ISSN: 0212-8799

186

Volumen 35(4)
July - August 2018

Archivos de medicina del deporte

Órgano de expresión de la Sociedad Española de Medicina del Deporte

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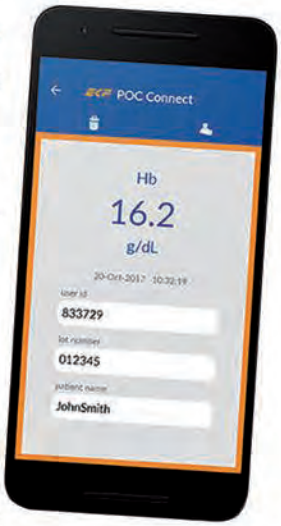

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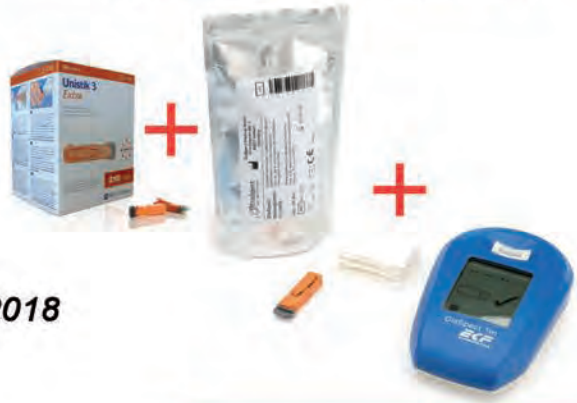

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Publicidad
ESMON PUBLICIDAD
Tel. 93 2159034

Publicación bimestral
Un volumen por año

Depósito Legal
Pamplona. NA 123. 1984

ISSN
0212-8799

Soporte válido
Ref. SVR 389

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

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

Archivos de medicina del deporte

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Summary / Sumario

Myokines relevance in exercise adaptations. A world still to be discovered

La importancia de las miokinas en las adaptaciones al ejercicio físico. Un mundo todavía por descubrir

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Nowadays, the beneficial effects of regular exercise are well-known, in fact, its effectiveness has been proved in at least 26 different pathologies[1]. However, little is known regarding the biomolecular and neuroendocrine mechanisms responsible for these effects.

In this regard, exercise has shown to trigger a cross-talk communication network that produces the activation and inhibition of different processes in several cell types facilitating, at least partially, the dissemination of the positive effects caused by exercise. The presence of this communication network can be observed in Catoire *et al.*[2] study, where 21 male adults (44-56 yr) performed 1h of cycling at 50% W_{max} with one leg, while the other leg remained in resting state. Muscle biopsies were taken from vastus lateralis of both legs before and after the exercise session revealing significant changes not only in the genetic expression of the exercised leg (938 genes) but also in the non-exercise leg (516 genes). The fact that some of these post-exercise genetic alterations were similar in the exercised and non-exercise legs, especially those changes related to the peroxisome proliferator-activated receptors (PPAR), reinforced the existence and relevance of circulating factors able to connect different tissues regulating the metabolic adaptations to exercise[2].

In humans, skeletal muscle has a critical role in the communication network established by these circulating factors among organs and tissues in response to exercise[3-5]. Skeletal muscle has a great adaptation ability that allows answering to any metabolic requirement stimulated by any previous locomotor stress. In fact, the locomotor stress caused or, in other words, the exercise dose performed dictates the adaptations that this tissue. Accomplishes in this context, a group of biomolecules called myokines have shown to promote a muscle-to-organ cross-talk communication[3,6].

Although the study of myokines is still a novel research topic, the existence of *exercise factors* with endocrine effects was proposed decades ago. In 1961, in an editorial from the journal Diabetes, Goldstein[7] speculated about the presence of what he called *'humoral factors'* or *'exercise factors'* released from the exercised muscles with the ability to mediate in glycaemia control, independently of insulin effects. Despite Goldstein's hypothesis[7] was not entirely correct, since glycaemia is not controlled by a single factor, the potential role of skeletal muscle as an endocrine tissue capable of producing and releasing exercise factors that regulate the metabolic adaptations to exercise remained untested. This idea persisted in latent state until last decade when Pedersen *et al.*[3] restarted the search for exercise factors focused on interleukin(IL)-6. The later confirmation of IL-6 as an exercise factor allowed to reinforce the idea of skeletal muscle as an endocrine tissue[3,6,8,9], as well as to delineate the term myokine to encompass all cytokines and peptides that are expressed, produced or released from skeletal muscle in response to repeated contractions exerting endocrine, paracrine or autocrine effects in other tissues and organs[3,6].

In the years after the elegant work performed by Pedersen *et al.*[3,6,8,9] several other myokines were discovered and categorized. The main muscle-to-organ cross-talk communication and functions that some of these myokines perform in response to exercise are presented below.

Glucose metabolism:

- *Muscle – Muscle.* IL-6 and IL-15 stimulate glucose uptake and oxidation via GLUT4 upregulation and translocation. Moreover, IL-13 has been related to glycogen production and oxidation, while fibroblast growth factor 21 (FGF-21) improves insulin sensitivity.
- *Muscle – Liver.* FGF-21 and IL-6 promote gluconeogenesis in the liver, while IL-6 and IL-15 regulate glucose production.

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- *Muscle – Pancreas.* IL-6 stimulates beta cells proliferation and preservation, while the chemokine (C-X3-C motif) ligand 1 (CX3CL1) has revealed to promote protective effects on pancreatic islets. Also, apelin activates insulin production in this organ.

  Lipid metabolism:
- *Muscle – Muscle.* Brain-derived neurotrophic factor (BDNF), IL-6 and IL-15 seem to increase lipolysis, while the alpha receptor of IL-15 (IL-15Rα) mediates in the energy substrate utilization by the mitochondria.
- *Muscle – Adipose tissue.* Irisin, apelin and IL-15 increase lipolysis, while irisin and IL-15 have anti-adipogenic effects. Besides, irisin and FGF-21 promote the browning of white adipocytes, and Nicotinamide N-methyltransferase (NNMT) facilitates fatty acid mobilization under low energy circumstances.
- *Muscle – Liver.* FGF-21 reduces the accumulation and increases the oxidation of fatty acid on this organ. Similar to adipose tissue, NNMT mobilizes fatty acid when energy availability is low.

  Bone metabolism:
- *Muscle – Bone.* The osteogenesis is stimulated by an increased osteoblasts activity promoted by irisin and IL-15Rα, as well as for a periosteum activation caused by leukemia inhibitory factor (LIF).

  Anabolic/catabolic balance:
- *Muscle – Muscle.* IL-6 and decorin have been associated with different hypertrophy pathways. Similarly, follistatin-related protein 1 (FSTL1) promotes the increase and maintenance of skeletal muscle mass by antagonizing myostatin effects. Lastly, IL-15 and IL-15Rα have anti-atrophic effects, especially in the presence of immune or metabolic diseases.

  Circulatory system:
- *Muscle – Endothelium.* Angiopoietin-like 4 (ANGPTL4), IL-8, IL-15 and FSTL1 activate angiogenesis in response to exercise, also facilitating endothelium preservation processes.

  Immune system:
- *Muscle – Immune cells.* IL-6, CX3CL1, chitinase-3-like protein 1 (CHI3L1) and, probably, FSTL1 and IL-15 promote anti-inflammatory effect when they are acutely produced in response to exercise. Although it has been suggested that these myokines mediate the metabolism of immune cells, mainly in lymphocytes B and T, the muscle-to-immune cells cross-talk communication remained to be elucidated.

In addition to the myokines mentioned above, there are ~3000 uncategorized myokines[10,11]. This reveals the vast potential of these biomolecules to establish a complex communication network which might be essential to facilitate the metabolic adaptations to exercise. Thus, the practical applications of the communication network formed by the myokines should not be limited to sports performance, as it is also relevant in some immune and metabolic pathologies. Nevertheless, most of the myokines have not been adequately characterized as a consequence of the tedious and complicated process required to complete this task, which is briefly described below[5]. Initially, the skeletal muscle origin of the target myokine needs to be confirmed via transcriptomic and proteomic; however, it should be taken into account that the genetic (mRNA) and protein expressions of myokines could not match, and that it remains unknown the stimuli that cause the expression of most myokines and the time-point in which these molecules are produced on this tissue. Subsequently, after skeletal muscle confirmation as the released tissue of the target myokine into the circulation, the post-exercise circulating expression should be analysed through the artery-venous difference. Finally, when skeletal muscle expression, production and release of a myokine have been characterized, the next step should be to determine those functions that the target myokine can exert in the different cell types able to uptake it from the circulation. In this regard, animal studies are indispensable to understand how the inhibition of a myokine can affect cell metabolism, although, human studies are also needed to support the functions of each myokine discovered in animal studies.

Unfortunately, in some cases, this process has not been followed and thus myokines research has reported some limitations. For instance, the identification of some myokines has been carried out only in non-exercise muscle tissue; consequently, the possibility of false negatives and the existence of undiscovered exercise factor cannot be avoided. Moreover, there are scarce of studies performed in human which support the existence and functions of some myokines described from *in vivo* and *ex vivo* studies in animals. Besides, in humans, some studies have reported a limited increase in skeletal muscle and circulating expression of some myokines in response to exercise; however, despite potential detection issues (e.g. time-point selection or antibodies efficacy), even low increased of these exercise factors might have an endocrine or auto-paracrine effect in response to exercise. Adding a higher level of complexity, some cytokines and peptides have reported exerting a dual function, sometimes antagonistic, depending on the tissue and stimuli that promote their expression. An example of that idea is IL-15[12] which stimulates pro-inflammatory effects when it is produced by T cells and remains chronically elevated in blood; while, in contrast, this cytokine promotes beneficial effect in several tissues when is released acutely and temporally by skeletal muscle in response to exercise.

Summarizing, myokines are capable of establishing a muscle-to-organ cross-talk communication network that facilitates exercise adaptations. Myokines are a hot topic that brings different research disciplines together given their unlimited implication in sports performance but especially as molecular targets in the prevention and treatment of some immune and metabolic diseases. Therefore, although myokines will possibly be a recurrent topic in the future, myokines' world is still to be discovered and given its potential repercussion to health and performance, rigorous studies are required to puzzle out the real implication of the communication network established by the myokines in the metabolic adaptations to exercise.

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Heart rate variability is lower in patients with intermittent claudication: a preliminary study

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Received: 14.09.2017
Accepted: 14.12.2017

Summary

Introduction: Peripheral arterial disease is a chronic disorder affecting blood flow to lower limbs and many patients can develop intermittent claudication (IC). They suffer a blood flow decrease to lower limbs, making impossible to walk short distances without feeling pain or stopping the gait. Heart Rate Variability (HRV) is a non-invasive tool based on the calculation of time variations along consecutive heartbeats. It is reasonable to think that, since HRV assess the autonomic balance through the cardiovascular system, it could be useful in the assessment of patients with IC.
Objectives: The aim of this study was to assess if there are differences in resting HRV between patients with IC and age matched controls, both with linear and non-linear analysis, and its possible relation with the gait capacity.
Methods: 14 control male subjects (60±5 years) and 14 male IC patients (64±6 years) underwent 10 minutes of HRV analysis. The study calculated Time Domain variables, Poincaré Plot analysis and nonlinear parameters (Entropy and slopes of Detrend Fluctuation Analysis).
Results: The main finding of this study is the presence of a clear sympathetic predominance at rest in the IC patients and a significant correlation between the parasympathetic rest tone and the distance covered in the 6MWT when all subjects are included.
Conclusions: HRV seems to be an accurate method to detect the sympathetic misbalance present in patients with IC but as a nonspecific finding that could be present in other cardiovascular pathologies. Complex structure of the heartbeat signal is not affected by IC.

Key words:
Peripheral arterial disease.
Walking ability.
Intermittent claudication.
Autonomic balance.

