the total distance (m) ($p< .01$), average speed (km/h) ($p< .01$), maximum speed (km/h) ($p= .022$), total impacts (g) ($p< .01$), body weight change (%) ($p= .038$), sweat rate (ml/min) ($p< .01$), and liquid intake (ml) ($p< .01$). Internal temperature (°C) was different between men and women after warn-up ($p= .044$) and final first period ($p= .007$). Also, it found a significant decreased in the maximum speed (km/h) ($p= 0.10$) and body load (AU) ($p= .026$) in the second period both in men and women. In conclusion, beach handball is a sport that is played a medium-high intensity [HR mean (men= 156.1±17.5 bpm, women= 158.1±19.8 bpm)]. As a practical implication, this study provides information that may be used as a base or support to plan and designing training methodologies according to the specific kinematics and thermal requirements of beach handball players.

Key words:
Sport. Dehydration. Heart rate. Body temperature. Kinematics.

Respuestas cinemáticas y termorreguladoras relacionadas con el sexo durante un partido oficial de balonmano playa en Costa Rica. Un estudio piloto

Resumen

El balonmano de playa es un deporte caracterizado por ser complejo, dinámico y fluido de constante intercambio de acciones defensivas y ofensivas. El objetivo de este estudio fue describir y analizar las respuestas cinemáticas y termorreguladoras en jugadores masculinos y femeninos de balonmano de playa durante un partido oficial en Costa Rica. Dieciséis jugadores participaron, ocho hombres y ocho mujeres. Todos los participantes fueron agrupados según su sexo en dos equipos, masculino y femenino, cada equipo jugó un partido contra otro equipo. Cada partido tuvo dos periodos de 10 min cada uno, con 5 min de descanso. Se utilizaron dispositivos GPS para cuantificar las respuestas cinemáticas, la frecuencia cardiaca fue obtenida mediante monitores cardiacos, se midió la temperatura interna utilizando píldoras TemCorp y se calculó la pérdida de peso corporal, la tasa de sudoración y la ingesta de líquido. Los principales resultados mostraron diferencias significativas entre hombres y mujeres en la distancia total recorrida (m) ($p< 0,01$), velocidad promedio (km/h) ($p< 0,01$), velocidad máxima (km/h) ($p= 0,022$), impactos totales (g) ($p< 0,01$), cambio en el peso corporal (%) ($p= 0,038$), tasa de sudoración (ml/min) ($p< 0,01$), y líquido ingerido (ml) ($p< 0,01$). La temperatura interna (°C) entre hombres y mujeres fue diferente después del calentamiento ($p= 0,044$) y al final del primer tiempo ($p= 0,007$). También, se encontró una disminución significativa en la velocidad máxima (km/h) ($p= 0,10$) y carga corporal (UA) ($p= 0,026$) en el segundo periodo en hombres y mujeres. En conclusión, el balonmano de playa es un deporte que se juega a intensidad media a alta [FC promedio (hombres= 156,1±17,5 lpm, mujeres= 158,1±19,8 lpm)]. Como implicación práctica, este estudio aporta información que puede ser usada como base para diseñar metodologías de entrenamiento acorde con los requerimientos cinemáticos y termorreguladores de los jugadores de balonmano de playa.

Palabras clave:
Deporte. Deshidratación. Frecuencia cardiaca. Temperatura corporal. Cinemática.

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Introduction

Currently, several sports federations have been developing and promoting disciplines that can to be played on the beach. Soccer, volleyball and recently the handball are among the most popular sports around the world, which are practiced on the sand, and in many cases in hot environments.

Beach handball is a sport characterized by being a complex, dynamic, fluid of constant exchange of offensive and defensive plays. It differs from the indoor handball in the conformation of the teams and in the tactical actions[1,2]. Eight players participate per team during a beach handball match, which can participate in offensive-defensive actions, only attack or only defensive, according to the tactical dispositions. Another difference is the score, which depends on the technical and motor complexity of the executions, for example, the players can make acrobatics moves to score, which will be awarded a double value (2 points) to the team.

There are few studies that have analysed the intensity of efforts in sports played on the beach. Researches so far published in beach handball have used heart rate (HR) as a parameter to evaluate the physical efforts of the players; it suggests that the practice of beach handball is a vigorous activity[3-6]. In this sense, Lara-Cobos[3] during the 13 matches and Silva *et al.*[4] during a game of female beach handball tournament found that the HR was maintained between 139 and 167 bpm, while other authors[5] reported for male players a mean HR of 164.3 ± 14.5 bpm during three matches.

As to the kinematic responses, recently a comparation was made[6] during four beach handball games the kinematic responses between sexes. They found that men covered more distance than women both in the first and the second period, likewise, men travel more meters at high intensities than women. Total body impacts and body load were higher in women than in men.

Regarding other sports practiced in similar conditions, the mean HR during a beach volleyball match is 149.5 ± 14.1 bpm[5], and in beach soccer matches is 165 ± 20 bpm[7]. The beach soccer players perform high-intensity activities during 3% to 9.5% of the match[7,8].

In addition to the physical efforts performed by the players during a beach handball match, it should also consider the thermal sensation and the effects caused by environmental conditions such as temperature and relative humidity[9,10]. The environmental conditions in combination with the intensity and duration of physical effort can generate excessive levels of sweating, dehydration, loss of body weight and elevation of body temperature in athletes, which may cause alterations in the thermoregulation of the body and in the cardiovascular system of the organism, which increases the possibility of athletes suffering health problems[11-14].

Karras, Chryssanthopoulos, and Diafas[15] evaluated the effect of playing beach handball matches in high humidity and environmental temperatures on the body fluid loss in female players. Zetou, Giatsis, Mountaki, and Komninakidou[16] did not find states of dehydration among elite players and not the elite beach volleyball, and the weight loss reported not exceed 800 grams per player during a tournament in high temperature (>33 °C). During soccer matches in the professional and recreational players, it has been reported an internal body temperature ranged between 37.5 °C and 39.5 °C[17,18].

Based on the scientific evidence so far reported about the beach handball, and the fact that in Costa Rica there are no studies on beach handball, only a few studies worldwide has been performed. To have a deeper understanding about this popularity increasing sport, the objective of this study was to describe and compare the kinematic responses, the change in the body weight, fluid balance and the internal temperature between male and female beach handball players during an official game in Costa Rica.

Material and method

Participants

Sixteen beach handball players participated, eight women and eight men. All players were team members of Costa Rican indoor handball top league club, all participated of an official beach handball tournament organized by the Federación Costarricense de Balonmano. The players were, apparently healthy, well trained (2-3 times/week) and played at least 1 official game/week, with none neuromuscular, cardiovascular or neurological disorders. Participant's characterization is shown in Table 1.

Ethical statement

All subjects were informed of the details of the experimental procedures and the associated risks and discomforts. Each subject gave written informed consent according to the criteria of the Declaration of Helsinki regarding biomedical research involving human subjects[19].

Equipment and procedures

Firstable, all the study methods and informed consent were given to the participants. The characterization of the participants was made taking, weight (Elite Series BC554, Tanita-Ironman®, ± 0.1 kg sensibility), height, age, sport experience. The weight was measured pre- and post- games.

All participants were grouped by sex in two teams, male group (MG) and female group (FG). Each game was conducted under official International Handball Federation rules, the same referees and against the same rival (handball club). Two official games of two periods, 10 min each, 5 min rest, were made. The participants were provided with

Table 1. Participant´s characterization data.

	Men (n= 8)	Women (n= 8)	Total (n= 16)
Age (years)	25.6 ± 9	26 ± 7	25.8 ± 7.8
Weight (kg)	78.1 ± 6.5	70.5 ± 12.7	74.3 ± 10.5
Height (cm)	177.8 ± 4.2	166.8 ± 7.6	173.1 ± 8
Sport experience (years)	9.2 ± 9.8	6 ± 6	7.6 ± 8
Training frequency (days)	3.1 ± 2.3	3.1 ± 1.6	3.1 ± 1.9

an integrated accelerometer and global positioning cell (SP PRO X II, 15 Hz, GPSport, Canberra) to measure the kinematics variables, total distance, body load, impacts, speed average. The impacts above 5g were considered based in Di Salvo *et al*[20] because of their influence in fatigue previously reported. GPS test, re-test reliability is r=0.75[21].

To measure the thermal stress participants swallowed a pill to measure intestinal internal temperature (CorTemp 2000, HQInc. and CorTemp Data Recorder V4.3), with an accuracy of ±0.1°C following fabricant. The pill was subministrated an hour before the game[22], and the first measurement was made to each player after the warm-up (15 minutes before start game), the second measurement was made at end the first period and the third measurement was made at end second time. They also wear a heart rate monitor band (Coded T14, Polar, Finland) to measure the heart beats per minute (bpm).

The environmental heat stress was assessed through the Wet-Bulb Globe Temperature (WBGT), obtained with an QUESTemp°36 WBGT (3M, Wisconsin), with a fabricant precision of ± 0.5°C in temperature and ± 5% in relative humidity. It was sat 10 meters from the lateral line of the court. The mean WTGB thermal stress index was 36.1 ± 1.6.

The players got liquid intake *ad libidum*, the total intake (ml) was measured after the game to estimate the sweating rate (SR) of each participant per minute played through the following formula[23].

$$SR = \frac{\text{(weight pre - weight post) + total liquid intake (ml)}}{\text{total minutes played}}$$

To know the percentage of body weight lost (%BWL), the following formula was used[23]:

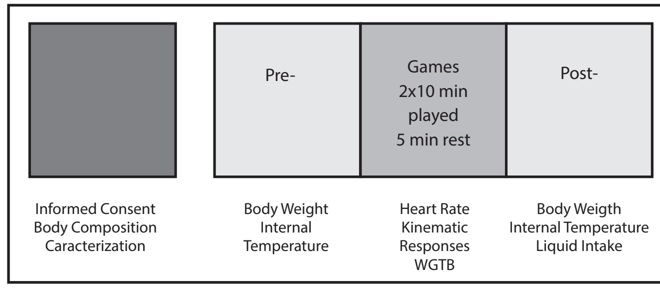
$$\%BWL = \frac{\text{(weight pre - weight post)}}{\text{weight pre}} \times 100$$

The measures were taken immediately before, during and after the official games, for more detail see Figure 1.

Statistical analysis

Descriptive statistics were implemented through the mean (M) and their respective standard deviations (±SD). Results are expressed as means ± standard deviation (SD). The normality of the data of each of the variables was checked by Shapiro-Wilk test and the Levene test for homogeneity of variance; Box's *M* test and Mauchley Sphericity for the homogeneity of the covariance matrices of the dependent variables. Data were analysed using independent group *t*-Student and was subjected a 2 (sex) x 2 (moment) mixed model ANOVA, with an alpha set prior at $p< .05$. The magnitudes of the differences were analysed using the omega squared (ω_p^2) for ANOVA analysis and qualitatively categorized as follow: ω_p^2 >.15 high effect, ω_p^2 around .06 moderate effect and ω_p^2< .01 as small effect (Cohen, 1977). The magnitudes of the differences were analysed using *d*-Cohen for t-student analysis categorized as follow: *d* < .2 small, *d* around .5 moderate and *d* < .8 large (Cohen, 1977). The data analysis was performed using Statistical Package for the Social Sciences (SPSS, IBM, SPSS Statistics, V 22.0 Chicago, IL, USA).

Figure 1. Schematical design.



Results

Table 2 shows heart rate and kinematics data by period and sex. There was not statistically significant interaction in cinematic variables in sex by period, as follow: total distance [$F_{(1, 14)}$: .039, p= .846, ω_p^2= 0 *(small)*], average speed [$F_{(1, 14)}$: .030, p= .865, ω_p^2= 0 *(small)*], maximum speed [$F_{(1, 14)}$: 2.431, p= .141, ω_p^2= .14 *(small)*], body load [$F_{(1, 14)}$: .005, p= .943, ω_p^2= 0 *(small)*], total impacts [$F_{(1, 14)}$: .252, p= 624, ω_p^2= 0 *(small)*].

The main effects analysis, presented significant differences by group (men *vs* women): total distance [$F_{(1, 14)}$: 12.847, p< .01, ω_p^2= .43 *(high)*], average speed [$F_{(1, 14)}$: 12.630, p< .01, ω_p^2= .42 *(high)*], total impacts [$F_{(1, 14)}$: 20.496, p< .01, ω_p^2= .59 *(high)*], were higher in men than women.

It was also found significant differences between first period and second period: maximum speed [$F_{(1, 14)}$: 8.912, p= .010, ω_p^2= .38 *(high)*], body load [$F_{(1, 14)}$: 6.233, p= .026, ω_p^2= .30 *(high)*] were lower in the second period.

Regarding the HR, no differences were found in heart rate between the sexes [$F_{(1, 14)}$: .046, p= .833, ω_p^2= .043 *(small)*], either between periods [$F_{(1, 14)}$: .192, p= .668, ω_p^2= .043 *(small)*].

Table 2. Heart Rate and kinematics data by period and sex.

	Men (n= 8)			Women (n= 8)		
	1st period	2nd period	Total	1st period	2nd period	Total
Heart rate (bpm)	155.9 ± 18.1	155.9 ± 19.8	156.1 ± 17.5	156.5 ± 23.1	159.3 ± 17	158.1 ± 19.8
Total distance (m)a	503.2 ± 138	435.5 ± 128.1	938.7 ± 211.8	332.2 ± 134.7	281.2 ± 87.7	613.4 ± 145
Average speed (km/h)[a]	3 ± .81	2.6 ± .8	2.8 ± .6	2 ± .8	1.7 ± .5	1.8 ± .4
Maximum speed (km/h)[a,b]	17.1 ± 1.8	14.7 ± 1.7	15.9 ± 2.1	14.0 ± 2.5	13.2 ± 2.0	13.6 ± 2.2
Body load (AU)[b]	9.4 ± 4	7.3 ± 3.7	16.7 ± 7.4	6.8 ± 3.2	4.6 ± 2.7	11.3 ± 4
Total impacts (g)[a]	696.6 ± 198.7	554.6 ± 188.4	1251.3 ± 302.8	397.9 ± 135.8	320.5 ± 168.5	718.4 ± 138.4

[a]Significant differences between sex p<.050.
[b]Significant differences between periods p<.050.

Table 3. Fluid intake, fluid balance and internal temperature variables by sex.

	Men (n=8)	Women (n=8)	ES *(rating)*
Weight change (%)	.1 ± .8[a]	.9 ± .8[a]	-.57 *(moderate)*
Sweat rate (ml/min)	72.2 ± 20[a]	41.3 ± 17.5[a]	.82 *(large)*
Liquid intake (ml)	1443.8 ± 399.5[a]	825 ± 349.5[a]	.82 *(large)*
Internal Temperature after warm-up (ºC)	38.1 ± .9[a]	39.0 ± .7[a]	.55 *(moderate)*
Internal Temperature final first period (ºC)	37.6 ± 1.6[a]	39.6 ± .8[a]	.80 *(large)*
Internal temperature final game (ºC)	37.9 ± 1.7	38.3 ± 1.6	.20 *(small)*

[a]Significant differences between sexes $p<.050$.

Table 3 shows fluid intake, fluid balance and internal temperature data by sex. There were found statistical differences between sex values of: the women presented a weight change % [$t(_{14})$= -2.288, p= .038, d= -.57 *(moderate)*], internal temperature after warm-up [$t(_{14})$= -2.217, p= .044, d= .55 *(moderate)*], and final first period [$t(_{14})$= -3.173, p= .007, d= .80 *(large)*] higher than men. While men had a sweat rate per minute played [$t(_{14})$= 3.296, p< .01, d= .82 *(large)*], and liquid intake [$t(_{14})$= 3.297, p< .01, d= .82 *(large)*]; higher than women. No differences were found in internal temperature final game between sexes [$t(_{14})$= -.956, p= .355, d= .20 *(small)*].

Discussion

The objective of this study was to describe and compare the kinematic responses, the change in the body weight, fluid balance and the internal temperature in male and female during an official beach handball game in Costa Rica.

Despite we have found few studies about beach handball, we discuss our results comparing it with handball indoor or with the scientific evidence so far reported about the beach handball and also other sport played on the sand in heat environment such as beach soccer and beach volleyball.

Kinematics responses

The total distance traveled per player in this study was 613.4 ± 145 m (38.8 ± 11.7 m/min) in average per game, which is lower than the reported by Pueo *et al.*[6] in elite beach handball. Men covered more distance (m) than women; it coincides with what is reported in the literature[6].

When comparing the distance traveled during beach handball match with indoor handball matches, differences are found. Female players U19 performed above 6300 m (105 m/min) per game, analyzed by video[25], whereas Michalsik and Aagaard[26] reported average distance traveled for men of 3627 ± 568 m and for women of 4002 ± 551 m. This could be due to the differences in the dynamics of play that are shown between both sport modalities (indoor vs beach) and in the surface where are practiced, in this sense the sand limits more the movements in comparing with the firm surface. Moreover, the results found in this study not agree with the total distance traveled in other sport played on sand like as beach soccer, who reports an average 1135 ± 26.8 m (97.7 ± 15.1 m/min) per game[7].

The maximum speed reached by the players in this study (14.7 ± 2.1 km/h) was shown below the value reported other sport as beach soccer during a match[7]. Men showed an average and maximum speed (km/h) higher than women. This may be related to the fact that men performed quickest movements and travel more distance running at high-intensity and in sprints[6]. The above, also might explain that men had more total body impacts than women.

It was also observed that the values of kinematics variables both men and women decreased in the second period. The maximum speed and body load was significantly, whereas the values of total distance, speed average and total impact not significantly. This decrease can be due onsets of muscle fatigue which causes alterations in the contractile responses, causing a decrease in the speed and efficiency of movements, reverberating in the physical performance during the game. Also, the extreme environment's conditions could affect. It have been notable that affect the physical performance of the athletes[9,10]. The WTGB in both games (36 ºC) was above the recommend values (<30 ºC) for sports practice[9,10].

No differences were found between sex and pre-post in kinematic responses and HR. Heart rate presented by the players during the matches coincides with that reported in studies of beach handball in female players[3,4,6], and in male players[5,6]. Compared with other sports such as soccer[7,8] and beach volleyball[5], heart rate also shows similar results. The above, demonstrate that handball matches were played at vigorous intensity as well have been reported in the literature[3-6]. Also, the results reinforce that beach handball is an activity that demands the use of aerobic and anaerobic energy systems.

Thermal responses

In this study, the percentage of body weight loss did not overcome 1% of the body weight of the players after the games. The body weight loss in men was 0.078 kg, while in women was 0.66 kg. These results are similar to the values reported of beach volleyball players[14]. However, this does not coincide with that reported by other authors, who found that beach handball players lost 2.8% body weight in average in beach handball matches of 30 minutes in high heat and humidity environments[16]. Likewise, these results are different from the reported in football players, in which it was observed that the body weight decreases 2.58 ± 0.88 kg after a match of 90 minutes[11].

This difference in the lost body weight could be due to the greater intake of liquid shown by men. For the case of the men, the liquid intake was similar to that reported in male beach volleyball players[16] but the liquid ingested by women was below the reported[16]. Nevertheless in male soccer players the liquid intake reported during matches[11] is higher than the reported in this study, which can be due to the duration of the activities; a football match lasts 90 minutes, while a beach handball match only 20 minutes. This difference may increase or decrease the need to ingest fluid, mainly because the quantity of liquid intake during sports activities with times less than one hour is shown insufficient in accordance with the recommendations[27].

Also, we can view that men had a higher liquid intake and sweating rate than women. These results agree with the literature, which has indicated that the higher fluid intake increased sweating during physical exercise because the liquid is used in the sweating and evaporation process as the main physiological mechanism to regulate body temperature[11,12]. Therefore these results evidenced that an adequate hydration can prevent health problems for athletes relations with dehydration[27].

In this study sweating rate per minute was 72.3 ml for men and 41.3 ml for women, both values are shown over the sweet rate reported in futsal players (12.3 ml/min played) after the games[24]. In this sense, a possible justification will be the environmental conditions of temperature and relative humidity to which the players were exposed to their respective analyzed events.

As for the internal body temperature, although we could not obtain the basal temperature of the athletes or before the game, after the first time, the temperature was 38.6 ºC and remained similar at the end the second time 38.3 ºC, it which is similar to the internal temperature of soccer players during 90-minute matches[17,18]. In the measurement after warn up and the final first time, women had an internal temperature higher than men. This values found in our study are observed as normal for well-trained players, who activate their thermoregulatory responses (sweating and evaporations) faster and more efficiently to prevent the body from suffering heat problems.

However, one of the limitations of this study was not having taken the effective time each player in the match, as well as the considerations of the demands according to the game positions. For future research, it is recommended to complement kinematic analyses and thermal responses with tactical analyses, because they can help to understand players' responses in competitions. Besides that, we suggest that for future research the effect of kinematics, physiological and thermal responses on performance in beach handball match should be analyzed.

In conclusion, beach handball is a sport that is played a medium-high intensity, whose behaviors and demands differ from other sports due to its characteristics of game, which conditions the players to make short but explosive movements, therefore the distances traveled are short due the rules allow players not to actively participate throughout the game.

Also, our results suggest that the physical effort performed by the players are different between sexes, which cause the thermoregulatory mechanisms of each player responds to the physical efforts and because to the environmental conditions.

As a practical implication, this study provides information that may be used as a base or support to plan and designing training methodologies according to the specific kinematics and thermal requirements of beach handball.

Conflict of interest

The authors do not declare a conflict of interest.

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Original article

Effects of a program of eccentric exercises on hamstrings in youth soccer players

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Summary

Objective: To determine the effects of a 6-week eccentric exercise program on the active knee extension range of motion in young soccer players.

Material and method: Randomized controlled trial. The sample was constituted by 37 youth players (18 control group and 19 experimental) of male sex between 14 and 16 years belonging to the under-15 and under-16 categories of a sports club in the Talca city, Chile. All the players were evaluated in a pre-intervention session (S0) by measuring the active knee extension range of motion in the dominant leg (DL) and non-dominant leg (NDL) with the Active Knee Extension (AKE) test using an electrogoniometer. The experimental group was subjected to eccentric exercises of the hamstring muscle 3 times a week for a period of 6 weeks. The intervention sessions were carried out prior to the usual training of the players. Both groups were reevaluated in 4 sessions: third (S1), sixth (S2), ninth (S3) and twelfth week (S4).

Results: In the control group there were no gains in the active knee extension range of motion, while in the soccer players who underwent eccentric exercise, a gain of 11.4 ° was observed for the DL and 7.8 ° for the NDL. In this group, significant changes occurred at S1 ($p = 0.005$) in PD and PND ($p = 0.008$); S2 in PD ($p <0.001$) and PND ($p = 0.006$); and S3 in the PD ($p = 0.004$).

Conclusion: A progressive training of eccentric exercises of 6 weeks on the hamstring musculature generates positive changes in the active knee extension range of motion, reducing the shortening of this muscle group, mainly, in the dominant leg. The effects are maintained until the third week after the intervention.

Key words:
Eccentric contraction exercises. Hamstrings tightness. Soccer. Sports.

Efectos de un programa de ejercicios excéntricos sobre la musculatura isquiotibial en futbolistas jóvenes

Resumen

Objetivo: Determinar los efectos de un programa de ejercicios excéntricos de 6 semanas de duración sobre el rango de extensión activa de rodilla en futbolistas juveniles.

Material y método: Ensayo clínico aleatorizado y controlado de corte longitudinal. La muestra fue constituida por 37 futbolistas juveniles (18 grupo control y 19 experimental) de sexo masculino entre 14 y 16 años pertenecientes a las categorías sub-15 y sub-16 de un club deportivo de la ciudad de Talca, Chile. Todos los jugadores fueron evaluados en una sesión pre-intervención (S0) midiendo el rango de extensión activa de rodilla en la pierna dominante (PD) y no dominante (PND) con el test *Active Knee Extension* (AKE) utilizando un electrogoniómetro. El grupo experimental fue sometido a ejercicios excéntricos de la musculatura isquiotibial 3 veces a la semana por un periodo de 6 semanas. Las sesiones de intervención se llevaron a cabo previo al entrenamiento habitual de los futbolistas. Ambos grupos fueron reevaluados en 4 sesiones: tercera (S1), sexta (S2), novena (S3) y duodécima semana (S4).

Resultados: En el grupo control no se observan ganancias en el rango de extensión activa de rodilla, mientras que en los futbolistas que fueron sometidos a 6 semanas de ejercicio excéntrico se observa una ganancia del rango de movimiento de 11,4° para la PD y de 7,8° para la PND. En este grupo los cambios significativos se produjeron a la S1 ($p = 0,005$) en PD y PND ($p = 0,008$); S2 en PD ($p < 0,001$) y PND ($p = 0,006$); y S3 en la PD ($p = 0,004$).

Conclusión: Un entrenamiento progresivo de ejercicios excéntricos de 6 semanas sobre la musculatura isquiotibial genera cambios positivos en el rango de extensión activa de rodilla, disminuyendo el acortamiento de este grupo muscular, principalmente, en la pierna dominante. Los efectos se mantienen hasta la tercera semana una vez finalizada la intervención.

Palabras clave:
Ejercicios de contracción excéntrica. Acortamiento de isquiotibiales. Fútbol. Deportes.

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Introduction

Soccer players are constantly exposed to the risk of sustaining musculoskeletal injuries, with the lower extremity being more affected than the upper one[1]. Greater injury incidence has been reported for youth soccer players than for professionals during training sessions, the most common being of muscular origin[2].

Hamstring injuries are as high as 37%[3], accounting for between 12 to 16% of the total number of soccer-related injuries[4]. Current investigations indicate that approximately 12% of the total of a competition season is lost due to injuries sustained by soccer players[5]. It has also been reported that between 12% to 30% of players suffered re-injury within the first 2 months of returning to sport, which has led to great concern among the leading elite soccer organisations[5]. In this context, it has been reported that hamstring injuries have a high re-injury rate following a return to sports training, reaching 12%[4].

In general, hamstring injuries primarily occur during sprinting, due to an intense and abrupt change from maximum eccentric contraction to concentric contraction during the deceleration of the knee extension6. This occurs in the final stage of the swing phase, causing a lengthening of the muscle structure associated with a load and/or contraction. The most-affected section corresponds to the biceps femoris long head, over the semitendinosus and semimembranosus muscles, due to the fact that their insertion points are the furthest away during the injury mechanism, with the myotendinous junction being the most common anatomical site of injury[6].

The risk of sustaining a hamstring injury is generally multifactorial, where it has been reported that some of the extrinsic factors are associated with training while other are directly associated with competition, however it is agreed that the most common factors are related to insufficient warm-up and muscle over-exertion[6,7]. On the other hand, intrinsic factors include muscle fatigue, decreased strength, agonist/antagonist strength imbalance and a lack of flexibility[6-8]. With regard to flexibility, its contribution to hamstring injuries is not clear, although it has been reported that shortened muscle-tendon units cause a delayed response in the adjacent muscles in the face of destabilizing situations, which could be associated with musculoskeletal injuries[9-11]. Specifically, with regard to hamstrings, the results were controversial and only some authors suggest a relationship between the lack of flexibility and the injury rate in soccer players during a normal season[12]. The differences in investigation findings could be attributed to the different evaluation methods used to measure hamstring flexibility. Hamstring flexibility tests include Straight-Leg-Raising (SLR), Sit and Reach (SR) and active knee extension (AKE). At present, the SLR is primarily intended for neurological evaluation, while the SR is considered unsuitable for hamstring evaluation due to the involvement of the lumbo-pelvic muscles in the test[13]. For its part, the AKE is an active mobility test that appears to be the most valid evaluation, give the fact that it can isolate the flexibility of the hamstring muscles[14]. This test measures the knee extension angle with a 90º hip flexion, with a system in which the femur is in the vertical position. Due to its validity and reliability, the test has been recommended as a good tool for assessing hamstring flexibility[14].

Eccentric contraction exercises could be a prevention mechanism for a range of soccer knee injuries. However, there is little information in the literature on the effects of these exercises on hamstring flexibility. It has been reported that eccentric exercises improve hamstring flexibility, increasing the active knee extension range by 1.67º in adolescents with hamstring shortening, after 6 weeks of rehabilitation, yet showing no differences with traditional muscle stretching techniques[15]. Moreover, it has been seen that the eccentric work of this muscle over a 6 week period, using the Nordic hamstring as the only exercise, improves the eccentric force of the muscle by 25 nm, optimising the kinematics with a more prolonged control in the Nordic hamstring fall of 5.6º and improved neuromuscular parameters during a motor task, increasing the electromyographic activity by 38%[16]. Increased flexibility in other muscle groups, such as the sural triceps, has been demonstrated following a program of eccentric exercise[17]. For their part, Ramirez-Campillo *et al.* (2015) applied a plyometric training protocol with an important eccentric component to a group of youth soccer players for six weeks, observing significant improvements in jump tests, agility, speed and flexibility of the lower extremity[18]. Although there are some investigations that suggest that eccentric exercise has positive effects on flexibility and other muscular parameters, the duration of this change over time has not been clearly described.

Therefore, the aim of this investigation was to determine the short and long term effect of a 6-week eccentric training program on the active knee extension range in youth soccer players.

Material and method

This is a randomised, controlled clinical trial. Simple random sampling was used to assign the participants to either an experimental group (n=19) or control group (n=18).

Participants

Of the 40 youth soccer players aged between 14 to 16 years, at a sports club in the city of Talca (Chile), 37 met the eligibility criteria described in Table 1. All participants were authorised by their legal guardians to participate in the investigation through informed consent approved by the ethics committee of the Santo Tomás University (Chile), observing the basic principles established in the Declaration of Helsinki.

Intervention

The investigation was conducted at the sports club's training field during the competitive period of the 2016 Clausura Tournament, comprising 15 dates with one match each weekend. Both groups (control and experimental) performed their normal soccer training for 5 days a week, consisting in warm-up, physical exercise, technical work, cool-down and stretches, in accordance with a program developed by the physical preparation team. The training sessions lasted 90 min. For 3

Table 1. Eligibility criteria of participants.

Inclusion criteria
- Male soccer players.
- Aged between 14 to 16 years.
- Shortening of hamstring muscles greater than 20º of the active knee extension range in at least one extremity.
- Approval of informed consent by the guardian.
Exclusion criteria
- Hamstring muscle tears, 2 months prior to the investigation.
- LL surgery, 6 months prior to the investigation.
- LL injuries requiring prolonged knee immobilization 1 month prior to the study.
- Musculoskeletal LL injury during the study, making it impossible to continue with the same.

LL: lower limb.

days a week (Monday, Wednesday and Friday), the experimental group was called 15 minutes before training and put through a program of eccentric hamstring exercises directed by a kinesiologist. Prior to this, a 1,000 m warm-up was made at a gentle jog (maximum level 4 according to the modified Borg scale). The design of the eccentric exercises was based on previous experience provided by the literature [6,19-21], with a rest of 1 minute between each set and applied for a 6-week period[15-17] (Table 2 and Figure 1).

Study variable

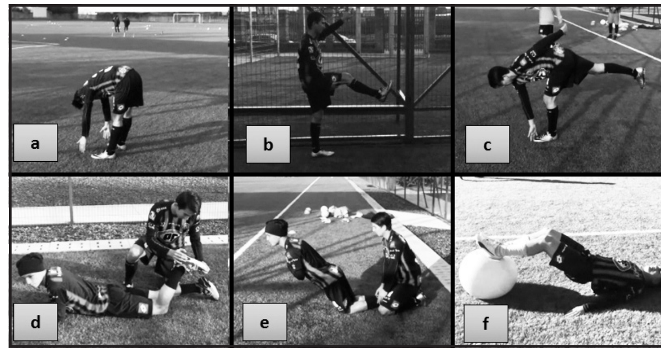
The 37 participants in the trial underwent the measurement of the degree of hamstring shortening through the active knee extension range of the AKE test[14] and measured with an electrogoniometer (Pasco®, Santiago, Chile) for the dominant leg (LD) and non-dominant leg (NDL), determined by the kicking leg. The measurement was taken with the subjects positioned in supine recumbency on a mattress with the hips

Table 2. Guideline for hamstring eccentric contraction exercises.

Week 1	Week 2	Week 3
Bipedal deadweight (3 x 10 rep)	Unipedal deadweight (3 x 8 rep)	Unipedal deadweight (3 x 12 rep)
Controlled kick (3 x 8 rep)	Controlled kick (3 x 12 rep)	Against manual resistance (3 x 8 rep)
Week 4	**Week 5**	**Week 6**
Against manual resistance (3 x 12 rep)	Nordic (3 x 8 rep)	Nordic (3 x 10 rep)
Nordic (3 x 6 rep)	Supine with ball Swiss ball bipedal (3 x 8 rep)	Supine with ball Swiss ball bipedal (3 x 12 rep)

Rep: repetitions

Figure 1. Eccentric hamstring exercises applied to the experimental group. a) bipedal deadweight. b) controlled kick, c) unipedal deadweight, d) against manual resistance, e) Nordic, f) supine with bipedal Swiss ball.



and knees bent at 90º, with the legs resting on a box with handles and a roll under the knees to maintain the femur vertical. The electrogoniometer was positioned with the fulcrum on the inter articular side of the knee, the fixed arm directed at the greater trochanter of the femur and the mobile arm at the lateral malleolus of the ankle, according to the criteria established by the *American Academy of Orthopaedic Surgeons* (AAOS). The measurements were taken over 5 sessions: pre-intervention (SO), third week (S1) sixth week (S2), ninth week (S3) and twelfth week (S4). S3 and S4 were made in the third and sixth post-intervention week respectively.

Statistical analysis

The GraphPadPrism 6.0 program was used for the statistical analysis. The average and standard deviation were considered to describe the general characteristics of the sample (age, weight, height and BMI). To describe the active knee extension range, the median, minimum and maximum values were used. The normality distribution and the homogeneity of variance were calculated using *the Shapiro-Wilk* and *Levenetests respectively. The Kruskall Wallis* nonparametric test was applied to determine differences in the active knee extension range, for the experimental group and the control group. *Dunn's post hoc* test was used to determine the differences between each of the measurements. For all the analyses, a significant value of 0.05 was considered.

Results

Of the 37 players selected, 30 completed the study (15 from the experimental group and 15 from the control group). The baseline characteristics of the soccer players taking part in the investigation are given in Table 3. It should be pointed out that the footballers taking part in the test primarily demonstrated right-leg dominance (93.4% control group and 80% experimental group) and only a small proportion had left leg dominance (6.6% control group and 20% experimental group).

For the control group of youth soccer players that are part of the under 15 and 16 categories, no significant differences were observed in the active knee extension range measured with the AKE test during

Table 3. Baseline characteristics of the sample (mean and standard deviation).

Characteristic	Control (n=15) mean (SD)	Experimental (n=15) mean (SD)
Age (years)	15.00 (0.85)	15.07 (0.80)
Body weight (kg)	65.49 (7.18)	61.8 (4.75)
Bipedal height (m)	1.72 (0.06)	1.70 (0.06)
BMI (kg/m^2)	22.03 (1.45)	21.33 (1.49)

SD: standard deviation; BMI: body mass index; kg: kilograms; m: metres.

the intervention and follow-up for both the DL (p = 0.314) and the NDL (p = 0.309) (Table 4). For the experimental group, an increase in the active knee extension range was observed for the DL (p = 0.0001) and for the NDL (p = 0.0014). The *post hoc* test (*Dunn's* test) revealed the following significant differences for the DL: S0 vs S1 (p = 0.005), S0 *vs* S2 (p < 0.001), S0 *vs* S3 (p = 0.004), S2 *vs* S4 (p = 0.001). For the NDL, differences were found in the following comparisons: S0 *vs* S1 (p = 0.008), and S0 *vs* S2 (p = 0.006 (Table 4).

Discussion

The main finding of this investigation shows a positive effect of the eccentric contraction exercises on the muscle length of the hamstring group, as evidenced by an increase in the active knee extension range and quantified through the AKE test with electrogoniometry in youth soccer players (14-16 years) with muscle shortening. This increase in range was achieved following 6 weeks of progressive training with regard to volume, intensity and difficulty, with 3 sessions a week. These results are similar to those obtained by Brughelli *et al.* (2010), who, after an intervention period of 4 weeks, concluded that the eccentric contraction exercises managed to increase the knee range and to lengthen the hamstring muscle in professional male soccer players[20]. These results are similar to those reported by Mahieu *et al.* (2008) with a 6-week training session on calf muscles with 64 voluntary healthy subjects of both sexes and with an average age of 22 years[17]. Exercises of this type have been shown to generate changes in strength, kinematics and neuromuscular parameters in sedentary subjects[16], while in football it has been indicated as a good tool to prevent hamstring injuries[22,23].

The changes in the active knee extension range caused by eccentric exercise could be due to a change in the passive stiffness at the myotendinous junction[24]. It is put forward that increased actin and myosin cross-bridging causes an increase in the calcium ions present in the muscle fibres; these ions are related to the rupture of the muscle cell membrane[24,25]. The process to repair the micro-damage generated by eccentric exercise would cause a restructuring of the connective tissue, increasing the stiffness[24]. However, it is thought that, when the eccentric exercise is repeated for a minimum period of 6 weeks, the passive muscle-tendon stiffness decreases and transfers part of the mechanical restriction of the tendon to the muscle, increasing the series elastic components of the muscle and tendon, improving the muscle length[17,24,26]. Coincidentally, the principal active knee extension range changes in our study are observed in the sixth week of intervention.

It has been reported that an adequate muscle length is one of the principal factors that protect against soft tissue injuries, primarily strains that alter the integrity of the connective tissue and related vascular structures, leading to muscle fibre damage[26]. An optimal length of the hamstring muscles could maintain an adequate amount of sarcomere or contractile units, in parallel and in series, directly influencing the cross-sectional area and permitting a greater recruitment of fibres from this muscle group. This would permit an adequate length-tension relationship and an increase in the lever arm, favouring greater strength production[27,28].

Van Doormaal *et al.* (2017), reported that there was no relationship between the lack of flexibility and a risk of injury, measured with the *sit and reach test*[29]. However, it has been demonstrated that this test is unable to individualise the hamstring muscles from the lumbopelvic muscles[13]. For this reason, it was decided to use the AKE test in this study in order to indirectly assess the hamstring flexibility, due to the fact that, in soccer it has been demonstrated that an adequate assessment of flexibility could be a useful injury prediction tool and that even flexibility work could be an injury prevention strategy[30].

On the other hand, it was observed that, 6 weeks after intervention, the DL or kicking leg had a greater change in the AKER (11.4°) than the

Table 4. Values in degrees for the active knee extension range during the evaluation weeks.

Measurement sessions	Control (n=15) median (min-max)		Experimental (n=15) median (min-max)	
	DL	NDL	DL	NDL
S0	21.2 (16.8 - 44.7)	25.2 (18.2 - 44.7)	27.9 (21.1–37.3)	27.4 (17.5-44.1)
S1	24.7 (18.2 - 43.1)	28.7 (20.9 - 37.2)	20.2 (13.1-42.1)	19.9 (12.3-41.9)
S2	23.6 (17.9 - 36.4)	26.7 (19.9 - 37.9)	16.5 (13.9-23.4)	19.6 (10.3-24.8)
S3	23.9 (18.8 - 43.9)	28.1 (21.2 - 37.8)	20.1 (14.3-33.0)	21.2 (13.4-33.7)
S4	24.3 (17.6 - 38.1)	27.5 (20.8 - 38.4)	23.6 (19.3-33.2)	23.1 (17.9-36.4)

S0: Initial evaluation (pre-intervention); S1: evaluation third week (halfway through intervention); S2: evaluation sixth week (end of intervention); S3: evaluation ninth week (third week of monitoring); S4: evaluation twelfth week (sixth week of monitoring); Min: minimum value; max: maximum value; DL: dominant leg; NDL: non-dominant leg.

non-dominant leg (7.8°). Although it has been reported that the kicking leg is subject to a greater number of muscle injuries in soccer players[31], there is little evidence that compares the results of eccentric exercise between the DL and NDL. The results obtained in this investigation could be explained by the greater neuromuscular adaptation of the dominant leg, as it is constantly used.