La variabilidad de la frecuencia cardiaca es menor en pacientes con claudicación intermitente: un estudio preliminar

Resumen

Introducción: La enfermedad arterial periférica es un trastorno crónico que afecta al flujo sanguíneo de los miembros inferiores y muchos pacientes desarrollan claudicación intermitente (CI), sufriendo una reducción del flujo sanguíneo que les hace imposible caminar cortas distancias sin sufrir dolor o tener que detenerse. La variabilidad de la frecuencia cardiaca (VFC) es una herramienta no invasiva basada en el cálculo de las variaciones de tiempo entre latidos sucesivos. Es razonable pensar que, puesto que la VFC evalúa el balance autonómico a través del sistema cardiovascular, podría ser útil en la valoración de pacientes con CI.
Objetivos: Evaluar si hay diferencias en la VFC de reposo entre pacientes con CI y controles de la misma edad (tanto con análisis lineal como no lineal) y su posible relación con la capacidad de marcha.
Métodos: Se realiza un análisis de VFC de 10 min a 14 controles (60±5 años) y 14 pacientes con CI (64±6 años). Se calcularon variables del dominio de tiempo, gráfico de Poincaré y parámetros no lineales. Todos los sujetos realizaron a continuación un test de 6 min.
Resultados: El principal hallazgo de este estudio es la presencia de un claro predominio simpático en reposo en los pacientes con CI y una correlación significativa entre el tono parasimpático de reposo y la distancia recorrida en el test de 6 min.
Conclusiones: La VFC parece ser un método adecuado para detectar la disfunción simpática presente en pacientes con CI pero como un hallazgo inespecífico que puede estar presente en otras patologías vasculares. La estructura compleja de la señal cardiaca no se ve afectada en la CI.

Palabras clave:
Enfermedad arterial periférica.
Capacidad de marcha.
Claudicación intermitente.
Balance autonómico.

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Introduction

Peripheral Arterial Disease (PAD) is an atherosclerotic occlusive disorder of arteries distal to the aortic bifurcation[1]. Due to the arterial occlusion, lower limb muscles do not receive the oxygen required while exercising provoking pain and necessity of stop walking. This phenomenon is called intermittent claudication (IC) and it affects around 12 million people in the United States of America[2]. The estimated overall prevalence of the disease is 3-10% at all ages and 15-20% in patients over 70 years[3]. Thus, one in five patients over 65 years has either symptomatic or asymptomatic PAD[4].

Atherosclerosis, and thereby PAD, are especially found in elderly and it is associated to diabetes mellitus and other cardiovascular risk factors such as hypertension, high body mass index and dyslipidemia[1,4]. Being current smoker or having smoked in the past increases also the possibilities of developing PAD[1].

PAD is asymptomatic in the first stages of the disease and people may be affected without knowing it[4]. In more advanced stages PAD turns symptomatic appearing IC and claudicating patients tend to reduce their mobility due to pain[2]. Moreover, the loss of work capacity affect not only to the ischemic limb but also to the healthy one[5].

Since the nineties, several qualitative and quantitative methods have been proposed to assess the state of the disease in IC patients[6-12] including studies of gait variability[13].

The analysis of Heart Rate Variability (HRV) is a non-invasive tool based on the calculation of time variations along consecutive heartbeats. It reflects cardiovascular (CV) response to autonomic activity in such a way that a reduced HRV is related to CV risk[14].

HRV analysis comprises different methods for its calculation[14]: A) The Frequency-domain analysis includes the determination of the frequency spectrum using the Fast Fourier Transform (FFT): high-frequency (HF), low-frequency (LF), very low frequency (VLF) and ultra-low frequency (ULF)[14,15]. B) The Time-domain analysis includes statistical measures which basically reflect parasympathetic activity, such as the Mean RR Interval, the Root-Mean-Square differences of successive heartbeat Intervals (rMSSD) or the percentage of RR intervals >50ms (PNN50)[14,15]. C) The Poincaré Plot analysis[16] provides an ellipse-shaped graph of RR intervals in which transverse (SD1) and longitudinal (SD2) diameters can be measured. SD1 reflects parasympathetic activity while SD2 is inverse to sympathetic activity. Recently, a new index based in Poincaré Plot has been proposed[17,18]. It is the Stress Score and it reflects in a direct way the sympathetic activity. D) The nonlinear analysis of HRV studies the complexity of the signal and it includes the fractal characteristics of the series[19].

It is reasonable to think that, since HRV assess the behavior of the autonomic system through the cardiovascular system, it could be useful in the assessment of patients with IC. To our knowlege, only four studies have analyzed HRV in patients with IC[20-23]. Two of them[20,21] did not find relation between HRV and the improvement in patients' walking ability. The third one[22] found significant differences in the HRV between patients and healthy subjects and suggested its use in the risk stratification. The fourth one[23] reported that time domain and non-linear indices of HRV were positively associated with maximal walking distance, but not with claudication distance, in symptomatic PAD patients.

The aim of our study was to assess if there are differences in resting HRV between patients with IC and age matched controls, both with linear and non-linear analysis, and its possible relation with the gait capacity.

Material and method

14 control male subjects (60±5 years, 90±12 kg, 174±7 cm) and 14 male PAD patients with IC (age 64±6 years, 83±17 kg, 168±7 cm) were recruited from two Hospitals in the town of Sevilla (Spain). The inclusion criteria for controls were not suffering from cardiovascular disease, not following any medical treatment and having an Ankle Brachial Index (ABI) >1. On the other hand, the inclusion criterion for the patients was to be referred by the Vascular Surgery Service of one of the two hospitals participating in the study, where they had to have a history with the diagnosis of PAD without surgery and an ABI <0.9[24,25]. All subjects included in the study (patients and controls) were non-smokers and none of them were taking any medications that had a relationship with the cardiovascular system in the past three months.

Subjects came to the Lab in the morning, 2 hours after breakfast, without drinking caffeine or exercising one day prior data collection. HRV was recorded for 15 minutes at rest in supine position using a Firstbeat Bodyguard recorder (Firstbeat Technologies Ltd, Jyväskylä, Finland). The first five minutes of every record were excluded assuming this time for relaxing. After the HRV record, each subject underwent a 6-minutes walking test (6MWT) in a closed hallway 50 m long.

All RR intervals were analyzed with the software Kubios HRV v2.0 (Biosignal Analysis and Medical Imaging Group, Department of Physics, University of Kuopio, Kuopio, Finland). All time series were visually examined to detect possible artifacts and to apply, if necessary, any of the filters available in the program.

The variables analysed were rMSSD and pNN50 in the Time Domine and SD1, SD2 and SS in the Poincaré Plot. The Sample Entropy (SampEn) and the slopes $\alpha 1$ and $\alpha 2$ of Detrend Fluctuation Analysis (DFA) were calculated as complexity indexes.

The normality of distribution was assessed through the Shapiro Wilk test. For the contrast of hypothesis between two distributions, the Student t-Test was applied for those variables with normal distribution (SD2, SampEn and DFA $\alpha 1$ and $\alpha 2$ for both groups) and the Mann–Witney U-Test for the non-normal (Mean RR, rMSSD, pNN50, and SS for both groups).

To assess de magnitude of the changes, the Effect Size was determined and interpreted according to the Hopkins criteria: 0.2 small; 0.6 moderate; 1.2 large; 2.0 very large; 4.0 extremely large[26].

A Pearson correlation analysis was performed between the distances covered in the 6MWT and all HRV variables.

The statistical analysis was performed using the SPSS Statistics Software version 18 (SPSS Inc, Chicago, IL, USA).

The study was approved by the Ethics Board of the University and all the subjects signed an informed written consent in accordance with the Declaration of Helsinki.

Results

Table 1 shows the results for the variables in the Time Domine and the Poincaré Plot. A significantly lower parasympathetic activity (lower rMSSD, pNN50 and SD1) is observed in patients as well as a significantly higher sympathetic activity (lower SD2 and higher SS). In both cases the difference not only was significant but also had an effect size large or very large.

Table 2 shows the results for the complex variables. Any significant difference is observed between patients and control subjects and the effect size was moderate or small.

The distance covered in the 6MWT was 518.77±61.51 m for controls and 326.82±87.76 for patients (p = 0.00001; Effect Size 2.57, very large). Four patients could not complete the 6 minutes of the walking test, stopping at 4 and 5 minutes. The distance covered at the time of stopping was counted.

Table 3 shows the correlations between distances and HRV parameters. There was no correlation in the groups separately, but when considering the total of subjects a significant correlation appears between the distance covered and rMSSD, pNN50, SD1 and SD2.

Table 1. Data for HRV variables in the Time Domine and Poincaré Plot.

		rMSSD	pNN50	SD1	SD2	SS
Control	Mean	22.73	3.85	15.83	62.9	20.16
	SD	8.19	3.87	5.67	24.92	14.22
Patients	Mean	10.19	0.33	7.21	25.25	45.55
	SD	5.27	0.39	3.73	9.13	19.51
	% change	-55.2%	-91.5%	-54.5%	-59.9%	125.9%
	P Value	0.005	0.013	0.006	0.0001	0.0002
	Effect size	1.86	1.65	1.83	2.21	-1.51
		Large	Large	Large	Very large	Large

rMSSD: Root-Mean-Square differences of successive heartbeat Intervals; pNN50: percentage of RR intervals >50ms; SD1: transverse diameter of Poincaré Plot analysis; SD2: longitudinal diameter of Poincaré Plot analysis; SS: stress score.

Table 2. Data for non-linear variables.

		DFA. α 1	DFA. α 2	SampEn
Control	Mean	1.31	1	1.28
	SD	0.14	0.12	0.3
Patients	Mean	1.22	1.07	1.36
	SD	0.12	0.1	0.13
	% change	-6.8%	6.2%	6.2%
	P Value	0.198	0.11	0.292
	Effect size	0.69	-0.64	-0.37
		Moderate	Moderate	Small

DFA: Detrend Fluctuation Analysis with slopes α1 and α2; SampEn: Sample Entropy.

Table 3. Correlation between HRV variables and distance covered in the 6 minutes walking test.

		Total distance	Control distance	Patients distance
rMSSD	r Pearson	0.47	-0.31	0.07
	p	0.02	0.31	0.84
pNN50	r Pearson	0.44	-0.01	0.28
	p	0.03	0.99	0.40
SD1	r Pearson	0.47	-0.30	0.07
	p	0.02	0.32	0.84
SD2	r Pearson	0.45	-0.56	0.11
	p	0.03	0.05	0.75
SS	r Pearson	-0.37	0.50	0.10
	p	0.08	0.08	0.77
alpha1	r Pearson	0.26	0.04	-0.15
	p	0.21	0.89	0.66
alpha2	r Pearson	-0.22	-0.20	0.18
	p	0.31	0.52	0.60
SampEn	r Pearson	-0.04	0.44	0.04
	p	0.85	0.13	0.91

rMSSD: Root-Mean-Square differences of successive heartbeat Intervals; pNN50: percentage of RR intervals >50ms; SD1: transverse diameter of Poincaré Plot analysis; SD2: longitudinal diameter of Poincaré Plot analysis; SS: stress score; SampEn: Sample Entropy.

Discussion

The main finding of this study is the presence of a clear sympathetic predominance at rest in the PAD patients and a significant correlation between the parasympathetic rest tone and the distance covered in the 6MWT when all subjects are included.

Parasympathetic HRV variables (rMSSD, pNN50 and SD1) were higher in controls indicating a healthier general state[27]. On the other hand, patients with IC had a higher sympathetic status showed by a lower SD2 and a much higher SS. Although the sample is not very large (as is usual in this type of study), the differences found between both groups present a very high level of significance for these variables together with a large or very large effect size. Therefore, there is no doubt about the existing differences.

Regarding nonlinear dynamics, no difference has been found between groups in the SampEn values and the alpha1 and alpha2 slopes of the DFA, indicating that, regardless of the existing autonomic imbalance, both groups retain the same complex structure in their heartbeat.

When comparing our data with the previously published works, we find that the Sandercock study[21] only analyzes HRV in the frequency domain using the Fast Fourier Transform, so it is not comparable with our results. The Leicht study[20] analyzes practically the same variables as we do, and in a very similar age range, but does not find differences between healthy subjects and patients with PAD. In our opinion, this may be due to the fact that this study includes men and women, which makes the variability of the data much greater (for example, rMSSD data provided by Leicht *et al* show a coefficient of variation of 77%). Regarding

the Goernig study[22], all subjects are patients with cardiovascular disease with and without PAD. They find significant differences in time domain variables between both groups and attribute it to the existence of PAD. In the study of Lima *et al*[23] there was no control group and they performed a treadmill test. They reported values of SDNN, rMSSD, pNN50, SD1 and SD2 much higher than ours.

As for the nonlinear variables, only the work of Leicht *et al*[20] reports data from SampEn, alpha1 and alpha2. The values referred by them are almost identical to ours and do not present differences between patients and healthy subjects, which seems to reinforce the idea that, whatever the changes in sympathetic-parasympathetic balance, the complex structure of the signal does not change.