In this investigation, the changes start to appear in both legs during the third week of intervention, and this coincides with the changes and architectural adaptations reported for hamstrings (primarily in the fascicle length) from that week onwards with eccentric exercises[32]. On the twelfth week of assessment, no differences were observed in either leg, in relation to the initial assessment, indicating that after 6 weeks of monitoring, during which the players continued with their training and sport competition as usual, the effects achieved in muscle length, caused by eccentric exercise in this study group, were lost. This is contrary to what is maintained by Brughelli *et al.* (2009), who indicates that the effects of eccentric exercise can be maintained for 23 weeks after intervention. However, his investigation was conducted on soccer players with a history of recurrent hamstring injuries and not on players with shortening[20]. Moreover, the activity of the soccer players during these 23 weeks is not sufficiently clear. On the other hand, this investigation specified that the players continued with their training sessions and normal competition matches during the 6 weeks following the intervention. Due to the differences of findings from one investigator to another, it would be interesting to determine the precise moment at which the beneficial effects of the eccentric contraction exercise disappear, an exercise which has been shown to be an active participant in the prevention of sport injuries[6]. This would make it possible to establish the frequency with which these exercises need to be performed in soccer training in order to avoid the shortening of the hamstring muscles, injuries and re-injuries. An investigation reported that a high-intensity plyometric training program performed twice a week could be implemented as a substitute for some exercises within regular soccer practice during the season, given the fact that it was determined that the inclusion of this type of exercises in youth soccer players improved explosive and strength performance in comparison with an isolated soccer training session[33]. Therefore, eccentric exercises could be beneficial not only in the rehabilitation of injured soccer players but also in the regular training of athletes as a method to prevent injuries and improve sport performance.

The limitations of this study include the fact that the sample only considers players from a specific soccer club and excludes the lack of complementary evaluations such as the measurement of the eccentric force through an isokinetic machine, which has been used in prior studies. Despite this, it is important to emphasise that this study was controlled and randomised, strengthening the methodological quality of the investigation.

In conclusion, a progressive intervention of eccentric exercises for the hamstring muscles for a period of 6 weeks, performed during the soccer competition season, generates positive changes in the active knee extension range in youth soccer players, reducing the hamstring shortening. These changes were principally evident in the kicking leg, where their effect was maintained for 3 weeks following the intervention. Due to the potential benefits of eccentric exercises on muscle length, it is recommended to include these exercises in the flexibility programs applied to soccer players. This could also reduce the risk of injury and enhance athletic performance.

Conflict of interest

The authors do not declare a conflict of interest.

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Original article

Estimation of the maximum blood lactate from the results in the Wingate test

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Summary

Muscle energy is provided by three mechanisms acting simultaneously, with differences in their power and capacity: alactacid anaerobic, lactacid anaerobic and aerobic. In efforts leading to exhaustion in less than two minutes, and in the initial and final stages of the efforts of medium and long duration, lactacid anaerobic mechanism has a fundamental role. The determination of lactacid anaerobic capacity is very important to estimate the performance capacity in many sports and physical activities. This paper proposes an indirect method to determine the maximum lactatemia, by the use of average performance in the Wingate test. The results of the Wingate test were transformed into lactate levels by a proposed formula, and were compared to the actual measurement of maximum blood lactate post maximum effort in field trials for different sport modalities. The method was tested in 185 athletes (103 men and 82 women) from different national teams from Venezuela, which practiced 18 sports (males) and 17 sports (females). Direct lactate measurements did not differ from levels calculated from the results of the Wingate test (men: 19.60 ±1.49 in Wingate test *vs.* 18.80±1.70 mmol.l^{-1}, in field measurement; women: 16.10 ± 1.47 *vs.* 14.82 ± 1.64, respectively). Direct correlation between the lactate levels obtained by measurement and by calculation was highly significant (all subjects r= 0.86, p<0.000000). In conclusion, calculation of lactacid anaerobic capacity with a formula that uses the result of Wingate test, may be a non invasive, non expensive, simple and reliable method.

Key words:
Lactacid anaerobic capacity. Wingate test. Physical performance. Exercise.

Estimación de la concentración máxima de lactato en sangre a partir de los resultados en la prueba de Wingate

Resumen

La energía muscular es proporcionada por tres mecanismos que actúan simultáneamente, con diferencias en su potencia y capacidad: anaeróbico alactácido, anaeróbico lactácido y aeróbico. En los esfuerzos que llevan al agotamiento en menos de dos minutos y en las etapas inicial y final de los esfuerzos de mediano y largo plazo, el mecanismo anaeróbico lactácido juega un papel fundamental. La determinación de la capacidad anaeróbica lactácida es muy importante para estimar la capacidad de rendimiento en muchos deportes y actividades físicas. Este artículo propone un método indirecto para determinar la lactatemia máxima, mediante el uso del rendimiento promedio en el test de Wingate. Los resultados de la prueba de Wingate se transformaron en niveles de lactato mediante la fórmula propuesta y se compararon con la medición real del lactato sanguíneo máximo después de un esfuerzo máximo en pruebas de campo para diferentes modalidades deportivas. El método fue probado en 185 atletas (103 hombres y 82 mujeres) de diferentes equipos nacionales de Venezuela, que practicaban 18 deportes (hombres) y 17 deportes (mujeres). Las mediciones directas del lactato no difirieron de los niveles calculados a partir de los resultados de la prueba de Wingate (hombres: 19,60 ± 1,49 en la prueba de Wingate frente a 18,80 ± 1,70 mmol.l^{-1}, en la medición de campo; las mujeres: 16,10 ± 1,47 frente a 14,82 ± 1,64 mmol.l^{-1} respectivamente). La correlación entre los niveles de lactato obtenidos por medición directa y la obtenida por cálculo fue altamente significativa (todos los sujetos r = 0,86, p <0,000000). En conclusión, la determinación de la capacidad anaeróbica lactácida con una fórmula que utiliza el resultado de la prueba de Wingate, puede ser un método no invasivo, económico, simple y confiable.

Palabras clave:
Capacidad anaeróbica lactácida. Prueba de Wingate. Rendimiento físico. Ejercicio.

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Introduction

Anaerobic source of energy, and more specifically the lactacid mechanism, is critical to the performance in efforts leading to exhaustion in less than two minutes, as well as at the start and the end of long duration efforts[1,2].

Lactacid capacity mechanism is closely linked to the ability of lactate production. In this sense it is important to know it, in order to evaluate the anaerobic capacity and its response to training.

Although some methods have been developed for the indirect determination of blood lactate[3-6], as far as we know, there is no evidence for the indirect determination of blood lactate from the Wingate test.

This paper proposes a method to estimate lactate production from average performance in the Wingate test, avoiding the direct determination by the extraction of capillary blood samples.

Material and method

Subjects

Subjects included were 103 men and 82 women, all members of various sport teams of national and international category of Venezuela, who voluntarily agreed to participate in this study. They were asked to sign a written consent; in underage cases this was done by their legal representatives. Biometric characteristics of the groups are presented in Table 1. Male subjects practiced 18 different sports and female subjects 17 sports (Table 2). Most of them were on the pre competitive period of their training program.

Wingate test

All subjects performed two Wingate tests[7,8] of 30 seconds duration with a charge equivalent to 7.5% of their body weight on a Monark cycle ergometer model 894 Ea, with a recovery period of 180 minutes between the two tests. The best result was used for the comparison with that of the field test.

Field Test

Forty eight hours after the Wingate test, the athletes performed various field exercises, according to the practiced sport of each subject. In those who were in aquatic sports, two 100-meter freestyle swimming tests were applied. Cyclists in their specialties performed twice 750 meters at the speed track. Skaters and ski sports did two 750 meters tests at the skating rink with skates. All others performed two 400-meter races at the track. In all cases the athletes were requested to undertake maximum efforts. The interval between tests was 10 minutes. After each test, blood samples were taken from the earlobe, previously cleaned and dried, at 1, 3, 5, 7 and 10 minutes. Sampling was interrupted when a measurement was obtained at a figure lower than the preceding assessment.

Table 1. Biometric data.

Subjects	Age (years)	Height (cm)	Weight (kg)
Men	23.2 ± 6.62	173.1 ± 7.13	73.68 ± 11.34
Women	20.63 ± 4.11	158.5 ± 8.24	56.23 ± 8.78

Table 2. Distribution of the athletes in different sports.

Sports	Men	Women
Athletics	14	2
Basketball	5	7
Boating	8	1
Boxing	4	-
Cycling	8	6
Hockey turf	-	10
Judo	-	1
Karate	-	2
Kempo	5	2
Modern pentathlon	6	1
Nordic skiing	2	-
Olympic wrestling	6	-
Rhythmic gymnastics	-	4
Rowing	1	-
Rugby	-	5
Sailing	-	2
Synchronized swimming	-	14
Skating	2	-
Soccer	7	-
Softball	-	3
Surfing	4	-
Table tennis	6	-
Triathlon	4	3
Volleyball	17	6
Water polo	2	13
Wushu	2	-
Total	103	82

Blood lactate concentration was assessed by a miniphotometer (Miniphotometer Plus LP20, Dr Lange, Berlin, Germany). The best value in any of the measurements was considered for statistical analysis.

Transformation of the results of Wingate test into lactate levels

A formula was developed to transform the average power in watts Wingate test (Wa) in energy units (Kcal), then the result is converted to lactate values (mmol), taking as reference the caloric equivalent of lactate (0.222 Kcal/g)[9-11]. In order to calculate the lactate concentration in mmol/l, it is necessary to know the total lactate production, for which the body water volume must be calculated, since lactate is evenly distributed in all body fluids except in the transcellular fluid (synovial, cerebrospinal fluid, vitreus humor…), reaching similar concentrations 3-5 minutes after the activity[12,13]. The water content of the body depends on the body fat content, so the body fat percentage was determined in all subjects[14]. The lean body weight was determined and based on this value; a water fraction of 0.70 was assumed. All of the subjects studied had a percentage of fat between the limits accepted for age and sex, and even a relevant percentage of the subjects studied had values lower than the normal lower limit, particularly in endurance sports.

Parameters were expressed in the following terms:

$$La\ (mmol.l^{-1}) = [(Wa \times 0,06 \times 50,045) / (Wt \times 0,7)] / 2$$

Where:

Wa = Wingate average value (watts).

Wt = Fat free body weight (kg)

Statistical analysis

Values are expressed as mean and standard deviation. Comparison between the determined and the calculated lactate levels was done with paired Student t test. Pearson method was used to calculate correlations between variables. Levels of $p<0.05$ were considered significant.

Results

The comparison between the measured levels of lactate after the field test and the calculation form the result of the Wingate test are shown in Table 3. The differences were neither significant in the male nor in the female group.

The correlation between the calculated value in the Wingate test and the values obtained with the measurement of blood lactate in the field test, in the different exercises performed by subjects were: male $r = 0,85$; $p< 0,000000$ (Figure 1); women $r = 0,74$; $p< 0,000000$ (Figure 2); the whole value for the 185 subjects tested was $r = 0,86$; $p< 0,000000$ (Figure 3).

Discussion

The Wingate test is a test widely used in the evaluation of athletes during the four last decades, and has been shown to be a good measure of the anaerobic alactacid and lactacid power, but it is also a good indicator of the lactácid capacity of the subjects.

The relationship between lactic acid production and muscle exercise was established more than 200 years ago[15]. And there is an obvious link between the maximum capacity of lactic acid production and the capacity of performance in efforts that lead to exhaustion between 30 and 120 seconds. Different lactate responses have been taken in relation to physical exercise to establish training criteria such as the lactic threshold (LT) and the maximum level of lactate in steady state (MLSS)[15]. These facts motivated us to present a non-invasive method for estimating the maximum lactate concentration.

The indirect tests that have been developed, have done so in order to calculate the critical speed in cycling in which the minimum level

Table 3. Lactate levels calculated from the Wingate Test and measured at field (mmol.l^{-1}).

Subjects	Wingate	Field
Men	19,60 ± 1,49	18,80 ± 1,70
Women	16,10 ± 1,47	14,82 ± 1,64

Figure 1. Correlation of lactate values calculated form the Wingate test and the levels measured after the field test in 103 men.

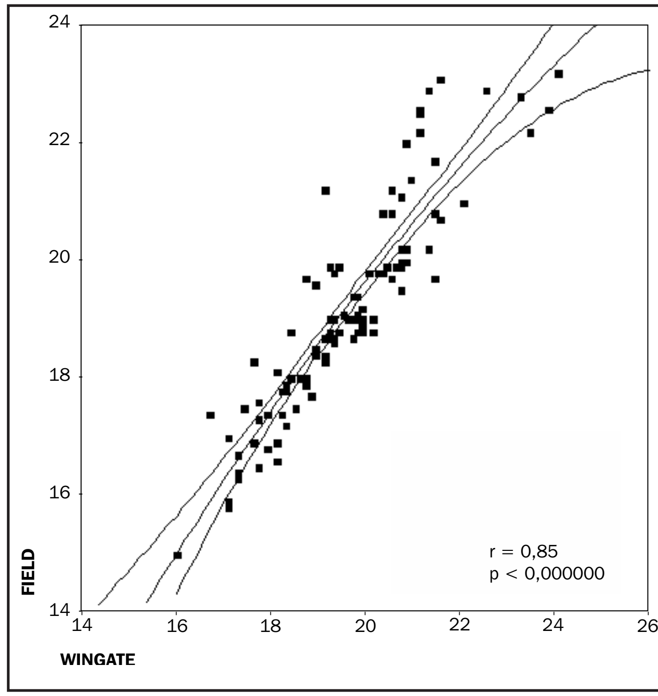
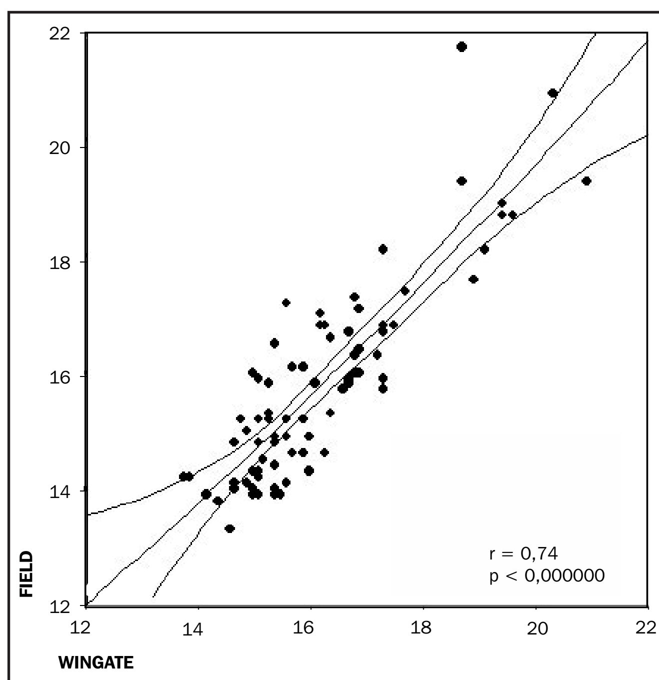
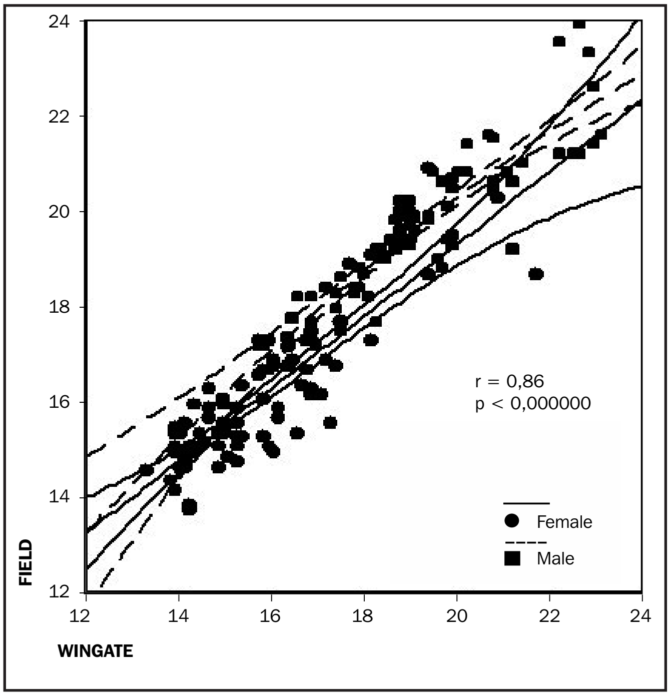


Figure 2. Correlation of lactate values calculated form the Wingate test and the levels measured after the field test in 82 women.



of lactate is reached, , which is the concentration that expresses the balance between the production and elimination of blood lactate, and others to determine the exercise intensity or running speed, or swimming that corresponds to the MLSS, as well as in other situations that

Figure 3. Correlation of lactate values calculated form the Wingate test and the levels measured after the field test in 185 athletes.



provide important information that allow to dose, control and evaluate the training with scientific criteria, which has a great practical interest. In this regard we invite groups of researchers interested in the subject to continue developing methods to estimate maximum lactatemia in various situations and with different procedures. This in addition to enrich the knowledge in the area would allow to contrast the results with the proposal that we present.

This study included male athletes from 18 sports and females that practice 17 different sports, all with more than three years of continuous practice on their relevant sports. The level of all participants was national or international category, forming very homogeneous groups in their respective sports. All of them had previously performed the Wingate test in one or more opportunities, so that their characteristics were known and familiar to them.

The presented method offers the possibility of estimating the maximum value of lactate by the transforming the average power obtained in the Wingate test (Wa) into blood lactate concentration (mmol.l^{-1}).

The results of the present study are limited to the group studied. It will be necessary to apply the formula to other groups, including less experienced athletes and hierarchy, to verify if the proposed procedure provides results similar to those obtained in the present work.

In conclusion a formula based in the results of the Wingate test is proposed to calculate capacity of lactate production in subjects that practice different sports. The method is simple, practical, non invasive and economical, and possibly a good predictor of lactacid anaerobic capacity.

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Conflict of interest

The authors do not declare a conflict of interest.

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Original article

Acute effect of an Intra-Set Variable Resistance of back squats over 30-m sprint times of female sprinters

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Summary

Introduction: Several pre-conditioning methods have been tested in order to produce Postactivation Potentiation (PAP) in men. However, it is unknown if Intra-Set Variable Resistance generates the same effect in female sprinters.
Objective: Thus, the acute effect of an Intra-Set Variable Resistance (I-SVR) protocol of back squats on 30-m sprint times of female sprinters was determined.
Material and method: Ten female sprinters were the subjects of this study (age = 20.3 ± 1.9 years, body mass 56.0 ± 6.9 kg, height = 1.64 ± 6.1 m, 30-m sprint = 4609.2 ± 236.4 ms). The pre-conditioning with I-SVR consisted of 4 back squats exercise sets: each set included 22% 1RM X 5 reps (equivalent to 1.0-1.1 m•s^{-1}), 60% 1RM X 4 reps (equivalent to 0.6-0.7 m•s^{-1}), and 30-m sprint X 3 with a 2-minute rest.
Results: The repeated measures ANOVA did not show significant differences in 30-m sprint after the application of pre-conditioning protocols with I-SVR ($p > 0.05$), while [La] provided evidence of a significant increase post-effort ($p < 0.0001$). However, great individual variations were observed.
Conclusions: Considering that the pre-conditioning with I-SVR did not increase the performance in women sprinters, which may be due to insufficient load to elicit a PAP response or that the fatigue induced outweighs the benefit, the coaches considering the use of this pre-conditioning protocol in order to generate PAP must explore its effectiveness individually. Factors such as strength levels, protocol resistance used to generate PAP, and, above all, the recovery interval between pre-conditioning and the following sprint need further research.

Key words:
Postactivation potentiation. Back squats. Sprinter women.

Efecto agudo de un protocolo de resistencia variable intra-serie en sentadillas sobre el tiempo en 30 metros lisos en mujeres velocistas

Resumen

Introducción: Varios métodos de pre-activación se han probado para desencadenar Potenciación Post Activación (PAP) en hombres. Sin embargo, se desconoce si la Resistencia Variable Intra-Serie genera el mismo efecto en mujeres velocistas.
Objetivo: Determinar el efecto agudo de un protocolo de Resistencia Variable Intra-Serie (RVI-S) en sentadillas sobre el tiempo en 30 metros lisos en mujeres velocistas.
Material y método: Diez velocistas de nivel regional fueron parte de este estudio (edad = 20,3 ± 1,9 años, masa corporal 56,0 ± 6,9 kg, estatura = 1,64 ± 6,1 m, 30 metros lisos = 4609,2 ± 236,4 ms). La pre-activación con RVI-S consistió en 4 series de sentadillas: cada serie incluyó 5 repeticiones al 22% de 1RM (equivalente a 1,0-1,1 m•s^{-1}) + 4 repeticiones al 60% de 1RM (equivalente a 0,6-0,7 m•s^{-1}) + 3 carreras de 30 metros separadas con una pausa de 2 minutos. Las variables fueron: el tiempo promedio de tres repeticiones de 30 metros de carrera y concentraciones de Lactacto ([La]).
Resultados: La ANOVA de medias repetidas no mostró diferencias significativas en el tiempo promedio realizado en 30 metros lisos después de la aplicación de protocolos de pre-activación con RVI-S ($p > 0,05$), mientras que las [La] mostraron incrementos significativos post esfuerzo ($p < 0,0001$). Sin embargo, se observaron grandes variaciones individuales.
Conclusiones: Considerando que la pre-activación con RVI-S no mostró incrementos en el rendimiento en mujeres velocistas, posiblemente por una carga insuficiente para desencadenar PAP o que la fatiga muscular superó el posible beneficio, los entrenadores que consideren el uso de este protocolo de pre-activación para genera PAP deben explorar la efectividad en forma individual. Factores tales como los niveles de fuerza, la resistencia del protocolo usado para generar PAP, y por sobre todo el intervalo de recuperación entre la pre-activación y la subsiguiente carrera necesitan de mayor investigación.

Palabras clave:
Potenciación post activación. Sentadillas. Mujeres velocistas.

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Introduction

In recent years, the topic of strength training has led to the development of varied and innovative training methodologies[1-3]. One of the methodologies used to naturally enhance acute muscular strength is Postactivation Potentiation (PAP)[4-6]. Several pre-conditioning training methods have been applied in order to generate PAP, such as ballistic exercises, maximum isometric exercises, and squats, among others[7-9]. Some research has shown that, with the correct conditioning load and the appropriate rest, the subject will enhance the strength level temporarily[5,6,10]. Currently, pre-conditioning with Variable Resistance (VR) has taken a key role in the PAP[3,11]. A review performed by Soria-Gila *et al.*[3] concluded that pre-conditioning with Intra-Set Variable Resistance (I-SVR) with elastic bands and/or chains generated a significant increase in strength levels. Meanwhile, Turner *et al.*[2] concluded that pre-conditioning with plyometric exercises improved acceleration in 20-m sprints. In the same way, Vanderka *et al.*[1] showed evidence that a pre-conditioning with half-squats produces PAP in athletes and soccer players.

In the description of the PAP phenomenon, it has been observed that subjects who have great power are more likely to potentiate[8,12]. More specifically, it has been shown that I-SVR load evidenced a positive acute effect over time in 30-m sprints in elite male military athletes[13]; furthermore, an increase in the performance of 10-yard distance was observed after applying a pre-conditioning with I-SVR through a back squats exercise at 85% 1RM + 30% of additional load with an elastic band in recreationally resistance-trained males[12]. Fukutani *et al.*[14] also showed a significant increase in CMJ post I-SVR pre-conditioning (heavy condition: 1 x 45 – 1 x 60 – 3 x 75 – 3 x 90% at 1RM in squats; moderate condition: 1 x 45 – 1 x 60 – 3 x 75% at 1RM in squats). However, despite the existing evidence, it is still uncertain whether these pre-conditioning loads can generate the same effect in other types of population, let alone in the female population. Specifically, evidence has shown that loads above 80% at 1RM in subjects with low strength level could be detrimental, generate fatigue, and decrease athletic performance[15,16].

Despite the fact that scientific evidence has shown that pre-conditioning stimuli can generate PAP[8,9], not all methods applied generate the same effect; specifically, if the strength levels, the rest interval time, and other variables such as training volume and intensity, are not sufficient to establish a dosage-response connection[17,18]. In a systemic review performed by Huerta *et al.*[11], the effects from using different methods of VR as pre-conditioning to generate PAP were analyzed. The researchers concluded that there was not enough evidence to truly know the real effect of VR over PAP. However, there are indications that I-SVR can generate acute changes in the explosive strength levels[11]. Unfortunately, evidence shows that subjects with low power levels have fewer chances to potentiate, in these population the fatigue induced can outweighs the possible benefit (PAP)[8,16]. In addition, the effect of sex (gender) over PAP is not completely described[9]. Therefore, a plausible line of research is to check whether pre-conditioning through I-SVR applied in elite male military athletes[13] can produce the same effect in sprinter women.

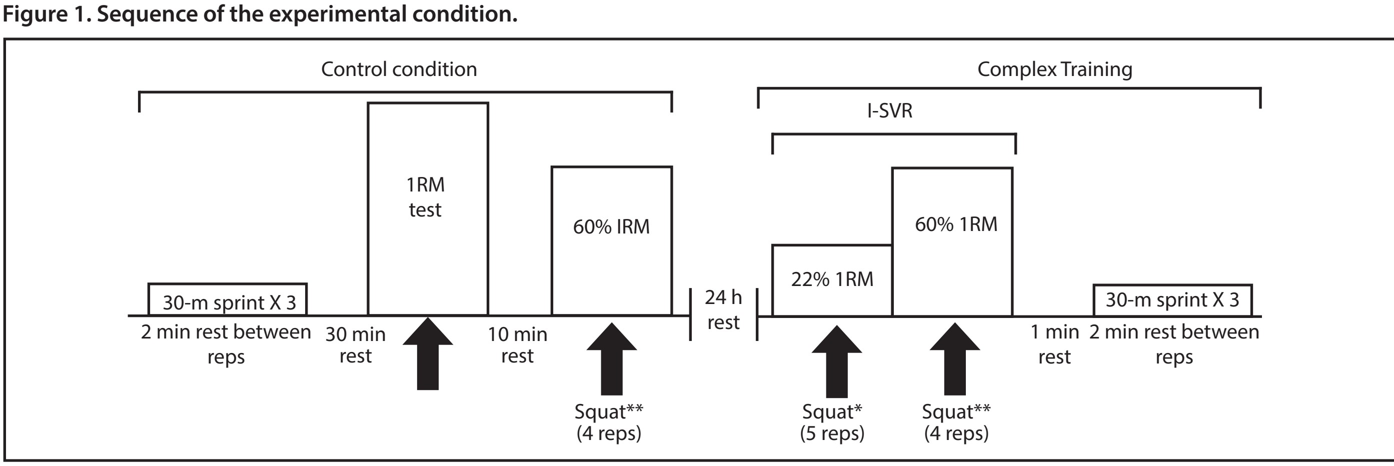
In connection to the above, it was the aim of this study to determine the acute effect of an I-SVR protocol in back squats over time in 30-m sprints in sprinter women.

Material and method

Experimental approach to the study

This study used a repeated measures design. All subjects were part of a control condition and an experimental condition (Figure 1); a 24-hour rest interval was set between both conditions. Each back squats set of pre-conditioning was performed with I-SVR. This variation of loads within the sets consisted of 4 sets of back squats exercises, with a load and repetition of each set being 1.0-1.1 m•s^{-1} X 5 repetitions (reps), 0.6-0.7 m•s^{-1} X 4 reps. The load was adjusted for each subject according to 1 repetition maximum (1RM), and the subjects were asked to perform back squats at the highest possible speed. Once the load was adjusted, all subjects performed the pre-conditioning at the required speed[19]. After performing pre-conditioning with back squats, 3 reps of 30-m sprints were performed with a 2-minute rest between each, the rest time between sets being 2 minutes. The dependent variables were: time in 30-m sprint and post-effort Lactate concentrations [La]. Some inves-

Figure 1. Sequence of the experimental condition.



*Load needed to move the squat bar between 1.0-1.1 m•s^{-1} (1.0-1.1 m•s^{-1} velocity in back squats).
**Load needed to move the squat bar between 0.6-0.7 m•s^{-1} (0.6-0.7 m•s^{-1}velocity in back squats).

Table 1. Characteristics of the subjects.

Subject	Age (y)	Body mass (kg)	Height (m)	% body fat*	Squat 1RM (kg)	Squat /body mass	30-m sprint (ms)
a	19.1	51.3	1.65	14.1	78.3	1.53	4826.0
b	22.5	43.0	1.52	14.1	79.6	1.85	4459.0
c	19.9	53.5	1.63	14.1	82.5	1.54	4386.7
d	17.7	60.0	1.70	18.8	92.7	1.55	4308.3
e	20.1	58.3	1.66	18.8	90.7	1.56	4633.3
f	21.3	56.9	1.64	14.1	93.0	1.63	4845.0
g	21.8	48.3	1.52	14.1	101.5	2.10	5009.3
h	23.1	63.8	1.63	18.8	112.0	1.76	4366.0
i	17.4	60.9	1.67	19.5	117.4	1.93	4721.7
j	20.3	63.7	1.60	19.5	115.9	1.82	4536.3
Mean	20.3	56.0	1.62	16.6	96.4	1.73	4609.2
SD	1.9	6.9	6.1	2.6	14.7	0.2	236.4

1RM: 1 repetition maximum.
*Sum of four skinfolds[4].

tigations have used 30-m sprints to observe changes in performance due to the PAP phenomenon[2,13], while [La] were used to observe the anaerobic metabolism[20]. Before starting the procedure, weight, height, and skinfolds were measured in all subjects. Fat percentage was obtained through the summation of all four skinfolds[21].

Subjects

10 sprinter women participated in this study (age = 20.3 ± 1.9 years [SD], body mass 56.0 ± 6.9 kg, height = 1.64 ± 6.1 m) (Table 1). All women and coaches were informed about the objective of the research and about the possible risks of the procedure. The subjects signed a written consent containing all the information of the study before proceeding with the protocol. The written consent and the study were approved by the Bioethics Committee of the Universidad de Playa Ancha, Chile (registry number 006/2017).

Procedures

All evaluated subjects had a 48-hour rest before the control condition intervention. The subjects were asked to refrain from caffeine ingestion or any substance that could increase their metabolism during the assessment. Both control condition and experimental condition took place between 9 am and 11 am. The procedure began with a warm-up consisting of 10 minutes of slow jogging, 5 minutes of dynamic stretching of the lower limbs, and then 3 X 80-m accelerations. Control condition included three evaluations: a) The mean times of 3 X 30-m sprint with a 2-minute rest. The times were measured at the starting point, 10 m, 20 m, and 30 m. The mean performance of all 30-m sprint reps was used for the statistical analysis and was named Control Sets (CS). 10-m and 20-m sprint times were also used for the statistical analysis (CS). 10-m, 20-m, y 30-m sprint were evaluated using a Chrono Jump® photocell and Chrono Jump software version 1.4.6.0®[13,20]. b) After a 30-minute rest, the indirect 1RM in back squats was measured using a lineal encoder Chrono Jump® and Chrono Jump software version 1.4.6.0®[22]. c) After a 10-minute rest, 4 reps of back squats between 0.6-07 $m•s^{-1}$ were evaluated. The load needed to move the bar in back squats between 0.6-07 $m•s^{-1}$ was equivalent to 60% 1RM[19]. The average performance in these four back squats reps was used for the statistical analysis.

The experimental condition consisted of 4 I-SVR sets. Each set included back squat pre-conditioning with I-SVR: 22% 1RM X 5 reps (equivalent to 1.0-1.1 $m•s^{-1}$), 60% 1RM X 4 reps (equivalent to 0.6-0.7 $m•s^{-1}$)[19], and the mean times of 30-m sprint X 3 with a 2-minute rest interval. At the end of each set, [La] post-effort was measured with an h/p/Cosmos Sirius®. Between each set there was a rest interval of 2 minutes. Mean times of three reps per sets in 10-m, 20-m, and 30-m sprints were the dependent variables. These time points were used in the statistical analysis in order to compare the postactivation performance to control condition.

Statistical procedures

All statistical analyses were performed using the *Entorno de Programación R* software[23]. The mean of 10-m, 20-m, 30 m, [La], and velocity in back squats were submitted to the Shapiro-Wilk test. An analysis of the variance of repeated measures (ANOVA) was used to examine the effect of pre-conditioning with I-SVR on the mean times of 10-m, 20-m, and 30-m sprint performance, [La], and velocity in back squats. The ANOVA was used with five time points: a) control session (control set [SC]) before pre-conditioning with I-SVR, b) experimental set 1 (S1), c) experimental set 2 (S2), d) experimental set 3 (S3), and e) experimental set 4 (S4).

Individual responses on the mean times of 30-m sprint performance were analyzed using means, DS, and delta between different conditions. The size of the effect (SE) for both cases was calculated using partial Eta-squared.

The Bonferroni correction was used as post hoc analysis when the level of significance showed important differences among the means ($p \leq 0.05$). The size of the effect for the pairwise comparison was calculated using Cohen's d-test with the following effect scale: insignificant ($d < 0.2$), small ($d = 0.2 - 0.6$), moderate ($d = 0. - 1.2$), large ($d = 1.2 - 2.0$), and very large ($d > 2.0$). The level of statistical significance for all analyses was set at $p \leq 0.05$.

Table 2. Variation of mean performance after the application of a pre-conditioning with I-SVR of back squats.

Variables	control set mean ± SD	set 1 mean ± SD	set 2 mean ± SD	set 3 mean ± SD	set 4 mean ± SD	ANOVA *p*	Square ETA Partial
10-m sprint (ms)	1880.7±68.2	1872.8±63.1	1864.6±64.9	1868.2±54.7	1860.3±50.9	ns	0.029
20-m sprint (ms)	3262.8±149.9	3247.6±145.3	3254.5±144.2	3262.3±141.9	3245.7±121.1	ns	0.005
30-m sprint (ms)	4609.2±236.4	4580.1±234.9	4615.8±224.9	4603.2±231.2	4592.4±194.6	ns	0.005
[La] (mmol/L)	1.52±0.2	5.79±1.5	8.14±1.9	9.38±2.3	8.41±2.1	*	0.878
Squat velocity ($m \cdot s^{-1}$)	0.689±0.03	0.692±0.07	0.675±0.06	0.678±0.04	0.692±0.09	ns	0.033

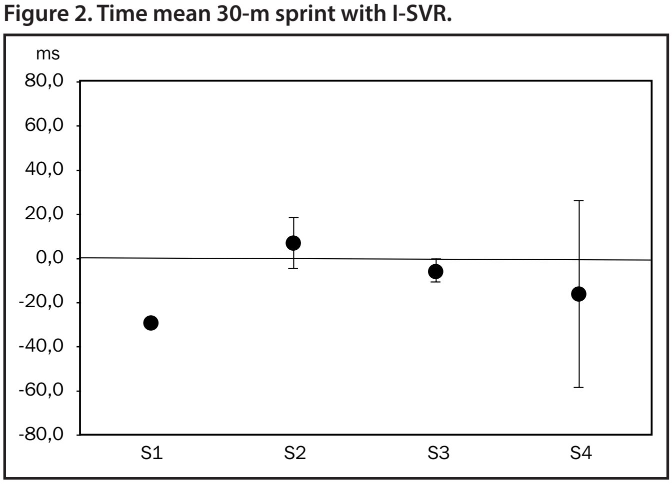
ms: (millisecond); SD: (standard deviation); * p<0.0001; ns (no significant).

Table 3. Individual performance mean variation post application of pre-conditioning with I-SVR of Back Squats.

Subjects	t-mean 30-m CS (ms)	t-mean t 30-m S1 (ms)	Δ S1-CS (ms)	% S1 vs CS	t-mean t 30-m S2 (ms)	Δ S2-CS (ms)	% S2 vs CS	t-mean t 30-m S3 (ms)	Δ S3-CS (ms)	% S3 vs CS	t-mean t 30-m S4 (ms)	Δ S4-CS (ms)	% S4 vs CS
a	4826.0	4549.3	-276.7	5.7	4543.3	-282.7	5.9	4569.3	-256.7	5.3	4726.7	-99.3	2.1
b	4459.0	4504.0	45.0	-1.0	4957.3	498.3	-11.2	4968.7	509.7	-11.4	4589.0	130.0	-2.9
c	4386.7	4790.7	404.0	-9.2	4639.7	253.0	-5.8	4619.7	233.0	-5.3	4749.3	362.7	-8.3
d	4308.3	4985.3	677.0	-15.7	4827.3	519.0	-12.0	4984.0	675.7	-15.7	4833.0	524.7	-12.2
e	4633.3	4493.3	-140.0	3.0	4594.3	-39.0	0.8	4562.0	-71.3	1.5	4751.3	118.0	-2.5
f	4845.0	4163.0	-682.0	14.1	4159.7	-685.3	14.1	4338.0	-507.0	10.5	4190.7	-654.3	13.5
g	5009.3	4534.3	-475.0	9.5	4647.7	-361.7	7.2	4430.7	-578.7	11.6	4408.7	-600.7	12.0
h	4366.0	4347.3	-18.7	0.4	4373.3	7.3	-0.2	4339.7	-26.3	0.6	4539.3	173.3	-4.0
i	4721.7	4661.3	-60.3	1.3	4671.0	-50.7	1.1	4487.7	-234.0	5.0	4657.0	-64.7	1.4
j	4536.3	4772.3	236.0	-5.2	4744.7	208.3	-4.6	4732.0	195.7	-4.3	4479.0	-57.3	1.3

I-SVR (intra-set variable resistance); t-mean 30-m (time mean in 30-m sprint); CS (control set); S1 (set 1); S2 (set 2); S3 (set 3); S4 (set 4); ms (milliseconds); Δ S_n-CS (delta time between experimental and control set); % S_n *vs* CS (percentage variation between experimental and control set).

Figure 2. Time mean 30-m sprint with I-SVR.



Results

Time in 10-m, 20-m, and 30-m sprint

Means and SD values are depicted in Table 2. ANOVA showed no significant differences for time in 10-m sprint (*F* = 0.26, *p* = 0.89, *ES* = 0.029), 20-m sprint (*F* = 0.04, *p* = 0.99, *ES* = 0.005), and 30-m sprint (F = 0.04, *p* = 0.99, *ES* = 0.005) (Figure 2).

Individual responses

The analysis showed that five out of 10 subjects (50%) increase in the mean performance of 30-m sprint throughout the experimental conditions, while seven out of 10 subjects (70%) showed an increase in their mean performance in one or more experimental sets in 30-m sprint time (Table 3).

Lactate

ANOVA showed significant differences in [La] post-effort (*F* = 64.49, *p* < 0.0001, *ES* = 0.878) (Table 2), while the post hoc analysis showed evidence of significant differences in all the pairs analyzed (Table 4).

Back squats speed

ANOVA did not provide significant differences for the time in back squats execution speed (*F* = 0.30, *p* = 0.87, *ES* = 0.033) (Table 2).

Discussion

Taking into consideration that the effects of sex (gender) and I-SVR over PAP were not completely outlined[9,24], the acute effect of a pre-conditioning protocol with I-SVR in back squats over time in 30-m sprints in high-level sprinter women had to be determined. The pre-conditioning

Table 4. Post hoc analysis for [La] among the control set and 4 experimental sets.