Limitations

The main limitation of the current study was the small sample size. However, it is very difficult to achieve a greater number of subjects when the homogeneity of the groups is established with the criteria of this study. Thus, the work of Gornig *et al*[22] contains two groups of 26 and 27 subjects but including all kinds of basic cardiovascular pathologies. The Leicht *et al* study[20] is done with two groups of 24 and 25 subjects but mixing men and women. Finally, the Sandercock et al study[21] included 52 patients but with different concomitant pathologies and taking 11 different drug types (including statins, beta blockers, ACE inhibitors or diuretics).

In conclusion, HRV seems to be an accurate method to detect the sympathetic misbalance present in patients with PAD but as a nonspecific finding that could be present in other cardiovascular pathologies. Complex structure of the heartbeat signal is not affected by PAD.

Acknowledgements

This study is part of the Research Project TEC2013-48439-C4-4-R. It has been partially supported by the Spanish Ministry of Economics and Competitiveness and FEDER Founds of the European Union.

We also want to acknowledge the implication and kindness of patients, controls and sanitary staff for making possible this project.

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

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SMD EEO
Sociedad Española de Medicina del Deporte

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

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The effect of one year of unstructured table tennis participation on motor coordination level among young recreational players

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Received: 04.10.2017
Accepted: 02.01.2018

Summary

Purpose: The aim of this study was to estimate the effect of unstructured table tennis participation on motor coordination level in young recreational players.
Method: A retrospective quasi-experimental study, with ex post facto design, was conducted. Sample was extracted from a population of 207 students aged 12 to 15 years enrolled in a public full-time school. Experimental (n=18) and control (n=18) groups were formed, resulting in a final sample of 36 participants (17 girls, 19 boys). Table tennis participation was experienced inside the school of the participants and consisted of an unstructured activity in which the subjects played recreationally during 30-40 minutes, 3 to 5 times per week, during one year. Post-intervention measures were performed within one week after one-year of table tennis participation. Motor coordination level was assessed using the Körperkoordinationstest für Kinder. Repeated measures analysis of variance was used to examine between- and within-subjects differences.
Results: Both groups showed higher values of motor coordination level over one-year. Tennis table participation group had significantly higher motor coordination levels than control group across both time periods (F=12.483, p=0.01). However, the interaction effect between tennis table participation and time was not significant (F=1.552, p=0.221).
Conclusion: Motor coordination levels of young recreational players were not improved due to unstructured table tennis participation, even after one year of regular practice. The lack of adequate opportunities for practice may have led to these findings. Additional research involving both structured and unstructured practice of this sport should be pursued.

Key words:
Motor coordination.
Table tennis.
Sport participation.
Adolescents.

El efecto de un año de la participación no estructurada del tenis de mesa en el nivel de coordinación motora entre los jóvenes jugadores recreativos

Resumen

Objetivo: El objetivo de este estudio fue estimar el efecto de la participación no estructurada del tenis de mesa en el nivel de coordinación motora en jóvenes jugadores recreativos.
Método: Se realizó un estudio retrospectivo cuasi-experimental. Se extrajo una muestra de una población de 207 estudiantes de 12 a 15 años matriculados en una escuela pública a tiempo completo. Se formaron un grupo experimental (n=18) y control (n=18), resultando una muestra final de 36 participantes (17 chicas y 19 chicos). La participación en tenis de mesa se llevó a cabo dentro de la escuela de los participantes y consistió en una actividad no estructurada en la que los sujetos jugaban recreativamente durante 30-40 minutos, 3 a 5 veces por semana, durante un año. Las medidas post-intervención se realizaron una semana después de completar un año de participación en el tenis de mesa. El nivel de coordinación motora se evaluó utilizando el Körperkoordinationstest für Kinder. El análisis de la varianza de medidas repetidas se utilizó para examinar las diferencias entre los sujetos.
Resultados: Ambos grupos mostraron mayores valores de coordinación motora a lo largo de un año. El grupo de participación en tenis de mesa tuvo niveles de coordinación motora significativamente más altos que el grupo control en ambos períodos de tiempo (F=12.483, *p*=0,01). Sin embargo, el efecto de interacción entre la participación en tenis de mesa y el tiempo no fue significativo (F=1.552, *p*=0,221).
Conclusión: Los niveles de coordinación motora de los jugadores jóvenes recreativos no mejoraron debido a la participación no estructurada en el tenis de mesa, incluso después de un año de práctica regular. La falta de oportunidades adecuadas para la práctica puede haber llevado a estos hallazgos. Debería llevarse a cabo una investigación adicional que incluya tanto la práctica estructurada como la no estructurada de este deporte.

Palabras clave:
Coordinación motora.
Tenis de mesa.
Participación deportiva.
Adolescentes.

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Introduction

Motor coordination is the harmonious functioning of body components involving synchrony of gross and fine motor control and motor planning[1]. As a measurable phenomenon, there are different assessment tools which can be used for estimating motor coordination levels. Among these tools, there are those which use gross and fundamental movement skills performance for estimating motor coordination levels in children and adolescents, such as the widely used M-ABC, BOT-2, TGMD-2 and KTK tests[2].

Motor coordination levels estimated through these tests were firstly used in clinical setting for assessing neurological or functional status, as well as developmental delays, in children. In the last years, however, the usefulness of motor coordination level as a measure is not restricted to solely clinical assessments[3]. There is a scope of evidence supporting a range of correlates of global motor coordination level[4], such as health outcomes[4,5], academic achievement[6,7] and sport-related attributes[8,9].

Sport participation is one of sport-related attributes that have been examined as a correlate of motor coordination level[1,8-12]. Previous studies have suggested a positive effect of structured sport activities on motor coordination level in children and adolescents[1,9,13]. Although unstructured sport activities have been recommended for acquisition of skill[14,15] and expertise[16-19] in sport, there is no evidence supporting these activities have a positive effect on motor coordination level when they are experienced singly, that is, without the concomitance of structured sport activities.

While structured sport activities involve formal adult led-sport activities that include all kinds of organized training[19], unstructured sport activities include informal youth-led activities, developed in play environments like backyard or street games[19]. Thus, a possible effect on motor coordination level may also vary due to organization of sport practiced, that is, structured or unstructured sport activity.

Nevertheless, even in unstructured activities is possible to experience adequate opportunities for practice. Therefore, the hypothesis that unstructured sport activities may also have a positive effect on motor coordination level cannot be ruled out. Indeed, individuals may develop their motor skills in an incidental manner[20], such as in unorganized active physical recreation[21].

Among several sports to be studied in the topic approached in this study, table tennis seems to be very interesting due to different reasons. First, table tennis is a massively popular sport[22] with nearly 40 million competitive table tennis players around the world and countless millions playing recreationally[23]. As a popular sport, it is important to know what are the benefits of table tennis participation across different populations, mainly among those who play recreationally. Second, table tennis is an open and complex motor task[24] marked by high ball speed and dynamically changing, unpredictable and externally paced environment[25]; also, evidence suggests that performance in table tennis is associated with different kinds of motor skills[24,26-29] in young players. Due these characteristics and evidence, it seems plausible to expect that table tennis participation has a significant effect on motor coordination level. Finally, In order to disseminate the table tennis participation among children and adolescents as well as to foment the so called Olympic legacy, before last Olympic Games was promoted an unstructured practice of this sport around public schools of Rio de Janeiro city. Among other things, it was emerged an opportunity to estimate the effect of unstructured table tennis participation on motor coordination level.

Understanding the benefits of unstructured table tennis participation on motor coordination level in young who play recreationally is a matter of public health, since motor coordination is associated with a range of health outcomes[4,5]. Therefore, the aim of this study was to estimate the effect of unstructured table tennis participation on motor coordination level in young recreational players.

Material and method

A retrospective quasi-experimental study, i.e. with ex post facto design, was conducted considering the period between July 2013 and July 2014. The sample was extracted from a population of 207 students, aged 12 to 15 years, enrolled in a public full-time school in the city of Rio de Janeiro, Brazil. Among these students, 53 had table tennis participation at least one time per week and 154 did not practice table tennis in the period. All students, including those who did not practice table tennis, had physical education classes one or two times per week.

Inclusion criteria required subjects to be under 15 years old with no history of injury or disease that could affect motor performance. Exclusion criteria consisted of students who were enrolled in regular sport participation outside school within July 2013 and July 2014. Additionally, from 53 students with table tennis participation, those who played table tennis less than three times per week for two or more weeks were also excluded. Based on these criteria, 59 subjects were excluded, being 35 with and 24 without table tennis participation.

Thus, the experimental group (i.e. with regular table tennis participation) was composed of 18 subjects (n=18). Of the 130 students remaining without table tennis participation, eighteen were randomly selected and assigned to the control group (n=18), resulting in a final sample of 36 participants (N=36). Ethical approval for this study was obtained from the University's Ethics Committee and parental consent and child assent were obtained prior to participation.

Table tennis participation was experienced inside the school of the participants and all the materials used for its practice were standardized following the International Table Tennis Federation recommendations. Body mass was measured to the nearest 0.1 kg using an electronic scale with participants wearing their school uniform. Standing height was measured while unshod with a meter wall to the nearest 0.1 cm. Motor coordination level was assessed using the Körperkoordinationstest für Kinder (KTK). Baseline measures were performed within one week before the start of table tennis participation. Post-intervention measures were performed within one week after one-year of table tennis participation. All measures were performed by a single trained physical educator as routine assessment of students in the physical education program of school.

Table tennis is a sport played with remarkably high speed which requires accurate timing and perceptual skills when practiced for expert players[30]. However, our investigation was conducted with non-athletes, young recreational players. Moreover, in this study was only experienced unstructured table tennis practice. Thus, sport performance was not focused and table tennis specific skills were not assessed. Instead,

motor coordination level was estimated using the KTK, a generic, non-specific test.

The KTK is appropriated to assess motor coordination level of participants because it is a reliable and valid instrument, with a teste-retest reliability coefficient of 0.97[31]. KTK is one of most used tools for assessing children's motor coordination[2] and has been applied in different research topics, such as health outcomes[3,5], academic achievement[6,7] and sport-related attributes[8,9]. KTK consists of four test items. The first is walking backwards along balance beams (3 m length) of decreasing width (6, 4.5 and 3 cm). Each beam was crossed three times where a maximum of eight steps per trial were allowed (72 steps overall); the sum of steps in all trials determined score 1. The second involved one-legged hopping over an obstacle, formed by an increasing pile of pillows (pillow size 60 cm × 20 cm × 5 cm; the maximum was 12 pillows or a height of 60 cm). Only three trials were allowed for each obstacle and three, two, or one point(s) were/was awarded for successful performance on the first, second, or third try, respectively. Therefore, a maximum of 39 points (including a ground level trial) could be scored for each leg; the points were summed to determine score 2. The third task was two-legged sideways jumping across a wooden slat (60 cm × 4 cm × 2 cm) for 15 s as quickly as possible. The number of jumps performed correctly was summed over two trials to determine score 3. The final task involved moving sideways on wooden boards (25 cm × 25 cm × 5.7 cm) as many times as possible in 20 s. One point was awarded for each time the plate was transferred and one more for stepping on it. The number of relocations was counted and summed over two trials to determine score 4. KTK takes into account motor coordination level is gender and age-related. Thus, the four scores acquired in each item test were gender and age-adjusted in according to KTK normative database. Finally, the motor coordination level for each participant was derived from the sum of the four adjusted scores obtained in the tests.

Table tennis participation consisted of an unstructured sport activity in which the participants played recreationally during 30-40 minutes for 3 to 5 times per week. The practice was exclusively individual and game-based. They had the opportunity to engage in table tennis participation daily together with their classroom colleagues, resulting in subgroups of 5-8 subjects for each one of two table's tennis available in the school. Due to school calendar, there was a recess of 45 days between the sixth and seventh months in which the subjects of experimental group did not play table tennis.

Descriptive statistics were determined for all variables. The Kolmogorov-Smirnov test confirmed acceptable normality of the data distribution. Repeated measures analysis of variance (ANOVA) was used to examine between- and within-subjects differences. A significance level of 5% ($\alpha = 0.05$) was adopted in all statistical tests. Data analysis was executed using Statistical Package for Social Sciences (SPSS ver. 22.0 software, IBM, USA).