Contrast	mean ± SD	mean ± SD	Δ	Confidence Interval	Student's t-test	ES
Pair 1 [La] mmol/L^{-1}	Control Set 1.52±0.2	Set 1 5.79±1.5	4.27 mmol/L^{-1}	3.12 - 5.41 mmol/L^{-1}	*	4.89
Pair 2 [La] mmol/L^{-1}	Control Set 1.52±0.2	Set 2 8.14±1.9	6.62 mmol/L^{-1}	5.15 - 8.08 mmol/L^{-1}	*	6.07
Pair 3 [La] mmol/L^{-1}	Control Set 1.52±0.2	Set 3 9.38±2.3	7.96 mmol/L^{-1}	6.13 - 9.58 mmol/L^{-1}	*	6.21
Pair 4 [La] mmol/L^{-1}	Control Set 1.52±0.2	Set 4 8.41±2.1	6.89 mmol/L^{-1}	5.35 - 8.42 mmol/L^{-1}	*	5.87

[La] (Lactate concentrations); SD (standard deviation); ES (effect size); * $p<0.0001$.

with I-SVR of 4 back squats exercise sets (30% 1RM X 5 reps + 60% 1RM X 4 reps) showed a significant increase in 30-m sprints performed by elite male military athletes[13]. In connection with the main aim of this study, ANOVA results did not show a significant difference among the Control Set and the four Experimental Sets ($p > 0.05$). Unfortunately, the references found with I-SRV were scarce[3,11,13], even less in women. However, the main premise in which the research was based was that pre-conditioning with VR generated a significant increase in acute muscular strength levels[3], and that increment was evidenced in the research carried out by Wyland *et al*[12]. The researchers presented evidence of a significant decrease in 10-yard times after performing squats at 85% 1RM + 30% additional load with an elastic band ($p = 0.002$)[12]. Another relevant precedent for this study was that the strongest subjects can generate PAP[14,16]. A study performed by Fukutani *et al.*[14] also showed evidence of such a phenomenon. In the study by Fukutani *et al.*[14], the sample used included weightlifters who were capable of lifting 2.4 times their own body weight in squats. After the I-SVR conditioning (heavy condition: 1 x 45 – 1 x 60 – 3 x 75 – 3 x 90% 1RM in squat exercises; moderate condition: 1 x 45 – 1 x 60 – 3 x 75% 1RM in squat exercises), PAP was observed in both conditions ($p < 0.05$). Equally, Hirayama *et al.*[25] reported PAP in CMJ after the application of protocols with I-SVR ($p < 0.05$). Meanwhile, Seitz *et al.*[8] determined that the size of the effect (SE) in speed tests was moderate after a pre-conditioning of the lower limbs (SE = 0.51). In more detail, at the end of this last study the researchers observed: a) a greater PAP effect among stronger individuals, unfortunately, in this study there was no connection between PAP and strength levels in back squats performed by sprinter women; b) a greater PAP effect with polymeric loads (SE = 0.47) when compared to other pre-conditioning methods such as high-intensity loads (SE = 0.41), traditional moderate intensity (ES = 0.19), and maximum isometric (ES = -0.09); c) that weaker subjects respond better to longer rest intervals; and d) that both weaker and stronger subjects evidence a greater PAP after conditionings with shallower squats[8]. In this regard, after an conditioning with I-SVR in a power zone ranging from 0.6 and 0.9 m•s^{-1} of vertical bar speed[19], Huerta *et al.*[13] reported a significant enhancement in 30-m sprints among the CS and the four experimental sets ($p < 0.001$). However, Huerta *et al.*[13] found that elite male military athletes are more likely to generate PAP due to the level of potentiation is dependent on the individual's level of strength and resistance training experience[8].

Considering that 50% of the sample enhanced their performance in 30-m sprints and that 70% showed improvements in one of the experimental sets, the authors believe that the methodology used[13] is applicable to female sprinters. However, if I-SVR pre-conditioning has to be implemented, individual responses should be checked, and it is advisable to use a longer rest between pre-conditioning and the following exercise[8]. This is due to the fact that the enhancement scope of the sprint might be affected by the rest interval among each set[7]. Moreover, the volume, type, and intensity of the conditioning stimulus have an impact on the connection between PAP and fatigue[26]. In research developed by Boullosa *et al.*[27] a CMJ in PAP was observed after a 9-minute rest. Unfortunately, the authors used a sample comprised of resistance-trained men (squat/body mass = 2.4), and that same research also concluded that the best method to induce PAP is independent from the rest between pre-conditioning and the following exercise[27]. Similarly Lim *et al.*[28] concluded that the pre-conditioning with single-joint isometric, multi-joint isometric, and multi-joint dynamic generates large individual variations; more specifically, when applying similar loads some athletes potentiate and others do not. Lim *et al.*[28] suggest that coaches should explore the effectiveness of different PAP protocols individually.

In connection to the secondary aim of this study – to determine the variations in general and local fatigue indicators during the application of an acute I-SVR protocol in back squats in female sprinters[20] – the results of ANOVA showed a significant difference among the CS and the four experimental sets in which [La] ($p < 0.0001$) but no significant difference in the execution of back squat exercises ($p > 0.05$). Similar to this research, a study performed by Huerta *et al.*[13] reported no significant changes in the maximum and average power in back squat exercises. The foregoing is understood as a non-existing occurrence of local fatigue in both sprinter groups after applying I-SVR pre-conditioning protocols. However, when comparing both results of the researches, there is a noticeable difference in [La] post-effort. While the men athlete group showed no significant changes in [La] post-effort after the application of a I-SVR protocol[20], women athletes showed a significant increase in [La] using the same I-SVR pre-conditioning loads as the men and 30-m sprint repetitions from the first to the fourth experimental sets. This allowed the authors to infer that these pre-conditioning loads with I-SVR generate different effects in groups with different training level[16]. While there was an increase in the performance of 30-m sprint in men[13], the average in women did not generate PAP. Perhaps, an increment in the rest period between each 30-m sprint repetition and among the experimental sets might trigger a PAP response in this group[8,16]. In a research carried out by West *et al.*[29], where performance was evaluated through CMJ, significant decreases were reported after the application of a backward sled dog protocol of 5 sets of 2 X 20-m loaded with 75% body mass ($p < 0.001$). An important precedent present in that research is that [La] increased significantly the moment the protocol application ended

($p < 0.001$). Also, it is important to notice that the load applied by West *et al*.[29] was heavier than the one applied in this research. However, the pattern of [La] is seen as a fatigue indicator in all the studies mentioned here, and for that matter it is also a parameter that must be considered in all protocols to generate PAP.

Conclusions

This study showed no evidence of enhancement in the time of the test performance (10-m, 20-m, and 30-m sprints) after the application of pre-conditioning protocols with PAP I-SVR. However, large individual variations were observed post I-SVR pre-conditioning. Therefore, a pre-conditioning with I-SVR in back squats exercise: 22% 1RM X 5 reps (equivalent to 1.0-1.1 $m{\cdot}s^{-1}$), 60% 1RM X 4 reps (equivalent to 0.6-0.7 $m{\cdot}s^{-1}$)[18], 30-m sprint X 3 with a 2-minute rest, does not generate PAP in all female sprinters. Considering that the pre-conditioning with I-SVR did not increase the performance in women sprinters, which may be due to insufficient load to elicit a PAP response or that the fatigue induced outweighs the benefit, the coaches considering the use of this pre-conditioning protocol in order to generate PAP must explore its effectiveness individually. Factors such as strength levels, protocol resistance used to generate PAP, and, above all, the recovery interval between pre-conditioning and the following sprint need further research.

Conflict of interest

The authors do not declare a conflict of interest.

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Heart rate and the distance performed by the soccer referees during matches: a systematic review

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Resumen

Introducción: El árbitro de fútbol tiene un relevante papel en la práctica de la modalidad y necesita de excelente condición física. El objetivo del presente estudio fue analizar la relación entre la frecuencia cardíaca y la distancia recorrida por los árbitros de fútbol de campo durante sus actuaciones en los juegos.
Material y método: Se realizó una amplia búsqueda de artículos, sin restricción de fechas, en las siguientes bases de datos electrónicas: Pubmed, Scielo y Google académico, siendo la última búsqueda efectuada el día 10/09/2017. Se utilizaron los siguientes términos de búsqueda: ("frecuencia cardíaca" o "heartrate" o "heart rate determination") AND ("distancia" o "distance" o "distance perception" o "vertical dimension") AND (árbitro de fútbol o "soccer referee" or "football referee").
Resultados: Se encontraron 78 artículos con potencial relevancia, 27 artículos contemplaron todos los criterios inclusión, sumando 428 árbitros de fútbol, analizados en 2.936 partidos de la modalidad.
Conclusión: Los árbitros necesitan una preparación muy específica. Recorren grandes distancias en los partidos, 10,36 ± 1,11 km por juego, pero de forma muy específica. Cambian mucho de dirección, de intensidad, de velocidad y rango de frecuencia cardíaca, esto sucede varias veces de forma no progresiva. En la mayoría de los juegos, se desplazan en baja intensidad, pero los estímulos de alta intensidad son muy intensos y duran muy poco de 2 a 4 segundos en su mayoría, estando directamente en los que en esas ocasiones llegan a alcanzar el 97% de su $FC_{máx}$. Se sugiere como una aplicación práctica una atención especial en la preparación y el análisis de los procesos decisivos. Los árbitros deben ser entrenados, evaluados y cuantificados en circunstancias que se asemejen a las condiciones de juego, tanto física, como psicológicamente. Es necesario enlazar las demandas físicas con las cognitivas en los entrenamientos y pruebas que asemejen a los ambientes de los partidos.

Palabras clave:
Fútbol. Frecuencia cardíaca. Desplazamiento. Revisión. Fisiología. Deporte. Movimiento. Carrera. Trabajo. Educación física.

Frecuencia cardíaca y la distancia recorrida por los árbitros de fútbol durante los partidos: una revisión sistemática

Summary

Introduction: The football referee has an important role in the practice of the sport, requiring excellent physical conditioning. The objective of the present study was to analyze the relationship between heart rate and distance covered by field soccer referees during their performances in games.
Material and method: A broad search of articles was carried out, without restriction of dates, in the following electronic databases: Pubmed, Scielo and Google academic, being the last search carried out on 10/09/2017. The following search terms were used: ("heart rate" or "heart rate determination") AND ("distance" or "distance perception" or "vertical dimension") AND
Results: There were 78 articles with potential relevance, 27 articles included all the inclusion and exclusion criteria, totaling 428 soccer referees, analyzed in 2,936 games of the modality.
Conclusion: The referees need a very specific preparation. They travel long distances in games, 10.36 ± 1.11 km per game, but in a very specific way. They vary greatly in direction, intensity, speed and range of heart rate, this happens several times in a non-progressive way. They work in matches with a FC_{med} ranging around 158,88 ± 3,99 bpm and, in most games, they move in low intensity, but high intensity stimuli are very intense and last very little from 2 to 4 seconds, being directly connected to the crucial bids, on these occasions they reach 97%of their $FC_{máx}$. Finally, it is suggested as a practical application a special attention is needed in the preparation and analysis of decision-making processes. Referees need to be trained, evaluated and quantified in circumstances that resemble game conditions, both physically and psychologically. It is necessary to ally physical demands with cognitive, that resemble the environments of the matches, in the trainings and tests.

Key words:
Soccer. Heart rate. Displacement. Review. Physiology. Sport. Movement. Running. Work. Physical education.

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Introduction

Soccer referees play an important role in the game as they are responsible for applying the match rules, making it possible to take fair and comfortable decisions that are definitive and that validate the outcome of the dispute[1].

The referee must be able to follow movements as closely as possible by finding a well-angled view. This enables referees to be impartial and fair, disconnected from any psychological or physical presssure[2-3], a practice that requires good resistance to carry out intermittent and prolonged exercises[4].

Scientific interest for soccer has increased considerably, as the sport is more dynamic. From the 1990s, research – which until that point had been too contingent – became more systematic, yet the change to the game pattern introduced by the W0rld Championship Team in 1994 appears to have been a milestone for both soccer and the academic community dedicated to studying this sport. Numerous relevant studies intensified after that event[4].

Yet the majority of studies focus on the player. Few studies address the physical needs of the football referee, as this person plays a role in the game and reaches very high heart rates. Catteral *et al.*[6] carried out research verifying that during matches, football referees reach average heart rate values (HR) of 165 beats/min^{-1}. Other studies[7-9] discovered equivalent values and in some cases even higher HR values during matches. These values correspond to approximately 85-90% of the maximum heart rate (HRmax)[7,9,10]. It would be reasonable to affirm that a suitable level of physical aptitude is required, principally of the cardio-respiratory system. Blood lactate increased substantially when comparing the pre-game assessment of the referee to the post-game assessment in the study by Castillo *et al.*[11]. Supporting the aforementioned, it is suggested that the anaerobic system is stimulated during matches.

The highest rate of injuries obtained by these professionals occurs during strenuous preparation[12]. The International Federation of Associated Football (FIFA) created a periodical test inspired on the movements carried out by referees during matches[13], which are strenuous in nature, setting another obstacle to attain so that football referees can be considered fit to participate in matches. To do this it is necessary to plan and carry out effective and specific training sessions.

However, until now there have been no systematic reviews analysing the effect of the heart rate of soccer referees, or about the distance covered during matches. In this regard, the aim of this study was to analyse the relationship between heart rate and the distance covered by soccer referees on the pitch during their participation in matches.

Material and method

The literary review was performed in accordance with the PRISMA[14] guidelines for systematic reviews and meta-analyses. A broad search was carried out, with no date restrictions, of the following electronic databases: Pubmed, Scielo and Google Academic, with the latter search carried out on 10/09/2017.

The following descriptions were entered in accordance with DeCS and MASH, highlighting that descriptions with no link or affinity to the focus and objective of the research were excluded: ("heart rate" or "heart rate determination") AND ("distance" or "distance perception" or "vertical dimension") AND ("*arbitro de fútbol*", "soccer referee" or "football referee"). It is worth noting that the last three terms were used to provide a direct connection to the study objective and because they are terms used in the articles available in the databases used in this review in which the focus is the soccer referee, as neither the DeCS or MESH presented descriptions related to these terms nor their possible synonyms. Furthermore, three descriptions were used at the same time, always combining a description of each study variable (HR_{av} and distance covered) with a description related to the target demographic (soccer referees) until all possible combinations had been used.

The inclusion criteria used for the studies were: a) studies performed with central referees on soccer fields; b) studies that analysed and/or quantified the heart rate and distance covered during matches; c) articles in English and Portuguese. The exclusion criteria used were: a) studies that only addressed heart rate and/or distance covered by referees in other activities or settings, that were not carrying out their activities during soccer matches on pitches; b) studies that did not aim to analyse matches in sub 20 and professional categories, as it is a reality within this sport that the athletes in the sub 20 category are frequently bound to the athletes in the category above, and they also compete in matches in the professional category; c) studies published before 1994. After inclusion, the studies were quantified related to the risk of bias according to the Loney scale[15], suitable for crosscutting studies, whose maximum score to be reached in a study is 8 points. As a result, regarding the criteria used, the search was given pursuant to the following flowchart.

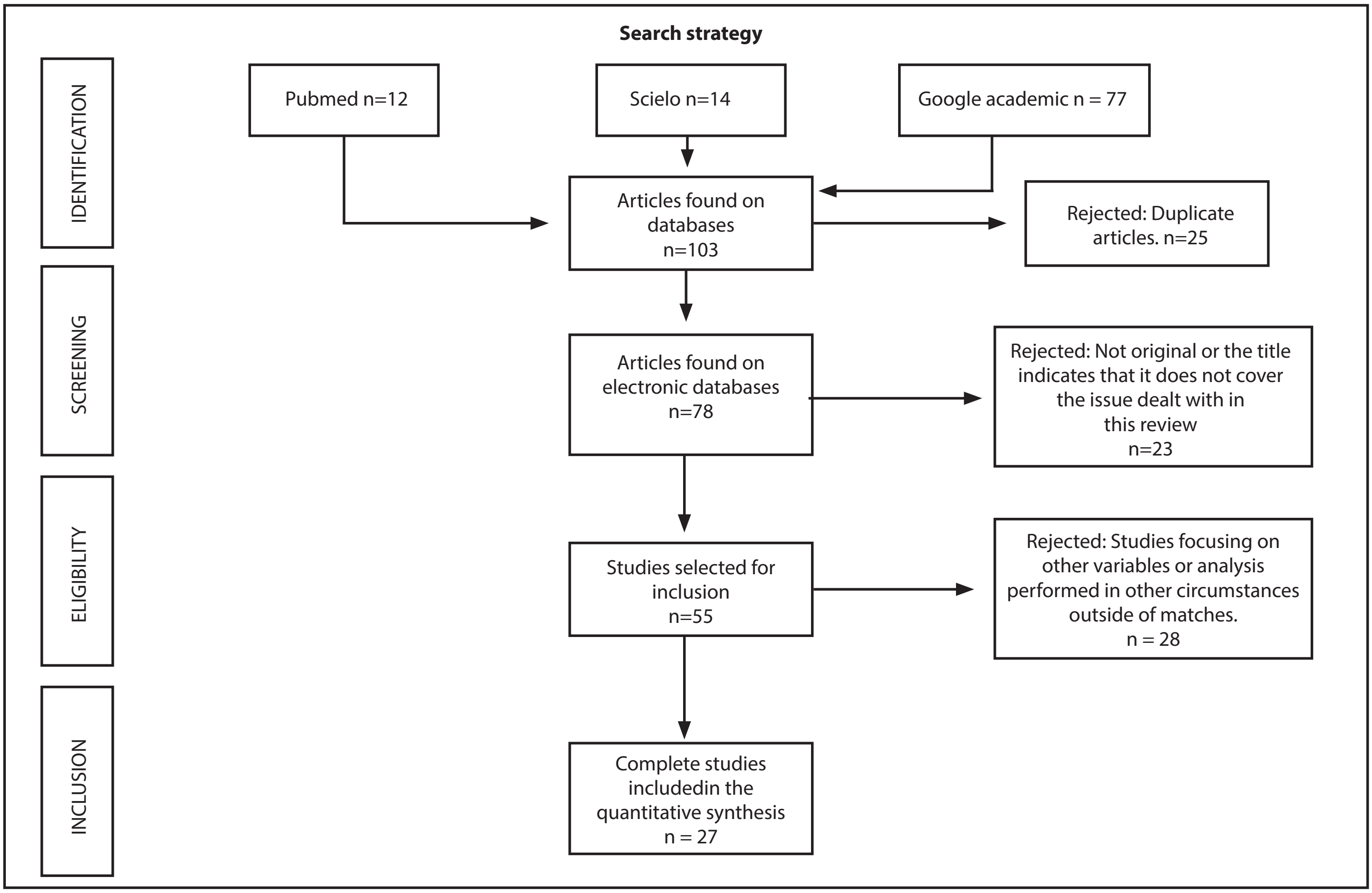
Results

The search of the electronic databases produced 78 potentially relevant articles, 27 articles that met all the inclusion and exclusion criteria, totalling 428 participants, all of which were professional-level central soccer field referees. The studies analysed the referees during their performances in soccer matches, which overall, including the studies found, revealed an analysis of these referees in 2,936 soccer matches. In all the studies, where necessary, a level of significance of $p<0.05$ was employed. The analysed articles were displayed to address the variables of interest in this systematic review. To do this, the studies were separated into two tables: the first with the aim of presenting the articles included in the research, and the second focusing on the variables of interest for this study (Figure 1).

Table 1 displays the descriptive characteristics of the 27 articles included in the review.

Table 2 displays the descriptive characteristics of the 27 articles included in the review. The first two columns identify the study, the first column indicates the bibliographic reference, and the second describes the study authors and year. The others present the average age of the

Figure 1. Flow chart displaying the search criteria, selection of studies included and reasons for excluding studies from the review.



study sample, the distance covered by the referees in the matches, and the HR_{av} and HR_{max}.

In terms of distance covered in the studied matches, the average was 10.36 ± 1.11 km, with 2,917 matches analysed. Only one article mentioned the length of refereeing experience[37], which separated its demographic into two groups: experienced and inexperienced referees.

With regards to the movement pattern during the distance covered in the match, various articles performed analyses whilst considering the type of movement pattern[6,7,9,16-19,26,27,29,33,40,41], where the types of movements described did not vary in terms of naming. In general, the patterns were described as: stopped, walking, jogging, running, running fast, sprinting and moving backwards. In all of these articles, the cut-off speed for the "running fast" mode was >18 km/hr or 5 m/sec.

An interesting fact was revealed in the studies mentioned, which was not thoroughly discussed by any of them: the time and distance covered in the backwards movements were much greater than in "sprint". Silva[40] verified in his results that the "sprints" represented less than 1% of the total playing time.

The other articles[6,7,9,17-19,23-25,29-31,34,35,37-40] performed their analyses based on the intensity of the movement, and, in all of them, the related cut-off point to define high intensity was >18 km/or or >5 m/sec. The results from these studies were very coherent in affirming that the referee, for the most part of the game, moves at low speed, but very intermittently, where the average speed – taken as the base for all the studies – was 5.9 ± 0.26 km/hr, but with short, high-intensity peak lasting an average of 3 ± 1.41 seconds. In these short peaks, the average maximum speed in the studies found was 19.84 ± 1.56 km/h. The highest value of maximum speed of a referee in the studies included in this systematic review was 25.96 km/hr, discussed in the study by Silva[39].

The HR_{av} of the articles found was 158.88 ± 3.99 bpm and the average HR_{av} was 185.02 ± 6.99 bpm. When relating the percentage of HR_{av} and HR_{max}, the HR_{av} of the studies displayed in Table 2 was 85.64 ± 1.94% of the HR_{max}.

Some studies[21,22,37,38] - for analytical purposes - divided the HR_{av} into bands based on the percentage in relation to HR_{max}, and sought to measure the time spent in each band during the game. Roman *et al.*[21] define these phases as follows: phase 1 (<35%), phase 2 (35-59%), phase 3 (60-79%), phase 4 (80-89%) and phase 5 (>90%) of the HR_{max} estimated using the Karvonen formula. Cipriano *et al.*[38] established these phases via absolute intervals of the HR as follows: phase 1 (75-104 bpm), phase 2 (105-125 bpm), phase 3 (126-146 bpm), phase 4 (147-167 bpm) and phase 5 (168-188 bpm), based on a maximum stress test in a laboratory; these authors separated phases 4 and 5 as performance

Table 1. Studies included in the systematic review.

Ref.	Author/Year	Competition	Sample (n) (Referees / No. of Matches)	Score on the Loney Scale
(8)	Johnston, McNaughton (1994)	Tasmania State League	10/10	5
(16)	Da Silva, Rodriguez-Añez (1999)	Paranaense Championship series A	9/9	4
(17)	D'ottavio, Castagna (2001)	Italian Championship series A	33/96	7
(7)	D'ottavio, Castagna (2001)	Italian Championship series A	18/18	6
(9)	Krustrup, Bangsbo (2001)	Denmark League 1st and 2nd Div.	27/43	8
(18)	Castagna (2002)	Italian Championship A and B	22/22	7
(19)	Rebelo *et al.* (2002)	Portuguese Championship	8/8	4
(20)	Roman *et al.* (2004)	Paranaense Championship 1998	12/15	4
(21)	Roman *et al.* (2004)	Paranaense Championship 1st Div.	12/12	4
(22)	Helsen, Bultynck (2004)	Euro Cup 2000	17/31	6
(23)	Castagna C *et al.* (2004)	Italian Championship Series A and European Cup	13/13	6
(24)	Mallo *et al.* (2007)	World Cup sub-17	12/12	5
(25)	Weston *et al.* (2007)	English Premier League 1st Div.	19/254	7
(26)	Oliveira *et al.* (2008)	Paulista Championship Sub 20	8/8	5
(27)	Da Silva *et al.* (2008)	Paranaense Championship series A and B	29/29	5
(28)	Silva (2008)	Paranaense Championship A and B 2005 and 2006	10/30	7
(29)	Da Silva *et al.* (2010)	Paranaense and Paulista Championships	16 (PN=9+SP=7)/16	6
(30)	Vieira *et al.* (2010)	Potiguar Championship 2009	11/21	4
(31)	Weston *et al.* (2010)	English Premier League 1st Div	22/778	7
(32)	Ardigò (2010)	Italian Championship 6th and 7th Divisions	6/20	5
(33)	Da Silva *et al.* (2011)	Paranaense Championship Series A	10/30	6
(34)	Weston *et al.* (2011)	English Premier League	59/1269	7
(35)	Dos Santos V *et al*. (2012)	Bahiano Championship 2012	30/138	6
(36)	Roman *et al.* (2012)	Paranaense Championship	12/12	4
(37)	Silva (2014)	Cearense Championship 3rd Division, Sub 20 and UNIMED Cup	28/28	6
(38)	Cipriani (2015)	Portuguese League 2013 and 2014	1/11	5
(39)	Silva (2016)	Goiano Championship 2016	2/3	5

Ref.: bibliographic reference; Author/Year: author and year the study was created; Competition: competition used to gather data; PN: referee from the state of Paraná in Brazil; SP: referee from the state of Sao Paulo in Brazil.

categories, but these bands are those in which the intensities are above the anaerobic threshold and below the VO_2max value, and it is expected that only trained individuals display this kind of performance. Furthermore, if efforts are made to study their results, it should be affirmed that the referees spent 50-69% of the match time in phase 4, above the anaerobic threshold.

Discussion

The aim of this systematic review was to identify studies in literature that address the physical demands of central soccer referees during matches. The studies analysed in this systematic review support Reilly and Gregson[42], who affirm that the distance covered by referees during soccer matches varies from 9 to 13 km. Despite the major advances made in soccer in terms of physical foundations, already in 1988 the work by Asami *et al.* - pioneering in their description of the motor actions performed by soccer referees and considered a classic in this field[41] – related their results that back up this distance. In this study the authors analysed the distance covered in a match by two classes of referees: one with those from the Japanese league, i.e. national referees, and the other international referees. The average movement of the national referees was 10.168 ± 756 metres, whilst international referees revealed an average movement of 9.736 ± 1.077 metres.

A large part of the studies found mention the distance covered, measuring this distance in each motor action carried out by these professionals during games. The referee spends a large amount of time performing low-intensity activities: walking or jogging. Some studies affirm that they walk more, whilst others claim that referees jog more during the game. This will depend in great measure on the intensity of the game. The percentage related to walking in the articles was between 30 and 60% during the match. This large variation in the walking percentage in matches seems to be influenced on the region where the match takes place. In the case of Brazilian referees, they walked 58% of the total time of the match, whilst another study of Danish referees[9], revealed a game time of 40% walking, and Japanese and Portuguese referees walked for 33% of the match[19,41]. The difference in game style

Table 2. Distance covered, HR_{av} and HR_{max} of the soccer referees during the matches.

Ref.	Author/Year	Average age of the sample	Distance covered	HR_{av}	HR_{max}
(8)	Johnston, McNaughton (1994)	---	9.40±0.83	1st half: 163 2nd half: 162	191.76
(16)	Da Silva, Rodriguez-Añez (1999)	---	9.29±0.62	---	---
(17)	D'ottavio, Castagna (2001)	37.8±2.1	11.49±0.98	---	---
(7)	D'ottavio, Castagna (2001)	37.5±2.14	11.17±1.69	163±5	183.5
(9)	Krustrup, Bangsbo (2001)	38 (from 29 to 47)	10.07±0.13	162±2	190.5
(18)	Castagna (2002)	37.0±2.4	11.63±0.9	---	---
(19)	Rebelo *et al.* (2002)	37±6.6	----	150±21,9	176±17
(20)	Roman *et al.* (2004)	37.1±6.8	10.71±0.89	---	---
(21)	Roman *et al.* (2004)	35.5±6.7	10.71±0.89	156.5±13.2	179.5±12.1
(22)	Helsen, Bultynck (2004)	40.2±3.9	---	155±16	182.35
(23)	Castagna *et al.* (2004)	37±3	12.95±0.54	---	---
(24)	Mallo *et al.* (2007)	33.4±3.8	11.05±0.93	161±8	187
(25)	Weston *et al.* (2007)	40.1± 4.9	11.62±0.73	---	---
(26)	Oliveira *et al.* (2008)	26.79.73±4.13	9.35±1.02	160.51±2	---
(27)	Da Silva *et al.* (2008)	38.9±3.8	9.15±0.07	---	---
(40)	Silva (2008)	38.89±3.79	9.18±0.39	---	---
(29)	Da Silva *et al.* (2010)	PN=38.44±4.0 SP=27.29±4.7	9.13±0.25 10.03±0.84	---	---
(30)	Vieira *et al.* (2010)	36.36 ± 6.34	10.50 ± 0.35	162.77 ± 7.44	182.22 ± 7.72
(31)	Weston *et al.* (2010)	(31-48)	11.53±0.74	---	---
(32)	Ardigò (2010)	22.6±2.4	11.39±0.69	163±8	201
(33)	Da Silva *et al.* (2011)	38±1.1	9.18±0.12	---	---
(34)	Weston *et al.* (2011)	(22-49)	11.77±0.80	---	---
(35)	Dos Santos *et al*. (2012)	---	10.05	---	---
(36)	Roman *et al*. (2012)	35.5±6.7	10.71±0.89	156.5±13.2	179.5±12.1
(37)	Silva (2014)	Ref. Exp. 31.17±5.18 No Exp. 28.60±5.06	Ref. Exp. 9.3±0.7 No Exp. 8.8±0.9	1st half: 157.23 ±12.92 2nd half: 155.31 ±12.43	1st half: 180.46±9.31 2nd half: 181.62 ±15.84
(38)	Cipriani (2015)	(one referee) 39	---	159	191
(39)	Silva (2016)	37.6±4.39	9.2±0.65	---	---

Ref. Exp.: referee with experience; No Exp.: inexperienced referee; PN: Paraná; SP: São Paulo; 1st half: first part of 45 minutes of play; 2nd half: second part of 45 minutes of play; PN: referee from the state of Paraná in Brazil; SP: referee from the state of Sao Paulo in Brazil.

(between countries) should also be taken into account when the results found are compared.

It is agreed that the most used motor actions by referees are jogging and walking[6-9,16-19,24,26,29,34,40,41], but it is also unanimous that the intensity of the game has a major influence on this aspect. The distance covered by the ball in the game directly influences the profile of referee behaviour[24]. The study by Weston *et al.*[25] performed with 19 referees, analysed 254 games in England during the Premier League. They studied a positive correlation of the physical performance of the referees with that of the players, and they also observed that the physical performance of the referees revealed a negative correlation between the first and second half of the matches; whereas the first half is very intense, this intensity tends to lessen in the second half, implying that referees may adopt more energy-saving behaviour. The study by Costa *et al.*[43], despite not being included in the articles of this systematic review, did not find any significant differences in the distance covered, nor in the maximum speed between the first and second halves of the match. Despite this, the average speed and the time that was spent at between 90-100% of the HR_{max} were greater in the first half of the matches. This alternation of intensity between the match halves was also verified in other studies[8,9,17,20,26,27].

Heart rate is another relevant factor. The HR_{max} during play represents on average 70 to 85% of the estimated HR_{max}. The study by Krustrup and Bangsbo[9] observed that the highest heart rate value reached by a referee in a match corresponded to almost 97% of his HR_{max}. This information could be linked to the literary data for soccer players. In this respect, it has been observed that the heart rate of a player during a match varies between 80 and 90% of the HR_{max}[44-46]; values similar to those displayed by football referees.

The match requires referees to perform very unusual movements, of an excessively intermittent nature, with many very quick and unexpected pace changes. The most demanded energy-producing system is aerobic, but anaerobic interventions seem to be the most important for soccer referee performance. Despite this, these interventions occur less throughout a match. The studies in this systematic review support this lesser amount of high-intensity actions (sprints) and even relate that they are less used than backward movements of referees in matches[6,8,9,17-19,24,25,29,40, 41].

On the other hand, despite physical condition being important, decision-making power is the crucial key to the game[29]. In this respect, some studies indicate that the most experienced referees tend to make more correct decisions[22,25,30,31,34,36,37]. Silva[37] concludes in his study that as well as tending to make more correct decisions, more experienced referees performed better in HC checks, even keeping up the pace between match halves. The study by Aoba *et al.*[47] revealed a significant difference between international and national level referees from the Japanese Football Association (JFA) in relation to the distance of the points in which fouls occurred to the place where the referees were positioned. In this study, the referees were assessed for distance of movement, distance from the points where fouls occurred to the place where the referees were positioned and heart rate. For all of these indicators, it seems that experience benefits referees in decision-making and in administrating physical effort during the game, a fact that requires further study, as it is necessary to analyse the distance at which the game actions occurred to where the referees were positioned at the decision-making instant. This can vary considerably and not alter the distance covered by the referee, and it is agreed that increased distance with relation to a game action makes it more difficult to evaluate. Perhaps this has occurred because more experienced referees tend to have better spatial evaluation of the field of play, and are able to alter their movement during the match, using less energy and reaching a comfortable distance at which to make assessments of the game.

In the case of referees from the Paranaense Soccer Federation[36], this line of reasoning is backed up; the study performed with soccer referees relates that those with more years of experience are more secure and do not need to be so close to analyse the game actions, and that the younger referees run more during matches. Although there is a protocol that orientates this game movement suggested by FIFA and its affiliated entities[1,48,49], it appears that refereeing experience can improve this movement, reaching correct decisions with less effort. The most important aspect for a successful soccer referee is clearly the power to make decisions, taken quickly and in a good metabolic state, modified depending on the instant of the game[31].

Cognitive issues are essential for this sporting modality. Some of these issues, such as self-esteem and anxiety for example, are associated to the risk of the players injuring themselves during disputes[50]. For soccer referees, cognitive factors are also important, and these can be influenced by aspects related to the game atmosphere, as well as by physiological factors. The study by Gomez-Carmona *et al.* [51] verifies that the aspects that influenced referees' decisions and that caused errors were: the part of the pitch, the period of the game, and the referee's HR_{max} percentage.

Helsen and Bultynck[22], performed a study about referees' decisions during matches. In this study, they indicate that these professionals make an average of 137 observable decisions in a match. This was measured through the body language of referees in video replays of matches, and the number varied from 104 to 162. The authors related that 64% of these decisions were taken in communication with assistant referees and with the fourth referee. They also affirm that it is important for referees to train on video, watching game actions, but it is not possible to take a referee to a specialist level simply using visual imitation. The training sessions and visual assessments are still very limited because they are generally carried out in static settings, which is understandable due to the complexity of simulating a decisive setting such as football referees in controlled game settings.

Conclusion

The results indicate that soccer referees cover large distances during games (10.36 ± 1.11 km), but they do so very specifically and there are a considerable number of direction, intensity, speed and heart rate changes. This occurs various times in a non-progressive way. The HR_{av} is de 158.88 ± 3.99 bpm during matches, and in the majority of matches the referees move at low intensity. However, the high-intensity stimuli are both very intense and very brief – around 2 to 4 seconds, linked directly to crucial moves within the game. On these occasions they reach 97% of their HR_{max}.

For practical advice, particular attention should be paid to preparation, as well as to analysing decisive processes performed by these professionals. Studies indicate that there is still considerable progress to be made in the cognitive aspect. Referees should be trained, assessed and classified in circumstances that are similar to match conditions. A better understanding of the conditions at these critical decision-making instants is necessary, both physically and psychologically, so that training sessions can be developed and fine-tuned more effectively.

Studies that research the connections between the physical and cognitive demands of this position and that compare the atmospheres of matches during training and official matches are recommended. This could help advance the practice of refereeing, and promote the success of soccer.

Conflict of interest

There is no conflict of interest in this study.

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The role of aerobic exercise in the prevention and management of atrial fibrillation. Friend or foe?

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Summary

Atrial fibrillation is the arrhythmia with the highest prevalence world-wide. In fact, scientific literature seems to show a high prevalence of atrial fibrillation in endurance athletes too. However, currently the relationship between atrial fibrillation and aerobic exercise is controversial. On the one hand, aerobic exercise could be defined as a useful tool to be used as primary prevention strategy for the development of cardiovascular diseases, including arrhythmias. On the other hand, some authors identify it as a risk factor, specifically if it is performed at high intensity with large regular volumes. But the exact mechanism by which aerobic exercise might increase the risk of atrial fibrillation is unknown, although it could be related to anatomical and functional changes at the cardiac level. This review aims to update the knowledge about the effect of aerobic exercise on atrial fibrillation to establish a prescription pattern. The results of the present work, according to the current evidence, show the aerobic exercise as a non-pharmacological strategy, both for the primary and secondary prevention of atrial fibrillation. The preventive effect of aerobic exercise on atrial fibrillation seems to be related to the reduction of associated risks. Although there is no consensus on the exercise load, it is considered that aerobic exercise should be practiced often and at a moderate-vigorous intensity to get the greatest benefits. More research is required to determine the best parameters of aerobic exercise in atrial fibrillation.

Key words:
Cardiac arrhythmia.
Primary prevention.
Secondary prevention.
Risk factor.

El papel del ejercicio aeróbico en la prevención y manejo de la fibrilación auricular. ¿Amigo o enemigo?

Resumen

La fibrilación auricular es la arritmia que presenta mayor prevalencia en la población a nivel mundial. De hecho, la bibliografía científica existente parece mostrar también una elevada prevalencia en deportistas de resistencia. Sin embargo, actualmente la relación entre la fibrilación auricular y el ejercicio aeróbico resulta controvertida. Por un lado, el ejercicio aeróbico puede considerarse una herramienta de prevención primaria para el desarrollo de enfermedades cardiovasculares, incluidas las arritmias. Por otro, realizar actividades de alta intensidad de manera regular con grandes volúmenes, ha sido identificada por algunos autores como un factor de riesgo. Actualmente, se desconoce el mecanismo exacto por el cual el ejercicio aeróbico podría incrementar el riesgo de fibrilación auricular, pero podría estar relacionado con cambios anatómicos y funcionales a nivel cardíaco. Esta revisión pretende realizar una actualización del efecto que presenta el ejercicio aeróbico sobre la fibrilación auricular para establecer una pauta de prescripción. Los resultados del presente trabajo, según la evidencia actual, parecen mostrar al ejercicio aeróbico como una estrategia no farmacológica útil tanto para la prevención, como para el tratamiento de la fibrilación auricular. El efecto preventivo del ejercicio aeróbico en la fibrilación auricular parece estar relacionado con la disminución de factores de riesgo asociados. Aunque no existe consenso sobre la carga de ejercicio, se considera que el ejercicio aeróbico debería practicarse regularmente y a una intensidad moderada-vigorosa para alcanzar los mayores beneficios. Se requieren más investigaciones para determinar los mejores parámetros de ejercicio aeróbico en la fibrilación auricular.

Palabras clave:
Arritmia cardíaca.
Prevención primaria.
Prevención secundaria.
Factor de riesgo.

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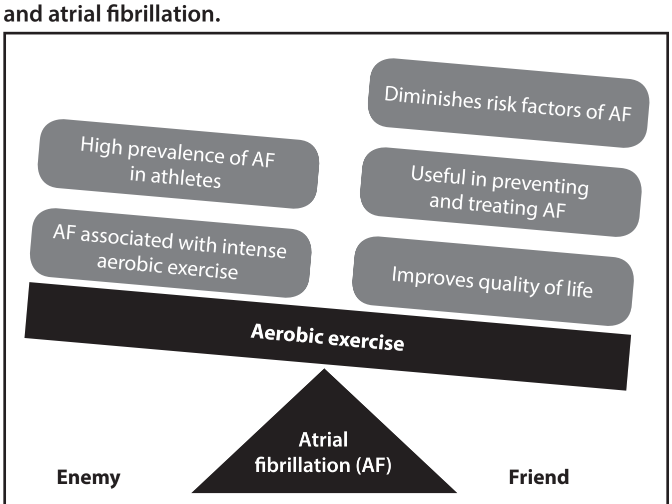
Introduction

A series of complications exist that can alter a normal heart rate, making it quicker, slower or more irregular[1]. Atrial flutter, ventricular tachycardia, supraventricular tachycardia, ventricular fibrillation and atrial fibrillation (AF) are the most common arrhythmias. Among them, AF is most prevalent – 1-2% of the general population[2,3] – and is associated with a high mortality rate and associated cardiovascular mortality[1,4].