Results

At the baseline, participants (N=36) showed mean values of age, body weight, height and motor coordination level as 13.2y (±0.5), 47.8 kg (±13.6), 1.56 m (±0.1) and 88.4 (±27.2), respectively. After one year, mean values were 14.3 y (±0.4), 53.7kg (±14.0), 1.62 m (±0.1) and 100.8 (±28.2). Descriptive statistics of the baseline and after one-year of table tennis participation of experimental (n=18, 11 boys and 6 girls) and control (n=18, 6 boys and 11 girls) groups are provided in Table 1.

Both control and table tennis participation groups showed higher values of motor coordination level after one year (Figure 1) and ANOVA revealed which this difference was significant (F=55.138, p<0.0001).

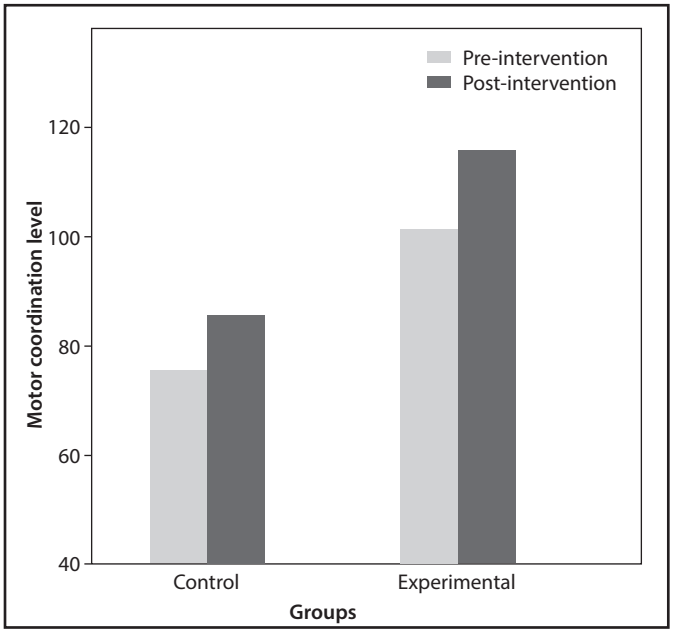
There was an overall difference in the motor coordination levels between groups. The mean of motor coordination level was 80.7 with a 95% of confidence interval between 69.3 and 92.0 for control group. For table tennis participation, the mean of motor coordination level was 108.5 with a 95% confidence interval between 97.2 and 119.9. Statistical analysis revealed that table tennis participation group had significantly higher motor coordination levels than control group across both time periods (F=12.483, p=0.01). The power of this comparison was 0.929.

The interaction between factors, that is, table tennis participation and time, was not significant (F=1.552, p=0.221). Therefore, these data

Table 1. Descriptive statistics (mean ± standard deviation) of the control group (CG) and table tennis participation group (TT) including age, anthropometry and motor coordination (MC) level at the baseline (pre-intervention) and after one-year (post-intervention).

	Baseline (pre-intervention)		After one-year (post-intervention)	
	CG	TT	CG	TT
Age (years)	13.0±0.4	13.3±0.5	14.1±0.4	14.4±0.5
Body weight (kg)	52.5±16.1	43.0±8.7	57.5±17.7	50.1±8.0
Height (m)	1.57±0.1	1.55±0.1	1.61±0.1	1.64±0.1
MC level	75.5±32.8	101.3±9.6	85.8±33.0	115.8±8.8

Figure 1. Motor coordination level at the baseline and after one-year in both control and experimental groups.



suggest there is no a significant effect of table tennis participation on motor coordination level of participants. A small effect size was observed across comparisons (Cohen's d=0.31).

Discussion

The main aim of this study was to estimate the effect of unstructured table tennis participation on motor coordination level in young recreational players. Both control and table tennis participation groups significantly increased their motor coordination levels over one year. However, there was not significant interaction effect between time and table tennis participation on motor coordination level of participants. Therefore, our results suggest there is no a significant effect of unstructured table tennis participation on motor coordination level of young recreational players after one-year of regular practice.

Overall, the participants of this study increased their motor coordination levels over one year. Both control and table tennis participation groups had significantly higher motor coordination levels after one year. Thus, there was an effect of the time on motor coordination levels of participants, regardless of engagement on table tennis practice. These findings were expected due to effects of growth and maturation on adolescent's motor performance. Growth and maturation occurred during adolescence are associated with increases on muscular strength and motor performance[32-35] like jump, agility and balance. Besides the motor coordination by itself, these physical and skills components are also related to performance on KTK tasks[36].

The main purpose of this investigation was to analyze the effect of unstructured table tennis participation on motor coordination level in young recreational players. Results indicated that table tennis participation group had significantly higher motor coordination levels than control group after one-year of regular practice. However, this finding cannot be explained by table tennis participation, because there was not significant interaction effect between sport participation and time. Therefore, our results suggest that difference between groups in motor coordination level after one-year of intervention was only due to effect of time, which it seems to be related to growth and maturation.

Besides growth and maturation, it is important to emphasize that opportunities for practice are a key factor for development of motor coordination level[37-39]. Therefore, the development of motor coordination among young table tennis players can be expected when adequate opportunities for practice are ensured for all individuals, as it is aimed in planned and structured activities[40]. Although individuals may develop their motor coordination in an incidental manner[20], such as in unstructured sport activities, not all kind of engagement in sport can exert a positive effect on motor coordination level among players. For example, if players do not experience adequate opportunities for practice, they may not develop their motor coordination level due table tennis participation. Moreover, there are other conditions of the environment that play important roles in the degree to which motor coordination develops[39], such as encouragement and constraints contained within the requirements of the movement tasks[37,38].

Therefore, the absence of effect of unstructured table tennis participation on motor coordination level in young recreational players can be related to characteristics of unstructured sport activities. These activities are not pedagogically planned[19] and, therefore, the conditions of the environment, such as opportunities for practice, may not have been adequate to the development of motor coordination level of table tennis participation group. As an individual and game-based practice, less skilled individuals tend to have less playing time and consequently fewer opportunities for practice when play against more skilled peers.

It's difficult to compare our findings with previous evidence due to paucity of studies on topic. While previous evidence has suggested significant associations between motor coordination and sport performance in children[8,13,41], including table tennis[24,26-29], little is known about the effect of table tennis participation on motor coordination level in children and adolescents. In this sense, two studies[42,43] found a significant effect of a 12-week table tennis exercise on motor skills in children. However, both studies examined children with attention deficit hyperactivity disorder and used structured table tennis participation.

As a limitation, only unstructured sport activities were investigated in this study. Also, there was an unbalanced male/female ratio of sample. Thus, possible differences between genders might have biased the results. Nevertheless, this study shed some light on the underexplored literature on the effectiveness of unstructured sport participation on motor coordination level in adolescents. To our knowledge, this was the first study to analyze the effect of unstructured table tennis participation on motor coordination level in young recreational players. As practical application, this study reinforces the assumption that not all kind of engagement in sport can exert a positive effect on motor coordination level among players, even when regularly practiced during one year.

Conclusions

Motor coordination levels of young recreational players were not improved due to unstructured table tennis participation, even after one year of regular practice. Our results seem to be related to characteristics of unstructured sport activities, as the conditions of the environment that are not adequately ensured for all players. Thus, the lack of adequate opportunities for practice may have led to these findings. Additional research involving both structured and unstructured table tennis participation should be pursued.

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Influence of the maximum heart rate determination criterion on the quantification of the internal load in soccer refereeing

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Received: 09.10.2017
Accepted: 10.01.2018

Summary

The aims of this present study were, on the one hand, to analyze the differences in the match internal load (CIP) between field referees (AC) and assistants (AA) measured by different methods of quantification during official matches, and on the other hand, to know whether exist differences in the CIP using different criteria to determine the individual maximum heart rate (FC_{max}) (FC_{max} achieved in the incremental test or FC_{max} achieved during the match). In this study participated 41 match officials who refereed during 21 official matches in a Spanish Third Divison League, of which, 21 were AC and 20 were AA. CIP was determined by Edwards method (Edwards'_CIP) and Stagno method (Stagno's_CIP) attending to the individual FC_{max} obtained during the match ($CIP_{PARTIDO}$) and during the YYIR1 test (CIP_{YYIR1}). AC registered higher values of Edwards_CIP and Stagno_CIP than AA with both criteria of determination of FC_{max}. In addition, despite high-very high-extremely high differences were observed CIP methods using different criteria to determine the individual FC_{max} ($FC_{maxPARTIDO}$ or $FC_{maxYYIR1}$) in all match officials, in AC and in AA, the associations were very high and almost perfect in the CIP calculated with different criteria of determination of FC_{max}. The results of this investigation suggest that it could be appropriate to use both determination of FC_{max} criteria to quantify CIP with Edwards'_CIP and Stagno's_CIP methods.

Key words:
Heart rate. Methods. Association. Competition. Soccer refereeing.

Influencia del criterio de determinación de la frecuencia cardiaca máxima sobre la cuantificación de la carga interna en el arbitraje

Resumen

Los objetivos de este estudio fueron, por un lado, analizar las diferencias en la carga interna de partido (CIP) entre árbitros de campo (AC) y asistentes (AA) medida mediante diferentes métodos de cuantificación en partidos oficiales, y por otro lado, conocer si existen diferencias en la CIP utilizando distintos criterios para determinar la frecuencia cardiaca máxima (FC_{max}) individual (FC_{max} alcanzada en un test incremental o FC_{max} alcanzada en el partido). En este estudio participaron 41 colegiados que arbitraron 21 partidos oficiales de Liga de la Tercera División de Fútbol de España, de los cuales, 21 eran AC y 20 AA. La CIP fue determinada mediante los métodos de Edwards (Edwards'_CIP) y de Stagno (Stagno's_CIP) atendiendo a la FC_{max} individual alcanzada en algún momento del partido ($CIP_{PARTIDO}$) y durante el test YoYo de recuperación intermitente, YYIR1 (CIP_{YYIR1}). Los AC registraron mayores valores de Edwards_CIP y Stagno_CIP que los AA con ambos criterios de determinación de la FC_{max}. Además, a pesar de que se observan diferencias altas-muy altas-extremadamente altas en los métodos de cuantificación de la CIP utilizando distintos criterios para determinar la FC_{max} individual ($FC_{maxPARTIDO}$ o $FC_{maxYYIR1}$) tanto en todos, en AC y en AA, las asociaciones fueron muy altas y casi perfectas en la CIP calculada con distintos criterios de determinación de la FC_{max}. Estos resultados sugieren que puede ser adecuado utilizar cualquiera de estos criterios de determinación de la FC_{max} para cuantificar la CIP tanto con el método Edwards'_CIP como con el método Stagno's_CIP.

Palabras clave:
Frecuencia cardiaca. Métodos. Asociación. Competición. Arbitraje.

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Introduction

It is very important to quantify the internal match load (IML) of football referees in order to have information with which to control weekly training loads[1]. Such knowledge of the IML of football referees can provide the professionals in charge of their physical preparation with a suitable tool to arrive at an optimal prescription of the training dose[2]. The IL in football referees, though it has also been determined using subjective methods such as the rate of perceived effort (RPE)[3], has chiefly been described using objective methods such as monitoring the heart rate (HR)[4-6]. Although the methods based on HR to determine IML have been widely used in competitions refereed by professional and/or international referees[4,7,8], few studies have been conducted at lower levels of competition[9], so knowing the IML in matches in these less competitive categories would also be of great interest.

The scientific literature describes different methods based on HR for the quantification of the match load[10-12], especially in team sports[13-16]. Some of the methods for quantifying IML most used are the calculation of the percentage of time spent by the athletes at different effort intensities[17,18], Edwards' method[19] and Stagno's method[20,21]. Specifically in football referees, different variables have been obtained which permit quantification of IML through methods based on HR like the time spent at different effort intensities and the match load quantification method according to Edwards' method[5,22-24]. These studies have observed that on-field referees (OFRs) spend approximately 95% of overall match time at over 80% maximum heart rate (HR_{max})[23], while assistant referees (ARs) spend around 50% of the time over this intensity[8,24]. Greater IML values have also been reported for OFRs compared to ARs in official national league matches using Edwards' method[5]. These differences in IML between OFRs and ARs may be due to the AR movement pattern, based on lateral movements and short accelerations and decelerations[1]. We do not know, however, if other IML quantification methods (e.g. Stagno's method) are sensitive to the differences found between OFRs and Ars.

To calculate the IML accumulated by OFRs and ARs in matches using the methods mentioned, the HR_{max} of individual referees is carefully taken as a reference[23,25,26] and from this value, the time spent in the different areas of intensity is determined. However, not all the studies published in the scientific literature use the same criterion to establish the individual HR_{max} of referees. While Boullosa *et al*. (2012) used the HR_{max} reached in an incremental field test (Yo-Yo intermittent recovery test level 1, YYIR1) for referees in non-professional Spanish league categories (regional and third division), other authors, such as Costa *et al*. (2013) or Castillo, Yanci *et al*. established the highest HR recorded in an actual match as the criterion for HR_{max}, in these cases with Brazilian referees and third division Spanish leagues referees, respectively. Due to the disparity of criteria used to establish individual HR_{max}, comparisons between results can be complicated. Comparisons of the results obtained in different studies are regularly made even though the method for determining HR_{max} is different, which may lead to major errors of interpretation. In this sense, it would be interesting to know if calculating the IML accumulated by football referees in official matches is conditioned by the criterion used to determine HR_{max}, that is to say, if the IML is different when different criteria are used to establish HR_{max}.

Therefore, the aims of this study were 1) to analyse the differences in internal load in official matches between on-field referees and assistant referees measured using different quantification methods, and 2) to find out if there are differences in the internal load using different criteria to determine individual HR_{max} (HR_{max} reached in an incremental text and HR_{max} reached in a match). The hypotheses established were, on the one hand, that the IML recorded using different load quantification methods is greater in OFRs than in ARs and, on the other, that, depending on the criterion used to determine HR_{max}, there could be differences in the magnitude of IML.

Material and method

Participants

41 referees belonging to the Navarre Committee of Football Referees who refereed Spanish league third division matches took part in the study. 21 of these were OFRs and 20 were ARs (Table 1). All the referees did at least three training sessions per week and refereed approximately three matches per month. The participants were informed of the procedures, methodology, benefits and possible risks of the study and signed an informed consent form. The study followed the guidelines set out in the Declaration of Helsinki (2013), was approved by the Ethics Committee for Research with Human Beings (CEISH) of the University of the Basque Country (UPV/EHU) and was carried out following the highest ethical standards established for research in sports and exercise science[27]. The associations were observed to be most likely (>99.5%) and very large-near perfect (r=0.76-0.93) in all the cases (Table 3).

Table 1. Characteristics of all the referees, on-field referees (OFRs) and assistant referees (ARs) taking part in the study.

	All (n = 41)	OFRs (n = 21)	ARs (n = 20)
Age (years)	26.95 ± 6.90	28.29 ± 6.44	25.55 ± 7.25
Weight (kg)	73.66 ± 7.75	72.81 ± 8.80	74.55 ± 6.57
Height (m)	1.77 ± 0.06	1.78 ± 0.07	1.77 ± 0.06
BMI ($kg \cdot m^{-2}$)	23.38 ± 2.13	22.96 ± 1.56	23.83 ± 2.58
Experience refereeing (years)	9.76 ± 5.70	11.52 ± 5.60	7.90 ± 5.31
Experience 3rd Division (years)	4.37 ± 4.75	4.38 ± 3.38	4.35 ± 5.95
$HR_{maxYYIR1}$ (ppm)	187.24 ± 7.86	185.57 ± 7.26	189.00 ± 8.27
$HR_{maxMATCH}$ (ppm)	173.63 ± 13.93	182.00 ± 8.82	164.85 ± 12.96
$\%HR_{maxYYIR1}$	92.78 ± 7.07	98.07 ± 2.69	87.23 ± 5.85

BMI: body mass index; $HR_{maxYYIR1}$: maximum heart rate reached in the test; $HR_{maxMATCH}$: peak heart rate reached in matches; % $HR_{maxYYIR1}$: percentage of the maximum heart rate in the test recorded during matches.

Procedure

This study recorded the physiological responses or IML of football referees who refereed 21 official matches of the Third Division Football League in Spain (Group XV). In order to calculate the IML for the matches, two different criteria were used to determine the individual HR_{max} for each referee, in an intermittent incremental field test ($HR_{maxYYIR1}$) conducted the week prior to the match, as well as the HR_{max} reached during the official match played ($HR_{maxMATCH}$). The HR values were recorded using the Polar Team 2 transmitter, strap and band (Polar Team System®, Kempele, Finland) with a sampling rate of 0.2 Hz. The participants were given instructions not to train during the 48 hours prior to the tests in order to avoid the effects of fatigue on the measurement results. The referees all had a similar diet based on 55% of total calories derived from carbohydrates, 25% fat and 20% protein. All the matches analysed were played on four pitches with similar dimensions and characteristics (100 x 64 m) and under non-adverse weather conditions (10-20 ºC). The scheduled time for all the matches played was 16:00 h.

Incremental field test to determine the HR_{max}

The YYIR1 test consisted in running back and forth a distance of 40 m (2 x 20 m) alternated with a 10 sec rest period in which the participants remained active by slow jogging, moving over a distance of 5 m. The running speed was progressively increased in unison with an audio signal that gradually reduced the time between the successive signals. The test ended for each participant when he was no longer able to cover the corresponding distance in the set time[28]. The maximum individual heart rate ($HR_{maxYYIR1}$) achieved by each referee in the test was recorded using Polar Team 2 heart rate monitors (Polar Team System®, Kempele, Finland).

Determination of HR_{max} at the matches

The HR at the official matches was recorded using Polar Team 2 heart rate monitors (Polar Team System®, Kempele, Finland). The highest HR achieved by each of the OFRs and ARs was taken as the HR_{max} of the match ($HR_{maxMATCH}$).

Determination of the internal match load

The IML was determined by the Edwards and Stagno methods, based on the individual HR_{max} reached at a given moment during the match (IML_{MATCH}) and also on the HR_{max} obtained in the YYIR1 test (IML_{YYIR1}).

Edwards Method

The IML measured by the Edwards method was calculated by multiplying the time spent at each effort intensity by a value assigned to each intensity (90-100% HR_{max}=5, 80-90% HR_{max}=4, 70-80% HR_{max} = 3, 60-70% HR_{max} = 2, 50-60% HR_{max} = 1). Subsequently the sum of all the values obtained was calculated, which represented the Edwards' value _IML[10,23], for both the $H_{RmaxMATCH}$ and the $HR_{maxYYIR1}$.

Stagno method

The IML measured by the Stagno method was calculated by multiplying the time spent at each effort intensity by a weighting factor for each intensity (93-100% HR_{max}=5.16, 86-92% HR_{max}=3.61, 79-85% HR_{max} = 2.54, 72-78% HR_{max} = 1.71, 65-71% HR_{max} = 1.25). The summation represented the Stagno's value _IML[11], for both the $HR_{maxMATCH}$ and the $HR_{maxYYIR1}$.

Statistical data analysis

The results are presented as a mean ± standard deviation (SD) of the mean. In order to determine the differences in the IML quantification methods (Edwards'_IML and Stagno's_IML) between OFR and AR or between the IML calculated by the different criteria for HR_{max}, we used the inference method proposed by Hopkins *et al*.[29] based on calculating the magnitudes of the differences (<0.2 low; 0.2-0.6 moderate, 0.6-1.2 high; 1.2-2.0 very high; >2.0 extremely high). Furthermore, 90% of the confidence limit was calculated (±90% CL) and the probability that the differences were true, based on the following ranges: 25–75%, possible 75–95%, probable; 95–99,5%, very probable; >99,5%, extremely probable[29]. On the other hand, we calculated the association between the IML values obtained based on the different criteria for HR_{max} through Pearson's correlation (r). To interpret the magnitudes of correlation between the IML quantification methods, the following scale was used: less than 0.1, trivial; 0.1 to 0.3 low; 0.3 to 0.5 moderate; 0.5 to 0.7 high; 0.7-0.9 very high; greater than 0.9, almost perfect [29]. Moreover, ±90% CL was calculated and the probability of true associations[29]. We also calculated the regression formula between the IML methods, based on HRmax achieved during the match (Edwards'_IML_{MATCH} and Stagno's_IML_{MATCH}) and the IML methods based on HR_{max} achieved in the YYIR1 (Edwards'_IML_{YYIR1} and Stagno's_IML_{YYIR1}) for the entire sample for the OFRs and ARs. The statistical analysis was made with the *Statistical Package for Social Sciences program* (SPSS Inc, versión 23,0 Chicago, IL, EE.UU.).

Results

The differences between $HR_{maxYYIR1}$ and $HR_{maxMATCH}$ were moderate and probable for OFR (-0.47; 0, ±56) and extremely probable and very high for AR (-2.80; ±0.68). Table 2 shows the differences recorded in the quantification methods for the internal load (Edwards'_IML_{MATCH}, Stagno's_IML_{MATCH}, Edwards'_IML_{YYIR1}, Stagno's_IML_{YYIR1}) between OFRs and ARs. The results obtained show that the OFRs recorded higher IML values (extremely probable and extremely high) than the ARs in both quantification methods. On the other hand, moderate, high and very high differences were observed in the IML quantification methods (Edwards'_IML and Stagno's_IML) using different criteria to determine the individual HR_{max} ($HR_{maxMATCH}$ or $HR_{maxYYIR1}$) for all participants, and also for OFR and for AR (Table 2).

Table 3 shows the associations between the IML methods based on HR_{max} achieved during the match (Edwards'_IML_{MATCH} and Stagno's_IML_{MATCH}) and the IML methods based on HR_{max} achieved in the

Table 2. Results obtained in internal load quantification for all the participants, on-field referees (OFRs) and assistant referees (ARs).

Methods	All	OFRs ARs	Differences OFR-AR	Effect size (%; ±90% CL)	OFR-AR; ±90% CL/Likelihoods
Edwards'_IML$_{MATCH}$ (AU)	348.06 ± 58.35	383.50 ± 33.65	310.84 ± 55.95	-19.8; ±55.9	-2.08; ±0.70 / ****
Edwards'_IML$_{YYIR1}$ (AU)	291.43 ± 91.69	363.68 ± 36.57	215.57 ± 66.83	-43.2; ±7.5	-3.90; ±0.76 / ****
Differences MATCH-YYIR1 (%; ±90% CL)	-32.0; ±9.9	-5.1; ±5.0	-34.1; ±9.4		
Effect size MATCH-YYIR1; ±90% CL/Likelihoods	-0.95; ±0.48 / ***	-0.57; ±0.52 / **	-1.63; ±0.56 / ****		
Stagno's_IML$_{MATCH}$ (AU)	254.67 ± 67.05	304.20 ± 40.22	202.67 ± 46.96	-34.6; ±7.0	-2.43; ±0.55 / ****
Stagno's_IML$_{YYIR1}$ (AU)	194.14 ± 103.92	278.52 ± 50.17	105.54 ± 62.87	-68.3; ±8.7	-3.32; ±0.58 / ****
Differences MATCH-YYIR1 (%; ±90% CL)	-54.7; ±13.3	-9.1; ±8.3	-57.5; ±12.2		
Effect size MATCH-YYIR1; ±90% CL/Likelihoods	-0.89; ±0.47 / ***	-0.61; ±0.57 / **	-1.99; ±0.61 / ****		

CL: confidence limits; ES: effect size; Edwards'_IML$_{MATCH}$: internal match load quantified with Edwards' method based on peak heart rate reached during matches; Stagno's_IML$_{MATCH}$: internal match load quantified with Stagno's method based on peak heart rate reached during matches; Edwards'_IML$_{YYIR1}$: internal match load quantified with Edwards' method based on maximum heart rate reached in the Yo-Yo intermittent recovery test level 1; Stagno's_IML$_{YYIR1}$: internal match load quantified with Stagno's method based on maximum heart rate reached in the Yo-Yo intermittent recovery test level 1; AU: arbitrary units.

Interpretation of likelihoods: *possible (25%-75% [probability that the true correlation is…] **likely (75%-95%); ***very likely (95%-99.5%); ****most likely (>99.5%).

Table 3. Association (r; ± confidence limit (CL), interpretation and likelihoods) and regression formula between the internal match load methods based on the maximum heart rate reached in matches (Edwards'_IML$_{MATCH}$ and Stagno's_IML$_{MATCH}$) and the internal match load methods based on the maximum heart rate reached in the Yo-Yo intermittent recovery test level 1 (Edwards'_IML$_{YYIR1}$ and Stagno's_IML$_{YYIR1}$) in the total sample, in on-field referees (OFRs) and assistant referees (ARs).