Age has been determined as the main risk factor for developing AF[5,6]. However, other conditions such as hypertension, obesity, chronic kidney disease or diabetes mellitus are also considered to be predisposing factors[7,8]. It has been demonstrated that regular aerobic exercise (AE) has positive effects on controlling blood pressure[9], body weight index[10], kidney function[11] and insulin sensitivity[12]. Therefore, AE can positively influence a number of predisposing factors and should be considered as a possible prophylactic to AF[13]. Maximum AE has also been successfully applied as a non-pharmacological treatment in AF patients, showing reversion rates of up to 27% in patients with scheduled electrical cardioversion[14]. Furthermore, AE positively affects well-being and quality of life of such patients independently of its efficacy on AF's symptomatology[15]. However, there is a certain controversy regarding the relationship between AE and AF (Figure 1). While moderate AE appears to be an adequate tool for FA prophylaxis and treatment, some research demonstrates that high doses of AE increase the probabilities of developing lone AF; in other words, without other associated heart diseases[16]. For example, the prevalence of AF in cross-country skiers has been registered at 12.8% compared to 1-2% within the general population[17]. An association, marked by the characteristics of the AE training load, appears to exist in the apparently paradoxical relationship between AE and AF. The volume, frequency and intensity of AE can determine its positive or negative influence, although the exact limits of this relationship are still unknown. Performing exercise of moderate intensity, volume and frequency appear to have a preventive effect, while vigorous exercise practised over a long time increases the risk of developing AF[14].

This paradox beckons a two-directional consideration regarding physical exercise. On the one hand, it concerns the perspective of training professionals and, on the other, that of clinicians. This work aims to review of the state of the art on AF – including its links to AE – and to establish a prescription framework for AE based on scientific evidence for the prevention and treatment of AF.

Figure 1. Controversy in the relationship between aerobic exercise and atrial fibrillation.



Atrial fibrillation

Heart contractions are produced through electrical signals that originate in the right atrium, concretely in the sinoatrial node (SA node). These signals make the atria contract and pump blood to the ventricles. Blood flows from the SA node through the muscular fibres to the atrioventricular node (AV node), which gives the signal to the ventricles to contract and pump blood to the lungs and the rest of the body[18]. In AF, electrical signals do not begin in the SA node but instead come from several different locations. Consequently, the heart's contractions are not synchronized and the atria and ventricles contract independently of one another[18]. This misalignment entails a loss of function in the atrium which, in turn, leads to blood stasis predisposing to blood clot formation[19].

Such an alteration in the heart's electrical system makes it beat quickly and irregularly[19]. In normal conditions, the heart beats regularly at a rate of between 60-100 beats per minute (bpm). In AF, this rate is higher—ventricular frequency between 90-170 bpm—and is accompanied by a high rate of atrial contraction (>300 bpm)[18,20]. An analysis of the heart rate via electrocardiogram (ECG) can allow an irregular heart rate that is characteristic of AF to be observed. Other defining aspects can also be observed, such as the absence of P waves, which sometimes appear as visible electrical activity in V1 derivations and irregular RR intervals[19,20].

Types of atrial fibrillation

Symptoms of AF include palpitations, angina pectoris, fainting—including syncope—, dyspnea, chronic fatigue and limited exercise tolerance; patients with AF can also, in some cases, be asymptomatic[1,21]. But regardless of its clinical pattern, AF negatively affects patients' quality of life[22]. *The European Heart Rhythm Association*[19-21] proposes a classification of AF based on its clinical presentation and its impact on patient quality of life (Table 1). Other possible references to classify AF are based on its form of presentation (i.e. acute or chronic) and duration of the arrhythmia (i.e. more or less than 48 hours). According to this classification, three types of AF are defined (Table 2): paroxysmal, persistent and permanent or chronic[20,23].

It is common for AF to co-exist with other cardiovascular diseases[24,25]. However, the type of AF most frequently associated with the

Table 1. Classification of atrial fibrillation types of the European Hearth Rhythm Association (EHRA).

Score	Characteristics
EHRA I	No symptoms.
EHRA II	Light symptoms that do not impede normal daily activity.
EHRAIII	Strong symptoms that affect normal daily activity.
EHRA IV	Incapacitating symptoms that impede normal daily activity.

Table 2. Classification of atrial fibrillation types based on their presentation and duration.

Type	Characteristics
Paroxysmal	Characterized by short-lasting episodes recurring within 48h, capable of evolving up to 7 days. This type of AF is spontaneously interrupted.
Persistent	Lasts 7 days or more Interruption of the arrhythmia is not spontaneous and must be induced by medication or electrical cardioversion.
Chronic	AF is classified as chronic when it is impossible to re-establish the heart's rhythm after one year of treatment or several recurrences. In this case, treatment must be interrupted and the arrhythmia should be accepted by the doctor and patient as chronic.

intense practice of AE is diagnosed with an absence of other symptoms after a physical examination, a thyroid function test, an electrocardiogram test and a stress test. This lone AF is usually diagnosed in young adult males (i.e. <60 years) with a prevalence oscillating between 2 and 50%, depending on the population of the study[16].

AF epidemiology

AF affects between 1-2% of the general population[26], with increases in those rates affecting as much as 0.5% more youths and adults younger than 40[13] and up to 8% in adults older than 80[27]. Regardless of age, the incidence of AF is 1.5 times greater in men than in women[23]. Despite a clearly established difference regarding the sexes and AF, the exact mechanisms of those differences are unknown; the influence of hormonal, structural and electro-physiological factors have been suggested in this respect[28]. In Spain, the total prevalence of AF is 4.4%[4] while in the USA it affects between 2.7-6.1 million people, with an estimated increase of 15.9 million people expected in 2050[7].

In contrast to what is observed in other cardiovascular diseases, AF has a higher prevalence among the physically active and athletic population, with a prevalence between 0.2% and 60%[3]. AF has been particularly linked to endurance sports and has proven to depend not only on the intensity of the activity but also the accumulated number of hours that the patient has practised the activity throughout his/her life[19]. It is remarkable that an inverse association has also been observed. Mont *et al.* (2002) recorded a greater rate of sports practise (62.7%) among lone AF patients in comparison with the general population (15.4%)[29]. The type of sport practised also appears to influence the probability of developing AF as it is more common in marathon runners, cyclists and cross-country skiers than those who practise other types of sports[7].

Participation in long-duration endurance sports has increased in recent years, which entails an increased incidence risk of AF associated with exercise in the forthcoming decades[30].

Risk factors

Based on the data related to prevalence, age appears to be the main risk factor in developing AF. Indeed, 70% of AF patients are within an age range between 65 and 85 years. AF is also commonly associated with other cardiovascular diseases. Hypertension is experienced by 70-80% of patients diagnosed with AF in the sedentary population[31]. Variations in blood pressure observed during episodes of hypoxemia and hypercapnia[5,8] in patients with sleep apnoea also appear to be responsible for predisposition in developing AF in this population (i.e. 4 times more probable)[5]. Finally, patients with cardiac insufficiency (CI) are 5 times more at risk of developing AF[5]. It is a two-way relationship between CI and AF inasmuch as patients with AF are also 2 to 3 times more at risk of developing CI[7]. The development of AF in CI patients can also predispose to an increased risk of thromboembolism and a symptomatic deterioration of CI[20].

Obesity is also considered a predisposing factor to developing AF. Concretely, it has been determined that there is a 49% probability of developing AF in obese patients in comparison with patients of normal weight[32]. This is likely due to alterations in the cardiac structure that can lead to increased intra-atrial pressure. Moreover, obese patients can be resistant to treatment with antiarrhythmics and radiofrequency ablation[7,8]. Other factors such as cigarette smoking, chronic kidney disease, diabetes mellitus, excessive alcohol consumption, thyroid disorders and family history are accepted as risk factors[5,6].

The high prevalence of AF among those who practise endurance sports indicates that AE could be a significant predisposing factor to developing AF[2]. Such an association with endurance sports suggests that AF could be more linked to the duration and frequency of the exercise performed than with its intensity. In this spirit, accumulated years of practising endurance activities has been associated with a gradually increased risk of AF (i.e. 1.16 OR for every 10 years practised)[13]. The same conclusion has been reached in other research. For example, Molina *et al.* (2008) reported an annual incidence rate of lone AF in marathon runners of 0.43/100 while the rate for sedentary men was 0.11/100[33]. Similarly, very frequent exercise (i.e. 5-7 sessions per week) increases the risk of developing AF in comparison with the sedentary population[34]. The same findings have been replicated upon comparing the incidence of AF in individuals that practise more than 5 hours of exercise per week with that of individuals who practise less than 1 hour per week[35]. Furthermore, recent meta-analyses have observed a significant association between age and the practise of sport. The risk of suffering from AF in adults aged under 54 years is almost twice as great as the general population; this association has not been observed in regards to older athletes. However, publication bias cannot be ruled out[36].

The mechanism behind high frequency, long-duration AE-induced AF could be related to the heart's ability to adapt to this type of stimulus, which induces a remodelling of the general cardiac structure[37] and, in particular, of the atria[2,38]. Recent research carried out with rodent models demonstrated how frequent AE (i.e. 1 hour per day for 8 to 16 weeks) increased susceptibility to develop AF. Subsequent analysis of heart structure and functioning pointed to atrial enlargement, fibrosis and changes in autonomous regulation as potential factors responsible for the development of AF[39]. In line with these findings, it has been shown that approximately 20 % of competitive athletes have a left atrial (LA) diameter of more than 40 mm^2.

Such findings are opposed to those published by Brugger *et al.* (2014). In this retrospective study, the structure and function of the heart were analysed in three groups of amateur runners with different accumulated doses of exercise throughout their lives: less than 1,500 hours, between 1,500-4,500 hours and more than 4,500 hours. The findings indicate that the structural and electrical remodelling of the heart does not influence mechanical atrial function and, thus, could not be considered responsible for the possible development of AF[40]. The incidence of AF in the runners that participated in this study was 6.6%, which is less than the average given their condition. Nevertheless, these findings provide an opportunity for future studies to clarify the physiological mechanisms behind exercise-induced AF.

Furthermore, the literature indicates that the relationship between physical exercise and AF is dependent upon the patient's sex. Intense physical exercise has been associated with lesser risk of AF among women and higher risk among men[41,42]. Mohanty *et al.* (2016) hypothesize that a "threshold effect" must exist in physical exercise which, once passed, makes risk of AF greater; this threshold would seemingly be different between men and women[41]. Despite that, the physiopathological mechanisms of the sexual differences regarding AF are still hypothetical[43].

Many studies on physical exercise and AF only include male athletes despite women undertaking a considerable proportion of athletic activities[36,42]. Recent research describes specific remodeling associated with the gender of endurance athletes. Apparently, men have a higher risk of AF associated with an enlarged right atrium and of greater remodeling in comparison with women[44].

In addition to the previously discussed aspects, genetic factors must also be considered given their relevance in recent publications[45,46]. Fatkin *et al*. (2018) offer three hypotheses to describe the relationship between genetic variations and AF in athletes caused by physical exercise. Firstly, genetic variations exist that can trigger AF in isolation from physical exercise. Secondly, genetic variations associated with AF could have an additive effect that is independent of physical exercise. Finally, complex synergistic interactions could exist between genetic factors and physical exercise. Moreover, mecanosensitive ion channels are proposed as a nexus between genetics and alterations in the heart's remodeling[45].

Atrial fibrillation treatment

Treatment of AF can be divided into two types of therapy: pharmacological and non-pharmacological. Pharmacological therapy attempts to restore sinus rhythm and to avoid thromboembolic complications[47,48], while non-pharmacological therapy is used when success is not reached through the former approach or as another option to improve the patient's symptoms and quality of life[49]. Antiarrhythmics and anticoagulants are two types of drugs prescribed in pharmacological therapy. Antiarrhythmic drugs can be used with the aim of controlling the heart rate or heart rhythm. This type of drug is used not only to improve the symptomatology of AF and reduce the possibility of a cardiovascular event from occurring, it is also used as secondary treatment to improve tolerance to AE[47]. On the other hand, anticoagulant drugs aim to reduce the probability of clot formation and emboligenic events, which is especially high for patients with AF[49].

Pharmacological therapy

Some of the drugs used to control the heart rate include digoxin, calcium channel blockers (CCB) – such as Verapamil or Diltiazem – and β-blockers. These drugs stall blood flow through the AV node, making ventricular contractions slower[47]. Each patient's characteristics should be taken into consideration when choosing the proper drug. For example, since β-blockers and CCBs reduce blood pressure this should be particularly taken into consideration if prescribed to patients with hypotension. Digoxin is recommended for patients with arterial hypotension or sedentary lifestyles. It is used as a complement to other drugs when ineffective alone[48,49]. According to a study by AFFIRM[47] on the efficacy of such drugs, when used as a first line of treatment they attained success rates of 70% for patients treated with β-blockers, 54% for CCB treatment–with or without digoxin–and 58% for digoxin treatment[47].

When patients did not apply pharmacological treatment to control their heart rhythm, the recurrence rate of AF was 71-84% in the first year. This rate can be reduced to 44-67% by applying pharmacological therapy[47]. Amiodarona is one of the drugs used to control the heart rhythm. Alternative drugs include Droneradona, Sotalol and Dofetidila[48]. Electrical cardioversion can also be used to control the heart rhythm. This method has 90% efficacy compared to pharmacological cardioversion (40% success rate), but it cannot be carried out on patients that are ineligible for sedation[47,48]. The risks associated with electrical cardioversion are thromboembolic processes, which entail a risk of 1-2% and can lead to a cerebrovascular accident (CVA). This risk can be mitigated with anticoagulants[20,47]. In any case, the use of antiarrhythmics after electrical cardioversion is necessary as the probability of recurrence remains high otherwise[48].

It has been demonstrated that drugs aimed at controlling heart rate and heart rhythm improve tolerance to exercise in patients with AF[50]. However, there are not enough studies to determine which strategy could be considered best to achieve improvements regarding risk of CVA or death[50]. Thus, choosing any of these strategies depends on each patient's circumstances[49].

One of the complications associated with AF is blood clot formation. This risk increases with age, from 1.5% in patients younger than 60 to 24% in patients older than 80, independently of the type of AF[49].

The European Society of Cardiology indicates that the $CHA_2DS_2\text{-}VAS_c$ scale be used to determine the risk of CVA in patients with AF. In patients with CVA risk factors ($CHA_2DS_2\text{-}VAS_c$ score of 1 or more in men and 2 or more in women) oral anticoagulants are recommended. Warfarin and other vitamin K antagonists were the first anticoagulants used with AF patients. However, the use of direct thrombin inhibitors (dabigatran) and activated factor X inhibitors (apixaban, edoxaban and rivaroxaban) has increased rapidly as they can be administered in fixed doses and do not require regular monitoring[51,52].

Non-pharmacological therapy

Non-pharmacological therapy for treatment of AF includes an invasive procedure, catheter ablation, and AE. Catheter ablation is an invasive procedure used when patients with resistance or intolerance to antiarrhythmic drugs in order to re-establish and maintain the sinus rhythm[52,53]. This procedure consists in placing catheters in the pulmonary veins to isolate electrical signals, making circular lesions that remodel the electrical system. The success rate of catheter ablation does not appear to depend on the patient as much as it does the type of AF[54]. In this regard, efficacy of the procedure for paroxysmal AF is >70% in a single attempt and can reach up to 80-90% recovery[49]. Conversely, several attempts are required to obtain reasonable results for persistent AF[53]. Moreover, a "hybrid" treatment is currently being proposed to patients that incorporates antiarrhythmic drugs after catheter ablation, but solid evidence does not exist supporting this procedure[52].

Similarly to the case of pharmacological therapy, the effects of therapy via AE depends on the dose administered. AE prevents the development of AF, most likely due to its beneficial effect on associated risk factors, such as heart disease, diabetes mellitus or obesity[13].

In a study performed by LEGACY, it was observed that weight loss in obese individuals with AF was responsible for reducing AF symptomatology, as per assessments via an AF Severity Scale and Holter monitor. This study included a total 355 individuals that were monitored over a period of 5 years. The group of participants who lost most weight (≥10%) presented better results in comparison with those who lost less weight. It, thus, appears possible that several mechanisms exist connecting weight loss with the reduction of AF, since being overweight is associated with several cardiovascular risk factors that are, in turn, associated with increased risk of AF. For this group of participants, in addition to following certain dietary recommendations, low-intensity physical exercise was practised initially three times a week, reaching up to 200 minutes of moderate-intensity physical activity per week[55].

But AE can also prove to be efficient as a treatment for patients with AF. Hegbom *et al.* (2007) administered a program consisting in 24 AE sessions over 8 weeks with a group of patients under 70 years of age with permanent AF. The sessions included exercises to strengthen the core interspersed with moderate-vigorous periods of AE (i.e. 70-90% maximum heart rate). The exercise regiment significantly improved the patients' quality of life, their tolerance to AE and their ability to perform basic everyday activities[56]. Moderate aerobic exercise (i.e. up to 70% maximum heart rate) also appears to be sufficient to generate improvements in patients' quality of life as well as their resting heart rate. Patients' high acceptance of this treatment is notable; adherence to the treatment was registered at 96%. It should be highlighted that the aforementioned AE interventions were brief in duration (i.e. 8 and 12 weeks, respectively), although quite frequent (i.e. 3 sessions per week) and ranging from moderate to vigorous intensity. The findings of this work should be interpreted with caution, as each patient's participation was subject to eligibility criteria and not all patients with AF would be capable of performing exercise programs of this sort. Finally, it is worth highlighting that AE at maximum intensity can be used as shock treatment for AF reversion. Gates *et al*. (2010) applied an incremental maximal exercise treadmill test (i.e. Bruce protocol) with a group of 18 patients aged 36 to 74 on scheduled electrical cardioversion. In five of the participants (i.e. 27%), their AF was reverted after 5.5-18.2 minutes of exercise in heart rate ranges of 164-203 bpm, probably owing to the abrupt change followed by a readjustment of the sympathetic/parasympathetic balance[14].

Conclusion

Scientific evidence demonstrates the efficacy of numerous options to treat AF. Among them, AE appears to be an adequate strategy not only for treatment but also to prevent AF. The findings indicate that performing moderate AE reduces the risk of developing AF and in some cases is efficient to improve the symptomatology of existing AF. It is still unknown how the intensity, volume and frequency of such activity influence efficiency in this regard. In fact, the long-term practise of intense AE is associated with a higher probability of developing AF. Considered as a whole, these findings suggest that AE can be a contrastive prevention strategy and potentially an alternative form of treatment in lieu of other therapies. While the recommended intensity of such exercise must depend on the patient's characteristics, the exercise should be performed frequently. However, there is a lack of scientific evidence establishing the combination of the safest and most efficient AE training load parameters and the possible interactions between AE and other treatments or associated diseases.

Conflicts of interest

The authors do not declare a conflict of interest.

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Sociedad Española de Medicina del Deporte

AJUNTAMENT DE REUS

VIII JORNADAS NACIONALES DE MEDICINA DEL DEPORTE

MEDICINA DEL BALONCESTO

22-23 DE NOVIEMBRE DE 2019

SOCIEDAD ESPAÑOLA DE MEDICINA DEL DEPORTE (SEMED)
REGIDORÍA D'ESPORTS / AJUNTAMENT DE REUS

rell Reus Esport i Lleure

AJUNTAMENT DE REUS Esports

REUS és ESPORT

CIUTAT DEL BÀSQUET CATALÀ REUS 2019

PROGRAMA CIENTÍFICO (PRELIMINAR)

DÍA 22 DE NOVIEMBRE, VIERNES

09.00-10.30 **PONENCIA: La Medicina del Deporte en el Baloncesto.**

Baloncesto femenino.

Organización y control médico en Selecciones Españolas.

Baloncesto en la discapacidad – baloncesto en silla de ruedas.

11.00 -12.30 **PONENCIA: Lesiones y Baloncesto**

La rodilla.

El tobillo.

Músculo y tendón.

12.30 -13.30 **CONFERENCIA INAUGURAL**

El médico de equipo.

15.30 -17.00 **PONENCIA: Muerte Súbita y Deporte**

Recomendaciones sobre participación deportiva en la cardiopatía isquémica.

El electrocardiograma en la prevención de la muerte súbita del deportista.

Arritmias y muerte súbita del deportista.

17.30 -19.00 **TALLER**

Electrocardiograma en deportistas.

DÍA 23 DE NOVIEMBRE, SÁBADO

10.00 -11.30 **PONENCIA: Controversias: Nutrición - Ayudas Ergogénicas. Los mitos de la alimentación en el deporte.**

12.00 – 13.00 **PONENCIA: Manejo del dolor en Medicina del Deporte.**

Bloqueos nerviosos en lesiones del aparato locomotor en Medicina del Deporte.