Methods	Edwards'_IML$_{MATCH}$				Stagno's_IML$_{MATCH}$			
	Edwards'_CIP$_{YYIR1}$		Stagno's_CIP$_{YYIR1}$		Edwards'_IML$_{YYIR1}$		Stagno's_IML$_{YYIR1}$	
Referees	r; ± 90% CL	Regression formula	r; ± 90% CL	Regression formula	r; ± 90% CL	Regression formula	r; ± 90% CL	Regression formula
All	0.88; ±0.06 *** VL. 100/0/0	y = 185.12 + 0.56x + 28.23	0.86; ±0.07 *** VL. 100/0/0	y = 254.15+ 0.48x +30.01	0.93; ±0.04 *** NP. 100/0/0	y = 55.89+ 0.68x + 24.48	0.93; ±0.04 *** NP. 100/0/0	y = 138.25 + 0.60x + 25.06
OFRs	0.82; ±0.06 *** VL. 100/0/0	y = 107.54 + 0.76x + 19.53	0.76; ±0.17 *** VL. 100/0/0	y = 241.79 + 0.51x + 22.49	0.87; ±0.10 *** VL. 100/0/0	y = 43.33 + 0.96x + 20.43	0.82; ±0.13 *** VL. 100/0/0	y = 121.39 + 0.66x + 23.69
ARs	0.81; ±0.14 *** VL. 100/0/0	y = 164.77 + 0.68x + 33.76	0.82; ±0.14 *** VL. 100/0/0	y = 234.13 + 0.73x + 33.17	0.84; ±0.13 *** VL. 100/0/0	y = 76.16 + 0.59x + 26.53	0.83; ±0.13 *** VL. 100/0/0	y = 137.89 + 0.61x + 27.49

Interpretation of likelihoods: *possible (25%-75% [probability that the true correlation is…] **likely (75%-95%); ***very likely (95%-99.5%); ****most likely (>99.5%).
Magnitude of correlations: T: trivial; S: small; M: moderate; L: large; VL: very large; NP: near perfect.

YYIR1 (Edwards'_IML$_{YYIR1}$ and Stagno's_IML$_{YYIR1}$) for all the referees, and also for the OFRs and ARs. It was observed that the associations were extremely probable (>99.5%) and very high almost perfect (r=0.76-0.93) in all cases (Table 3).

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Discussion

The aims of this study were 1) to analyse the differences in internal load in official matches between on-field referees and assistant referees measured using different methods of quantification, and 2) to find out if there are differences in the internal load using different criteria to determine individual HR$_{max}$ (HR$_{max}$ reached in an incremental text and HR$_{max}$ reached in matches). The main results show that the OFRs reported higher values of IML than the ARs, both when calculated using Edwards' IML method and when calculated using Stagno's IML method. Meanwhile, even though large-very large-extremely large differences were observed in the IML calculated using the different criteria to determine individual HRmax (HR$_{maxMATCH}$ and HR$_{maxYYIR1}$), associations between the two methods were very large and near perfect for all the participants,

OFRs and ARs. The chief finding of this research is the large association observed between the two IML quantification methods, meaning that either can be used, provided that one is consistent and that results obtained using different criteria are not compared.

OFRs and ARs are in charge of controlling the behaviour and conduct of players during matches. To meet their function on the field of play, each needs to play a different role, the ARs having their activity limited to half the pitch in order to judge, above all, offsides and the OFRs moving all over the pitch to call the infringements that occur during the match. This fact, coupled with the fact that OFRs register higher values in the external load indicators (e.g., total distance covered, number of accelerations and decelerations, changes of direction, etc.)[5,7,9], may have led the ARs to register lower IML values than the OFRs with the methods used in this study. These results are consistent with those observed by Castillo, Weston, *et al*. (2016) with non-professional referees, because they also noted that the IML of OFRs is greater than that of ARs. Other studies have also observed higher HR_{max} values in national professional OFRs compared to ARs, albeit not in IML values but in certain HR parameters[8,26]. Other research with national referees has observed that OFRs record HR values that correspond to 87% of HR_{max} while ARs obtain values of 78% HR_{max}[26]. In the same vein, it has been observed that OFRs spend more time over 90% HR_{max} than ARs (35 *vs.* 15 min.)[24]. Given that both the IML and the external load factors, such as the distance covered at high speeds (OFRs = 2783 ± 630 m *vs*. ARs = 793 ± 268 m), recorded by OFRs and ARs during matches are different, mainly due to the roles they play and the limits of the playing field[1], it would be interesting to implement different training protocols for OFRs and ARs based on the specific demands of match situations and, in this way, programme the most suitable training loads and recovery strategies on the basis of IML.

Many scientific studies use different methods to determine the HR_{max} with which to calculate IML[8,22,28]. Normally, the results obtained in the different studies are compared with each other even though HRmax has been obtained using different criteria. This could generate a problem because to date we do not know if the IML values are the same when different criteria to determine HR_{max} are used. In the present study, it has been observed that despite the differences in IML (both in Edwards'_IML and in Stagno's_IML) calculated on the basis of HR_{max} reached in YYIR1 and in matches, both in OFRs and ARs, the associations between the IML quantification methods using different criteria for determining HR_{max} are very large-near perfect (r = 0.76-0.93). This is the first study to analyse the influence of the HR_{max} calculation criterion on IML. The results obtained in our study show that the criterion to determine HR_{max} reached in YYIR1 or in matches influences the magnitude of IML. In this regard, it should be noted that the percentage of HR_{max} reached in tests with respect to that registered during matches (%$HR_{maxYYIR1}$) is greater in OFRs than in ARs, meaning that the criterion of HR_{max} used may determine differences in IML. This shows that it may not be appropriate to compare IML values measured using different HR_{max} determination methods. However, the IML values obtained from $HR_{maxMATCH}$ show a large-very large-extremely large association with the IML values obtained on the basis of $HR_{maxYYIR1}$. The strong associations observed between the two criteria for determining HR_{max} ($HR_{maxMATCH}$ and $HR_{max\ YYIR1}$) to quantify IML, both with Edwards'_IML method and Stagno's_IML method, reveal that either of these methods to quantify IML can be used for football referees during matches since they provide similar information, but that it is not appropriate to compare IML results obtained using different criteria.

Conclusions

The main conclusions of this study were 1) that OFRs record higher IML values than ARs when measured with different methods (Edwards'_IML and Stagno's_IML), and 2) that the large-very large-extremely large differences and the very large and near perfect associations between the IML quantification methods (Edwards'_IML and Stagno's_IML) using different criteria to determine individual HR_{max} ($HR_{maxMATCH}$ and $HR_{maxYYIR1}$) with all the referees, both OFRs and ARs, suggests, on the one hand, that it may not be appropriate to compare IML results calculated using different individual HR_{max} determination criteria and, on the other, that either of these criteria is valid to determine HRmax in order to quantify IML with either Edwards'_IML method or Stagno's_IML method.

Our thanks to:

The Navarre Committee of Football Referees (CNAF) for its involvement and collaboration in this research project.

Grant

This project was funded by the Basque Government through the Department of Education, Language Policy and Culture's Non-PhD Research Staff Training Programme.

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Regional adiposity and cardiorespiratory fitness related to fat percentage in amateur cyclists

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Received: 08.01.2018
Accepted: 11.01.2018

Summary

Introduction: Regional adiposity monitoring can detect patterns related to sports performance. The objective of this study is to determine the degree of sensitivity and specificity of skinfolds in relation to a percentage of body fat, estimated as ideal for a particular sport modality, as well as other ergometric variables.
Material and method: Participated in the study 136 male, *amateur* cyclists, ranging 40-60 years old, with a weight: 72.8 ± 8.5 kg, height: 169.5 ± 6.5 cm, BMI of 25.6 ± 2.3 kg/m^2 A total of annual covered km of 8372.9 ± 3429.6. Were analyzed 8 skinfold (tríceps, subscapular, bicipital, crestal, ileospinal, abdominal, anterior thigh and medial calf) under ISAK guidelines. Also were collected the maximum load achieved (W), the VO_{2max} and the ergometric index. Variable associations were performed using the correlation coefficient of Spearman. Ten percent fat mass was established as ideal for this type of athletes. We analyzed the sensitivity and specificity in relation to the percentage of ideal fat using ROC curves, according the best cut-off point by the Youden index.
Results: The values of sensitivity and specificity (S/E) are greater for the subscapular skinfold: 93/89 and ileospinal: 100/78 compared with those of the limbs. There are inverse correlations of fat mass with covered km/year (r=-0.27, p=0.0017), with maximal aerobic power (r=-0.33, p=0.0001), Ergometric index (r=-0.59, p<0.0001) and VO_{2max} (r=-0.28, p=0.0006).
Conclusions: Subscapular and ileospinal skinfolds have a great sensitivity and specificity to discriminate adequate body fat percentage in *amateur* cyclists and are more sensitive the trunk skinfolds than those of the limbs. Also emphasize the body mass index and ergometric index.

Key words:
Fat mass percentage. Skinfolds. Graded exercise test. ROC curves.

Adiposidad regional y *fitness* cardiorrespiratorio en relación al porcentaje de grasa ideal, en ciclistas *amateur*

Resumen

Introducción: La monitorización de la adiposidad regional puede detectar patrones que se relacionan con el rendimiento deportivo. El objetivo del presente trabajo es determinar el grado de sensibilidad y especificidad de los pliegues cutáneos de grasa en relación a un porcentaje de grasa corporal, estimado como ideal para una práctica deportiva determinada, así como otras variables ergométricas.
Material y método: Participaron en el estudio 136 ciclistas *amateur,* varones, entre 40-60 años, con un peso de 72,8 ± 8,5 kg, talla de 169,5 ± 6,5 cm, IMC de 25,6 ± 2,3 kg/m^2 un total de km anuales recorridos de 8.372,9 ± 3.429,6. Se analizaron los datos de los pliegues tricipital, subescapular, bicipital, crestal, ileospinal, abdominal, muslo anterior y medial de la pierna, bajo las recomendaciones de la ISAK. Igualmente se recogieron datos de la carga máxima alcanzada, el VO_{2max} y el índice ergométrico. Se realizaron asociaciones de variables mediante los coeficientes de correlación de Spearman. El valor de 10% de masa grasa fue el establecido como ideal para este tipo de deportistas. Se analizaron la sensibilidad y la especificidad en relación al porcentaje de grasa ideal mediante curvas ROC, designando el mejor punto de corte mediante el índice de Youden.
Resultados: Los valores de sensibilidad y especificidad (S/E) son mayores para los pliegues subescapular: 93/89 e ileospinal: 100/78 comparado con los de los miembros inferiores. Existen correlaciones inversas de la masa grasa con los km recorridos/año (r=-0,27, p=0,0017), con la potencia aeróbica máxima (r=-0,33, p=0,0001), el índice ergométrico (r=-0,59, p<0,0001) y el VO_{2max} (r=-0,28, p=0,0006).
Conclusiones: El pliegue subescapular e ileospinal poseen una gran sensibilidad y especificidad para el diagnóstico discriminante de unos valores adecuados de grasa corporal en ciclistas aficionados y son más sensibles los pliegues del tronco que los de los miembros. Así mismo destacan el índice de masa corporal y el índice ergométrico.

Palabras clave:
Porcentaje de grasa. Pliegues cutáneos. Ergometría. Curvas ROC.

Award for the Best Oral Communication of the VII Jornadas Nacionales de Medicina del Deporte. Zaragoza. 24-25 November 2017.

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Introduction

Monitoring body composition and particularly regional adiposity can identify patterns related to sports performance. Although body composition can be a reflection of numerous factors not related to physical activity and training, many acknowledge that certain specific conditions of low or high adiposity alone can be influential in many different sports and in the performance of athletes in competitions[1].

Having information on the regional adiposity and body composition profiles of sportsmen and women can be very useful for coaches, for example to improve their athletes' development programmes and permit longitudinal monitoring of changes in their body composition, which may reflect sports fitness. Maintaining an ideal body composition over the year can help ensure performance in an athlete's sport and also serve as a means of controlling his/her health and well-being.

Similarly, long-term aerobic training produces not only physiological changes in the aerobic metabolism, but also general and regional body composition changes, and differences according to sex can be found[2,3]. Improvements and positive effects in fat distribution have also been detected when comparing continuous aerobic exercise with high-intensity exercise routines after 12 weeks of training, this study finding that work capacity improved with both types of exercise, that there were no differences in abdominal or gluteal circumference, and no differences were found in lipid and biochemical variables[4]. According to the 2015 Spanish survey of sport habits, cycling is a very popular activity in the country, with about 22.2% of the population cycling at least once a week[5].

The aim of this study was to determine the degree of association between fat mass and parameters of aerobic condition in non-professional male distance cyclists and to determine the sensitivity and specificity of the fat skinfolds and aerobic fitness factors in relation to a percentage of total body fat estimated as ideal for the type of sport studied.

Material and method

136 amateur male cyclists aged between 40 and 60, weighing 72.8 ± 8.5 kg, measuring 169.5 ± 6.5 cm and with a BMI of 25.6 ± 2.3 kg/m^2, who cycled a total of 8,372.9 ± 3,429.6 km a year took part in this cross-sectional study.

Their anthropometric data were obtained using a sports-medicine study protocol: weight, height and skinfolds (triceps, subscapular, biceps, iliac crest, iliac spine, abdomen, front thigh and medial calf) taken by the same researcher with a Slim guide calliper accurate to 1 mm, following the recommendations of the ISAK[6,7]. Fat mass was estimated by the sum of 4 folds: triceps, subscapular, iliac spine and abdomen, applying Faulkner's equation[8], respecting the recommendations of the consensus document.

Values were also obtained for maximum aerobic power (in watts) and ergometric index (watts/kg), and estimated values of VO_{2max} were arrived at using the heart rate relationship method and Uth's equation[9] following a staged stress test on a Monark 818E mechanical cycle ergometer (Sweden). The stress test consisted of a 10-minute warm-up at 50 W before testing actually began with increases of 25 W/min until exhaustion. The heart rate was determined on a continuous basis simultaneously through an electrocardiographic monitoring system (Hellige, Germany) and a Polar heart rate monitor (Polar, Finland). The ergometric index was calculated using the equation: peak watts reached during ergometry/body weight (kg).

Statistical analysis

The data are expressed as the mean ± standard deviation. The normal distribution of the variables was tested using the Kolmogorov-Smirnov test. Rank correlation between the variables was analysed using Spearman's rho. Sensitivity and specificity were analysed in relation to the ideal fat percentage using ROC curves and designating the optimal cut-off point using the Youden index. The value of 10% fat mass for Faulkner's equation was categorized for subsequent statistical analysis as the value established as ideal for this type of male athlete10. The data were processed using MedCalc version 17.8 for Windows. The accepted level of significance was $p < 0.05$ in all cases.

Results

Fat mass has a low-moderate inverse relationship with km covered annually, VO_{2max}, the ergometric index and maximum aerobic power, all of these relationships being significant ($p<0.05$). Meanwhile, fat mass has a direct relationship with body weight ($p<0.001$) (Table 1).

Correlations with km cycled per year

The trunk skinfolds (iliac crest, iliac spine and abdomen) reveal significant inverse relationships with km covered (r= between -0.24 and 0.34, all $p<0.05$), while no significant correlation was found with the limb skinfolds ($p>0.05$) (Table 2).

Table 1. Spearman's rank correlation coefficients between fat mass and demographic and ergometric variables.

		HRmax (ppm)	Age (years)	km (year)	Weight (kg)	Erg Ind (W/kg)	VO_{2max} (mL/kg/min)	MAP (W)
FM	r	-0.052	0.158	-0.27	0.385	-0.595	-0.289	-0.337
(%)	p	0.551	0.066	0.0017	<0.0001	<0.0001	0.0006	0.0001

r: correlation coefficient; p: level of significance; MAP: Aerobic power in W; Erg Ind: Ergometric index; VO_{2max}: Estimated maximal oxygen uptake (mL/kg/min); FM: fat mass.

Correlations with maximum aerobic power

All the skinfolds showed significant inverse correlations ($p<0.05$), except the medial calf skinfold ($p>0.05$) (Table 2).

ROC curves

Greater sensitivity and specificity values were obtained for the trunk skinfolds than the limb skinfolds. The Youden index values were higher for the trunk skinfolds (Table 3) than the limbs (Figure 1). The subscapular skinfold is particularly worthy of note for its greater sensitivity and specificity (Table 3).

Table 4 shows the sensitivity and specificity values relating to the ROC curves of certain physiological variables. The variables with the highest sensitivity and specificity values are the body mass index and the ergometric index (Figure 1).

Discussion

To our knowledge, this is the first study to analyse the sensitivity and specificity of anthropometric variables, such as individual fatfolds and functional parameters, in order that they be discriminated by an

Table 2. Correlation coefficients and significance between trunk and limb skinfolds and physiological variables.

		Trunk skinfolds				Limb skinfolds			
		SBSC	CRES	SPIN	ABD	TRI	BIC	MCAL	THI
km year	r	-0.086	-0.273	-0.246	-0.341	-0.104	-0.112	-0.148	-0.086
	p	0.3267	0.0015	0.0043	0.0001	0.2345	0.1997	0.0893	0.3293
MAP	r	-0.398	-0.246	-0.262	-0.20	-0.274	-0.303	-0.152	-0.214
	p	<0.0001	0.0039	0.0021	0.0197	0.0013	0.0003	0.0792	0.0128
Erg Ind	r	-0.544	-0.533	-0.442	-0.564	-0.365	-0.469	-0.234	-0.2
	p	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0064	0.02
VO_{2max}	r	-0.209	-0.283	-0.214	-0.288	-0.19	-0.298	-0.14	-0.126
	p	0.0144	0.0009	0.0122	0.0007	0.0271	0.0004	0.1056	0.1445
FM	r	0.823	0.811	0.893	0.891	0.691	0.742	0.567	0.584
	p	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Weight	r	0.126	0.382	0.325	0.475	0.243	0.262	0.133	0.067
	p	0.1431	<0.0001	0.0001	<0.0001	0.0043	0.002	0.1232	0.435

MAP: Aerobic power in W; Erg Ind: Ergometric index; VO_{2max}: Estimated maximal oxygen uptake (mL/kg/min); FM: fat mass; SBSC: Subscapular; CRES: Iliac crest; SPIN Iliac spine; ABD: Abdomen; TRI: Triceps; BIC: Biceps; MCAL: Medial calf; THI: Front thigh.

Table 3. Sensitivity and specificity of fatfolds for the diagnosis of the ideal percentage of body fat.

Fold	*Cut-off*	Sens	95% CI	Spec	95% CI	+LR	95% CI	-LR	95% CI	*Youden Index*
ABD	>12	85.61	78.4-91.1	88.89	51.8-99.7	7.7	1.2-49.0	0.16	0.1-0.3	0.74
SBSC	>8	93.18	87.5-96.8	88.89	51.8-99.7	8.39	1.3-53.3	0.077	0.04-0.2	0.83
CRES	11	87.88	81.1-92.9	88.89	51.8-99.7	7.91	1.2-50.2	0.14	0.08-0.2	0.77
SPIN	>5	100	97.2-100	77.78	40.0-97.2	4.5	1.3-15.3	0		0.78
TRI	>7.5	55.3	46.4-64.0	100	66.4-100			0.45	0.4-0.5	0.55
BIC	>3	78.03	70.0-84.8	88.89	51.8-99.7	7.02	1.1-44.7	0.25	0.2-0.4	0.67
THI	>10	71.76	63.2-79.3	88.89	51.8-99.7	6.46	1.0-41.1	0.32	0.2-0.5	0.61
MCAL	>5.5	77.69	69.6-84.5	66.67	29.9-92.5	2.33	0.9-5.9	0.33	0.2-0.6	0.44

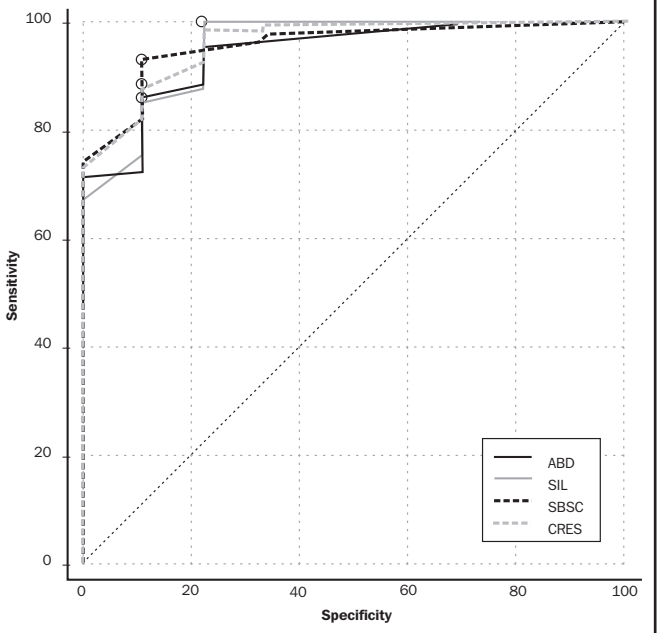
ABD: Abdomen; SBSC: Subscapular; CRES iliac crest; SPIN: Iliac spine; TRI: Triceps; BIC: Biceps; THI: Front thigh; MCAL: Medial calf.

Table 4. Sensitivity and specificity of physiological variables for the ideal percentage of body fat.

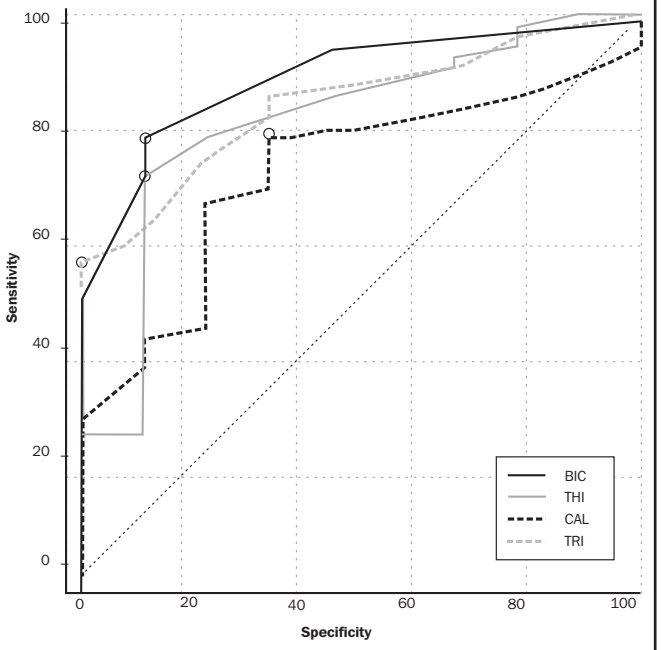
Fold	*Cut-off*	Sens	95% CI	Spec	95% CI	+LR	95% CI	-LR	95% CI	*Youden Index*
km/year	>8000	45.6	36.7-54.7	75	34.9 - 96.8	1.82	0.5-6.2	0.73	0.5-1.1	0.20
VO_{2max}	≤43.59	54.69	45.7-63.5	100	63.1 - 100			0.45	0.4-0.5	0.55
BMI	>23.57	87.5	80.5-92.7	75	34.9 - 96.8	3.5	1.1-11.6	0.17	0.09 0.3	0.62
ERGI	4.98	83.59	76.0-89.5	75	34.9 - 96.8	3.34	1.0-11.1	0.22	0.1-0.4	0.58

VO_2: VO_{2max}; BMI: Body mass index; ERGI: Ergometric index.

Figure 1. Top: ROC curves for the trunk skinfolds (abdomen, supraspinal, subscapular and iliac crest). Bottom: ROC curves for the limb skinfolds (biceps, front thigh, medial calf and triceps).



ABD: Abdomen; SIL: Supra-iliac; SBSC: Subscapular; CRES: Iliac crest



BIC Biceps; THI: Front thigh; CAL: Calf; TRI: Triceps

ideal fat weight value for a highly popular sport and to determine their relationship with aerobic fitness variables.

In this sense, the results can be considered relevant for coaches, technicians and athletes as a way to control changes related to training and physical activity. This cross-sectional study is limited insofar as discovering the influence and effects of the volume of training is concerned, as only a longitudinal intervention study could reach any conclusions in this regard.

The data obtained in this study are an analysis of the relationship between fat mass, individual skinfolds and the performance values obtained in a physiology laboratory, and variables resulting from the effect of the training load on regional body composition variables. We also believe that comparing these same variables with performance variables on flat and rising terrain could be of great interest and could shed light on the relationships between fat deposits and the effects of air resistance (on flat terrain) and those situations in which gravity plays a greater role (uphill terrain). The relationships between adiposity and performance are well known, adiposity explaining many of the associations between physical activity and physical fitness in active men, as well demonstrated by Serrano *et al.*, who showed that adiposity and age were strong predictors of VO_{2max}, and that the energy spent in vigorous activities was inversely proportional to adiposity[11].