Distrofia Simpático Refleja y Lumbalgia – Síndrome facetario en deportistas.
¿Qué ofrece la Unidad de Dolor?

13.00 -13.45 **CONFERENCIA DE CLAUSURA**
Actualización en dopaje.

COMUNICACIONES CIENTIFICAS

El Comité Científico invita a todos los participantes a remitir comunicaciones científicas (comunicaciones orales y póster-presentación interactiva) a las VIII Jornadas Nacionales de la Sociedad Española de Medicina del Deporte.

Temas para presentación de Comunicaciones Científicas:

- Medicina del deporte.
- Entrenamiento y mejora del rendimiento.
- Biomecánica.
- Cardiología del deporte.
- Fisiología del esfuerzo.
- Nutrición y ayudas ergogénicas.
- Cineantropometría.
- Lesiones deportivas: diagnóstico, prevención y tratamiento.
- Actividad física y salud.

Derechos de inscripción	Antes del 18-7-2019	Del 18-7-2019 al 19-9-2019	Desde 27-9-19 y en sede Jornadas
Cuota general	125 euros	150 euros	200 euros
Miembros ARAMEDE/ FEMEDE	100 euros	125 euros	175 euros
Médicos MIR*	60 euros	75 euros	125 euros
Estudiantes**	30 euros	30 euros	30 euros

*Es necesaria acreditación.
**Grados, Licenciaturas y Diplomaturas: Medicina, CC Actividad Física y Deporte, CC de la Salud...). Es necesaria acreditación. No se considera estudiantes los profesionales que cursen estudios, ni a graduados, licenciados y/o diplomados.

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CONCLUSIONES DEL GRUPO AVILÉS

12 y 13 de noviembre de 2018

- **El Grupo Avilés manifiesta la necesidad de mantener la celebración de estas jornadas con periodicidad anual.**
  Parece imprescindible que, en el modelo administrativo y deportivo español, los responsables de la medicina del deporte de ámbito estatal, de las Comunidades Autónomas (CCAA), locales y de los Centros de Alto Rendimiento y Tecnificación, mantengan su colaboración y que el Grupo Avilés se constituya como Red de Centros capaz de canalizar las informaciones y propuestas entre los profesionales responsables de la Medicina del Deporte en las administraciones.
  La colaboración debe mantenerse a pesar de las dificultades, y las administraciones nacionales y autonómicas deben responsabilizarse de ello.

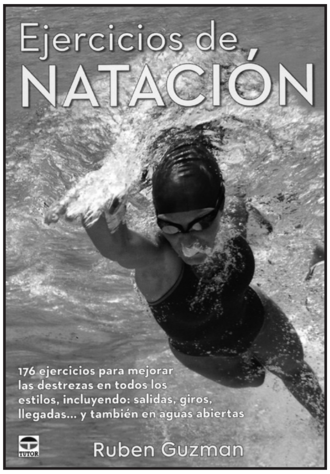
- **El Grupo Avilés conoce y está de acuerdo en la necesidad de redactar e implantar el Plan de Apoyo a la Salud en el Deporte por parte de la Agencia Española de Protección de la Salud en el Deporte (AEPSAD) y el Consejo Superior de Deportes (CSD).**
  Este Plan debe desarrollar los artículos 41 a 50 del Cap. III de la Ley Orgánica 3/2013 de Protección de la Salud del deportista y lucha contra el Dopaje en la actividad deportiva (LOPSD).
  El Grupo acepta la propuesta por parte de la AEPSAD, en constituirse como grupo de expertos para el desarrollo de dicho Plan.

- **El Grupo Avilés insta a la AEPSAD y al CSD a que desarrolle el artículo 46 de la LOPSD de 2013, sobre Reconocimientos Médicos para la práctica del Deporte.**
  Para ello propone la revisión del Documento SISTEMA DE RECONOCIMIENTOS MÉDICOS PARA LA PRÁCTICA DEL DEPORTE elaborado por la Subcomisión de Protección de la Salud de la Comisión de Control y Seguimiento de la Salud y el Dopaje, actualizado por la Sociedad Española de Medicina del Deporte.
  Una vez revisado este documento por el Grupo Avilés, la Sociedad Española de Medicina del Deporte y otros expertos, insta a la Administración a que aborde la regulación de Reconocimientos Medico-deportivos obligatorios dentro de su ámbito de competencias (expedición de licencias deportivas nacionales o autonómicas homologadas para las CCAA).
  Todo este proceso se ha de poner en marcha de un modo progresivo y con un estudio de impacto económico y administrativo. Se deben contemplar los diferentes niveles deportivos, los tipos de actividad y las especialidades deportivas.
  El Grupo Avilés se pone a disposición de la Administración como grupo de expertos en Medicina del Deporte.

- **El Grupo Avilés recuerda el impacto positivo de planes y estrategias de promoción de la ACTIVIDAD FÍSICA BENEFICIOSA PARA LA SALUD (AFBS), como el Plan A+D del CSD, por ello pide al CSD y a la AEPSAD que vuelva a diseñar, desarrollar e implementar acciones en este sentido, además haciéndolo en una aproximación colaborativa, tal y como recomienda la Organización Mundial de la Salud.**
  El Grupo Avilés pone a disposición de la Administración los ejemplos de buenas prácticas en Prescripción de Actividad Física a través de la Medicina del Deporte, con evidencias de mejora significativas de la salud y de muy importante ahorro económico, como un elemento muy importante en esta estrategia.

- **El Grupo Avilés manifiesta el interés y la necesidad de fomentar la Investigación en materia de Medicina del Deporte.**
  Necesidad de reimplantar y mantener convocatorias específicas de investigación en materia de deporte y medicina del deporte, bien en los Planes Nacionales I+D o bien propias y específicas de la AEPSAD-CSD, dado el impacto positivo que tienen para el deporte.

- **El Grupo Avilés manifiesta su preocupación por las dificultades que viene experimentando la formación especializada en Medicina del Deporte desde hace ya muchos años.**
  Entiende que el mantenimiento de la especialidad es imprescindible para que el Deporte Español cumpla sus objetivos como actividad saludable y para obtener el rendimiento del ámbito deportivo que hasta ahora ha tenido.



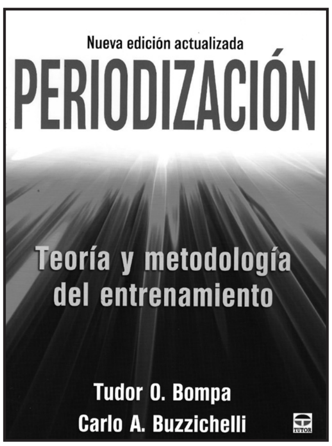
EJERCICIOS DE NATACIÓN

Por: Rubén Guzmán
Edita: Ediciones Tutor. Editorial El Drac.
Impresores 20. P.E. Prado del Espino. 28660 Boadilla del Monte. Madrid.
Telf. 915 599 832 – Fax: 915 410 235
E-mail: info@edicionestutor.com Web: www.edicionestutor.com
Madrid 2018. 368 páginas. P.V.P: 21 euros

La técnica es fundamental para el rendimiento en natación. Ya sea en la piscina o en aguas abiertas, tanto los entrenadores como los nadadores saben que la eficiencia a la hora de entrar en el agua y moverse equivale a milisegundos de mejora; milisegundos que marcan la diferencia en una competición. Ahí es donde este libro ofrece ayuda. Incluye 176 ejercicios para perfeccionar las brazadas, corregir defectos y mejorar las sensaciones en el agua.

Además de dominar los cuatro estilos de competición, se aprenderá los fundamentos de la posición del cuerpo, las remadas, las salidas, los giros y las llegadas. Encontrará, el lector, incluso una sección de ejercicios en aguas abiertas y sesiones de ejercicios con bandas de resistencia para realizar en seco.

Describe esta obra con gran precisión todos los estilos, todas las destrezas y todo lo que se necesita para ser un nadador de éxito.



PERIDIOZACIÓN. TEORÍA Y METODOLOGÍA DEL ENTRENAMIENTO (nueva edición actualizada)

Por: Tudor O. Bompa y Carlo A. Buzzichelli
Edita: Ediciones Tutor. Editorial El Drac.
Impresores 20. P.E. Prado del Espino. 28660 Boadilla del Monte. Madrid.
Telf. 915 599 832 – Fax: 915 410 235
E-mail: info@edicionestutor.com Web: www.edicionestutor.com
Madrid 2019. 416 páginas. P.V.P: 49,95 euros

Con este libro se puede aprender cómo maximizar las ganancias del entrenamiento. Guiado por la experiencia de sus autores, este texto aporta la información básica para comprender las últimas investigaciones y procedimientos relacionados con la teoría del entrenamiento, a la vez que proporciona al lector los soportes científicos de los principios fundamentales de la periodización. Esta edición actualizada presenta una exhaustiva exposición de la periodización basada en la teoría y metodología de Tudor Bompa.

Incluye: una revisión de la historia, los términos y las teorías relacionados con la periodización; la discusión de la importancia del diseño de un plan anual a nivel competitivo y específico del deporte, descartando cualquier aproximación válida-para-todos; un amplio capítulo sobre la integración de las habilidades biomotoras dentro del proceso de entrenamiento; actualización completa de la información sobre las sesiones de entrenamiento, los microciclos y los macrociclos; un extenso capítulo sobre los métodos para desarrollar la fuerza muscular, incluyendo la manipulación de las variables de carga y la conversión en fuerza específica; y una detallada explicación del entrenamiento de la velocidad y la agilidad, diferenciándolo entre los deportes individuales y los de equipo.

ESTUDIO LONGITUDINAL DE SOBREPESO Y OBESIDAD EN ESCOLARES DE EDUCACIÓN PRIMARIA (Memoria final)

Por: José Naranjo Orellana, Fco. Javier Alonso Alfonseca, Mª Dolores Carranza Márquez, Julio David Ruda Puente
Edita: Consejería de Turismo y Deporte. Junta de Andalucía.
C/Juan Antonio de Vizarrón s/nº. 41092 Sevilla.
E-mail: publicaciones.ctd@juntadeandalucia.es
Sevilla 2018. 111 páginas

Este es el primer estudio longitudinal de obesidad infantil realizado en España. Se comparan datos longitudinales de composición corporal por Cineantropometría y por bio-impedancia en niños y niñas y se analizan longitudinalmente diferentes criterios diagnósticos de sobrepeso y obesidad.

Han sido estudiados alumnos de tres colegios públicos a lo largo de seis cursos de Educación Primaria, entre 2011 y 2017.

De los resultados obtenidos se deduce que hay un claro conflicto con los criterios utilizados para definir los límites con los que diagnosticar sobrepeso y obesidad, por lo que es de gran importancia que al facilitar datos de prevalencia (fijos o comparados) se informe de qué criterios se están utilizando y no comparar nunca datos obtenidos con diferentes criterios de diagnóstico o comparando periodos de tiempo donde estos criterios hayan variado.

2019		
9th Annual Sports Medicine Winter Summit	6-10 Marzo Park City, Utah (EEUU)	web: https://www.cmxtravel.com/conferences/sports-medicine-summit-2/
XV Congreso sobre Medicina y Deporte de Alto Nivel	8-9 Marzo Madrid	web: https://deporteenlanube.es/
XVI Congreso Nacional de Psicología de la Act. Física y del Deporte	13-16 Marzo Zaragoza	web: www.psicologiadeporte.org
V Congreso de Prevención de Lesiones Deportivas	14-15 Marzo Murcia	web: http://eventos.ucam.edu/prevencion-lesiones-deportivas
Nutrition Science & Practice Conference (ASPEN19)	23-26 Marzo Phoenix (EEUU)	web: http://www.nutritioncare.org/conference/
7th International Conference & Exhibition on Physiotheraphy & Physical Rehabilitation	25-26 Marzo Roma (Italia)	web: https://physiotherapy.annualcongress.com/
8th World Congress on Physical Medicine and Rehabilitation	25-26 Marzo Sidney (Australia)	web: https://rehabilitation.conferenceseries.com/
XXXVI Congresso FMSI: "Biological age, chronological age"	27-29 Marzo Roma (Italia)	web: www.fmsi.it/
I Curso monográfico del hombro en el tenis. Patología específica	29-30 Marzo Santander	web Secretaria Técnica: www.congresos-santander.com
XVII Congreso de la Asociación Argentina de Traumatología del Deporte	11-12 Abril Buenos Aires (Argentina)	web: http://aatd.org.ar/
5th International Scientific Exercise and Quality of Life: From Healthy Childhood to Active Aging	11-13 Abril Novi Sad (Serbia)	web: https://www.kif.unizg.hr/znanost/konferencije?@=61jg
2019 AMSSM Annual Meeting	12-17 Abril Houston (EEUU)	web: https://www.amssm.org/
40 Years of Comparative Sport and Physical Education	22-24 Abril Maia-Porto (Portugal)	web: http://iscpes.pt/portal/
XIII Congreso de SETRADE	25-26 Abril Palma de Mallorca	E-mail: sanicongress@setrade.org web: http://www.setrade.org/
XXVIII Isokinetic Medical Group Conference: "Football Medicine meets the universe of sport"	27-29 Abril Londres (Reino Unido)	web: http://www.footballmedicinestrategies.com/en/2019-wembley/3988/482/
The International Conference on Sport, Education & Psychology	2-3 Mayo Bucarest (Rumanía)	web: www.futureacademy.org.uk
International Conference on Medicine and Science in Athletics	3-5 Mayo Doha (Qatar)	web: www.aspetar.com
1er Congreso Internacional de Podología Deportiva	10-11 Mayo Plasencia (Cáceres)	web: www.sepod.es
3rd International Conference Sport, Recreation, Health	10-11 Mayo Belgrado (Serbia)	E-mail: conference@vss.edu.rs
12th Biennial ISAKOS	12-16 Mayo Cancún (México)	web: www.isakos.com

57° Congreso SERMEF	15-18 Mayo Sevilla	web: http://congresosermef.com/index.php
22nd International Symposium on Adapted Physical Activity (ISAPA)	14-18 Junio Charlottesville (EE.UU.)	web: http://isapa2019.org
2019 AIESEP International Conference	19-22 Junio Nueva York (EE.UU.)	web: https://aiesep2019.adelphi.edu
30 Jornadas AEMB	20-22 Junio Madrid	web: http://aemeb.es/madrid-2019/
XL Juegos Mundiales de la Medicina-International Sports Medicine Symposium	22-29 Junio Budva (Montenegro)	web: http://www.medigames.com
VIII Congreso Iberoamericano de Nutrición	3-5 Julio Pamplona	web: http://www.academianutricionydietetica.org/congreso.php?id=7#
24th Annual Congress of the European College of Sport Science	3-6 Julio Praga (Rep. Checa)	E-mail: office@sport-science.org
II Congreso Mexicano de Medicina del Deporte	3-6 Julio Mérida-Yucatán (México)	web: https://comede.mx/
13th Congreso Mundial de la International Society of Physical and Rehabilitation Medicine	9-13 Julio Kobe (Japón)	web: http://www.isprm.org
2nd International Conference on Physical Education, Sports Medicine and Doping Studies	15-16 Julio Sídney (Australia)	web: https://sportsmedicine.conferenceseries.com/
15th European Congress of Sport nd Exercise Psychology	15-20 Julio Münster (Alemania)	web: https://www.fepsac2019.eu
Congreso colombiano de nutrición y dietética y II Internacional en alimentación y nutrición	15-17 Agosto Manizales (Colombia)	web: https://acodin.org/congreso-2019/
9th VISTA Conference	4-7 Septiembre Amsterdam (Países Bajos)	web: www.paralympic.org/news/amsterdam-host-vista-2019
Congress on Healthy and Active Children	11-14 Septiembre Verona (Italia)	web. http://i-mdrc.com/fourth-assembly/
14th International Congress of shoulder and elbow surgery (ICSES)	17-20 Septiembre Buenos Aires (Argentina)	web: www.icses2019.org
56° Congreso SECOT	25-27 Septiembre Zaragoza	web: www.secot.es
IX Congreso de la Sociedad Cubana de Medicina Física y Rehabilitación	1-4 Octubre La Habana (Cuba)	web: http://www.rehabilitacioncuba.com
11th European Congress on Sports Medicine	3-5 Octubre Portorose (Eslovenia)	web: http://www.efsma.eu
13th European Nutrition Conference On Malnutrition In An Obese World	13-18 Octubre Dublín (Irlanda)	web: www.fens2019.org

50 Congreso Nacional de Podología y VI Encuentro Iberoamericano	18-19 Octubre Santander	web: https://50congresopodologia.com/
Congreso Internacional de Fisioterapia	25-26 Octubre Toledo	web: congreso@coficam.org
5th World Conference on Doping in Sport	5-7 Noviembre Katowice (Polonia)	web: http://www.wada-ama.org
26th Word Congress TAFISA	13-17 Noviembre Tokyo (Japón)	web: www.tafisa.org
10th Annual International Conference: Physical Education Sport & Health	23-24 Noviembre Pitesti (Rumanía)	web: http://sportconference.ro/
56 Congreso Argentino de COT	28 noviembre-1 Diciembre Buenos Aires (Argentina)	web: www.congresoaaot.org.ar
2020		
14th ISPRM World Congress – ISPRM 2020	4-9 Marzo Orlando (EE.UU.)	web: http://www.isprm.org/congress/14th-isprm-world-congress
Congreso FESNAD	11-13 Marzo Zaragoza	web: http://www.fesnad.org/
IOC World Conference Prevention of Injury & Illness in Sport	12-14 Marzo Mónaco (Principado de Mónaco)	web: http://ioc-preventionconference.org/
25th Annual Congress of the European College of Sport Science	1-4 Julio Sevilla	E-mail: office@sport-science.org
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)	web: www.globalevents.gr
26th TAFISA World Congress	13-17 Noviembre Tokyo (Japón)	web: www.icsspe.org/sites/default/files/e9_TAFISA%20World%20Congress%202019_Flyer.pdf
2021		
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 Psicología del Deporte	Taipei (Taiwan)	
Congreso Mundial de Podología	Barcelona	web: https://cgcop.es/newweb/eventos/
2022		
XXXVII Congreso Mundial de Medicina del Deporte FIMS	Guadalajara (México)	web: www.femmede.com.mx

Cursos *on-line* SEMED-FEMEDE

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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 "ELECTROCARDIOGRAFÍA PARA MEDICINA DEL DEPORTE"

ACREDITADO POR LA COMISIÓN DE FORMACIÓN CONTINUADA (ON-LINE 1/5/2018 A 1/5/2019) CON 2,93 CRÉDITOS

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 "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 "AYUDAS ERGOGÉNICAS"

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

Curso "CARDIOLOGÍA DEL DEPORTE"

ACREDITADO POR LA COMISIÓN DE FORMACIÓN CONTINUADA (ON-LINE 1/5/2018 A 1/5/2019) CON 6,60 CRÉDITOS

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 "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

ACREDITADO POR LA COMISIÓN DE FORMACIÓN CONTINUADA (NO PRESENCIAL 15/12/2015 A 15/12/2016) CON 10,18 CRÉDITOS

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.

Curso "CINEANTROPOMETRÍA PARA SANITARIOS"

Curso dirigido a sanitarios destinado a adquirir los conocimientos necesarios para conocer los fundamentos de la cineantropometría (puntos anatómicos de referencia, material antropométrico, protocolo de medición, error de medición, composición corporal, somatotipo, proporcionalidad) y la relación entre la antropometría y el rendimiento deportivo.

Curso "CINEANTROPOMETRÍA"

Curso dirigido a todas aquellas personas interesadas en este campo en las Ciencias del Deporte y alumnos de último año de grado, destinado a adquirir los conocimientos necesarios para conocer los fundamentos de la cineantropometría (puntos anatómicos de referencia, material antropométrico, protocolo de medición, error de medición, composición corporal, somatotipo, proporcionalidad) y la relación entre la antropometría y el rendimiento deportivo.

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 ap-pointments.

   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 denomi-nated 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 sub-mitted articles and will inform about its acceptance and possible date of publication.

9. After hearing the reviewers' suggestions (journal uses peer correc-tion 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.

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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.

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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.

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Sociedad Española de Medicina del Deporte

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