This correlational study could provide us with evidence of the effect of continuous exercise and training on total body fat values or regional adiposity patterns. The relationship between skinfolds and fat mass was in all cases both direct and significant, although the correlation values were greater in the trunk skinfolds than the limb skinfolds. We believe that this was due to the fact that the study was carried out on a sample of males and it has been well established that for reasons of sexual dimorphism, there exists a greater fat deposition on the trunk in male subjects[12,13] than on the limbs and, therefore, the distance covered, the maximum aerobic power values and the ergometric index have to some extent a greater relationship with the trunk skinfolds. It would appear that continuous aerobic exercise has a greater effect on the trunk skinfolds than on those on the limbs, with the consequent beneficial effect of lower trunk fat and, as a result, a reduction in the cardiovascular and metabolic risks associated with this factor[14]. Similarly, there exist correlations between skinfolds and body weight for all the skinfolds, those on the trunk being stronger.

In their longitudinal intervention study of physical exercise, Keating et al. compared a form of continuous exercise with a form of high intensity interval training, discovering that continuous exercise performed at an intensity of between 50 and 65% VO_{2max} produced a significant drop in trunk fat and visceral fat, something which was not observed in the HIIT group[4]. These results fall in line with the data obtained in this study, because presumably the type of activity carried out by the subjects of study was performed at low intensities, promoting the chronic activity of lipolysis mediated by hormones over many years, with the subsequent increased availability of fatty acids, in conjunction with a greater metabolism, resulting in a greater uptake and oxidation of fatty acids[15].

Other authors have also found a relationship between training load, fat mass and body weight. A decrease in body weight has been related to a loss of fat weight and an increase in physical activity[16].

Meanwhile, other authors have found no relationship between training load and fat level[2]. Knechtle did not find significant correlations between running time and fat percentage or between fat percentage and the number of km covered per week.

The reduction of fat mass, also known as "non-functional mass", and an increase in fat-free mass is related to enhanced performance and this would be consistent with the data obtained in this study[17].

In the study, age shows direct but not significant correlations with fatfolds. This may be due to the fact that athletes of this kind, highly accustomed to an annual training routine, always maintain very similar regional fat deposit and total body fat values over time[2, 18].

There are no studies of sensitivity and specificity using ROC curves to discriminate ideal body fat values. The most specific and sensitive skinfolds are the subscapular skinfold with a cut-off point of 8 mm and the iliac crest skinfold with 11 mm. Among other variables analysed, the body mass index gave a cut-off point of 23.57 kg/m^2 and an ergometric index of 4.98 W/kg. These associated cut-off points could be considered very suitable values of adiposity and cardiorespiratory fitness for amateur cyclists aged from 40 to 60, and could be used to evaluate cyclists in this age range. Some of the statements made may be speculative and more research into these relationships with longitudinal studies is needed.

Conclusions

The greatest strength of this study lies in the potential usefulness of the different cut-off points for coaches and athletes. The subscapular and iliac crest skinfolds are very sensitive and specific for discriminating appropriate body fat values and body mass and ergometric indices in amateur cyclists. This correlational study provides us with evidence of the effect of continuous training exercise on body fat values.

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Acute effects of badminton practice on the surface temperature of lower limbs Introduction

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Received: 08.01.2018
Accepted: 18.01.2018

Summary

Introduction: The objective was to evaluate the effect of badminton training on the skin temperature of lower limbs and the possible asymmetries derived from the one-sidedness of the sport.
Material and method: 19 badminton players participated in the study (Age: 34.4±14.1 years, Height: 168.1±7.8 cm, Body mass: 66.2±13.9 kg). Each player was tested before and after performing a 2-hour standardized badminton workout. To record body temperature, a VARIOCAM® HR model thermographic camera was used. The images of the anterior and posterior parts of the lower limbs were divided into three zones (thigh, knee and leg).
Results: The mean temperature of the dominant lower limb was higher after training in the anterior knee (pre=31.52±0.91 ºC *vs* post=32.15±0.51 ºC, P=0.003) and in the anterior leg=32.10±0.75 ºC *vs* post=32.81±0.73 ºC, P<0.001). In the non-dominant lower limb an increase after training was recorded in the medial temperature in the anterior thigh area (pre=32.15±0.85 ºC *vs* post=32.50±0.52 ºC, P=0.018), in the anterior area of the knee (pre=31.55±0.91 ºC *vs* post=32.26±0.56 ºC, P<0.001), in the anterior area of the leg (pre=32.22±0.76 ºC *vs* post=32.80±0.74 ºC, P<0.001) posterior of the leg (pre=32.13±0.69 ºC *vs* post=32.50± 0.65 ºC, P=0.006). No differences were found in the surface temperature between the dominant and non-dominant lower limbs at any instant or in the analyzed area.
Conclusions: The results show that the anterior regions of the knee and leg in both lower limbs and the anterior region of the thigh and posterior leg in the non-dominant lower limb are those that show a greater increase in temperature after a training of badminton should be where they focus more attention in the recovery period and in the return to calm after training.

Key words:
Lower extremity. Thermography. Badminton.

Efectos agudos de la práctica del bádminton sobre la temperatura superficial de los miembros inferiores

Resumen

Introducción: El objetivo fue evaluar el efecto de un entrenamiento de bádminton sobre la temperatura superficial de los miembros inferiores y las posibles asimetrías derivadas de la unilateralidad del deporte.
Material y método: 19 jugadores de bádminton participaron en el estudio (Edad: 34,4±14,1 años, Estatura: 168,1±7,8 cm, Masa corporal: 66,2±13,9 kg). Cada jugador fue analizado antes y después de realizar un entrenamiento de bádminton estandarizado de 2 horas. Para registrar la temperatura corporal se utilizó una cámara termográfica VARIOCAM® modelo HR. Se tomaron las imágenes de la parte anterior y posterior de los miembros inferiores divididos en tres zonas (muslo, rodilla y pierna).
Resultados: La temperatura media del miembro inferior dominante fue mayor después del entrenamiento en la zona anterior de la rodilla (pre=31,52±0,91 ºC *vs* post=32,15±0,51 ºC; p=0,003) y en la zona anterior de la pierna (pre=32,10±0,75 ºC *vs* post=32,81±0,73 ºC; p<0,001). En el miembro inferior no dominante se registró un incremento después del entrenamiento en la temperatura media en la zona anterior del muslo (pre=32,15±0,85 ºC *vs* post=32,50±0,52 ºC; p=0,018), en la zona anterior de la rodilla (pre=31,55±0,91 ºC *vs* post=32,26±0,56 ºC; p=0,001), en la zona anterior de la pierna (pre=32,22±0,76 ºC *vs* post=32,80±0,74 ºC; p<0,001) y en la zona posterior de la pierna (pre=32,13±0,69 ºC *vs* post=32,50±0,65 ºC; p=0,006). No se encontraron diferencias en la temperatura superficial entre el miembro inferior dominante y no dominante en ningún instante ni zona analizada.
Conclusiones: Los resultados muestran que las regiones anteriores de la rodilla y de la pierna en ambos miembros inferiores y la región anterior del muslo y posterior de la pierna en el miembro inferior no dominante son las que muestran un mayor incremento de temperatura tras un entrenamiento de bádminton debiendo ser en ellas donde recaiga mayor atención en el periodo de recuperación y en la vuelta a la calma después del entrenamiento.

Palabras clave:
Extremidades inferiores. Termografía. Bádminton.

Special Award for Oral Communication of the VII Jornadas Nacionales de Medicina del Deporte. Zaragoza, 24-25 November 2017

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Introduction

Badminton is one of the most popular sports in the world with around 150 million players, according to the figures provided by the International Badminton Federation. It is characterised as a unilateral sport with short, continuous movements, jumping actions, changes of direction and rapid arm movements in a wide range of body postures, with the aim of returning the shuttlecock[1]. The unilateral nature of badminton, both in the lower and upper limbs, may result in changes in the muscle and tendon architecture which could be detrimental in the long term[2,3].

Badminton injuries constitute between 1% and 5% of all sports injuries[4-6]. The injury rate for badminton is between 2.9 and 5.0 per 1,000 playing hours[7], which is far lower than the incidence injury rates for contact sports, such as football[8], rugby[9] and basketball[10], with rates of more than 10 injuries per 1,000 playing hours. In contrast to other sports, the injury rate in badminton is greater during training than at matches[11], with minor injuries being the most common. Out of all the injuries, those caused by overuse are approximately three times higher than traumatic injuries, both at matches and during practice sessions[12]. Categorising the injury rate by location, the highest rates are for the lumbar spine, knee joint and shoulder joint on the dominant side[12].

Thermography is a non-invasive technique that makes it possible to visually represent the entire process, during and after exercise. This device permits a quantitative, accurate evaluation of the spatial distribution of the skin temperature, and the evolution time, permitting a data recording speed of up to 100 Hz[13]. Thermography is widely used for medical diagnostic analyses and is being increasingly used to record physical exercise-associated skin temperature changes[13], while it is valid for detecting possible sports injuries by showing alterations in the temperature of the tissues involved[14]. The type of thermal alteration will depend on the intensity of the biological phenomenon that is occurring and the size and depth of the tissue involved. For example, due to the low heat transfer capacity of fat, the mean temperature will be lower in individuals with high adiposity[15]. The most important uses of thermography in the area of sports are the prevention and monitoring of injuries; the detection of muscle imbalances; the quantification of the thermal response to the training load; the detection of delayed onset muscle soreness and the lactate threshold; and the evaluation of fitness and performance[16]. However, we have found no studies in the literature that address any of these aspects in relation to badminton.

Finally, considering the concept of anatomical proportionality, the thermal response between contralateral body parts is expected to be symmetrical in baseline conditions[16]. Thermal monitoring that compares bilateral body parts indicates that differences of up to 0.25-0.62 ºC[17,18] are considered normal. However, differences that are above these values may indicate problems in the region of interest examined: a higher temperature, contrasted with the individual's usual thermal profile, may correspond to an inflammatory problem, while a temperature below the normal value may represent a degenerative problem[19,20]. It is important to be aware that thermography can be an indication of the existence of a thermal abnormality in the tissue characteristics, but it can never serve as an anatomic descriptor of the same[20]. To date, although studies have been conducted on potential muscle asymmetries in order to assess the physical condition of athletes in bilateral sports such as swimming[21], we have not found any investigation that focuses on unilateral sports such as badminton.

Therefore, the aim of this study is to evaluate the effect of badminton training on the surface temperature of the lower limbs and the possible asymmetries resulting from the unilateral nature of the sport.

Material and method

Material and method

An experimental study was conducted, with the voluntary participation of 19 amateur badminton players (Aged: 34.4 ± 14.1 years; Height: 168.1 ± 7.8 cm; Body mass: 66.2 ± 13.9 kg; Fat percentage: 14.1 ± 6.9%). All participants were licensed players with a minimum experience of 5 years in this sport, regularly training 2 $h*day^{-1}$ 3 $days*week^{-1}$. The laterality of the players was recorded in order to differentiate between the dominant lower limb and the non-dominant lower limb. Excluded from the sample were those players with an injury or any pain that would prevent them from doing their usual sports practice.

All players were informed in writing and orally of the objective and procedure of the investigation, through informed consent. All the players handed in their signed consent before the start of the study. The players were free to abandon the activity, with no need to give any kind of explanation and with no penalty imposed by their club for doing so. The study was approved by the Ethics Committee of the Virgen de la Salud Hospital, in accordance with the principles of the latest version of the declaration of Helsinki.

Experimental design

In this present investigation, an experimental study was conducted. All the players participating in the study were part of the same training group and were analysed on the same day and in the same practice conditions. Measurements were taken individually and at two different times: before and after standardised badminton training with a two hour duration (pre-training and post-training).

The training comprised four distinct parts: 1) 15 minute standardised warm-up including an aerobic part, followed by dynamic stretching of the upper and lower limbs and specific exercises with a shuttlecock on the court. 2) technical hitting sequences and defence and attack exercises of 2 against 1 on the badminton court, with a 40 minute duration (each player performed three 4 minute series, acting as a "feeder" for his/her fellow players when not performing the exercise). 3) individual badminton matches for 40 minutes. 4) cooling down session with games on the badminton court followed by stretching exercises with a total duration of 20 minutes.

Experimental protocol

Evaluation of the players

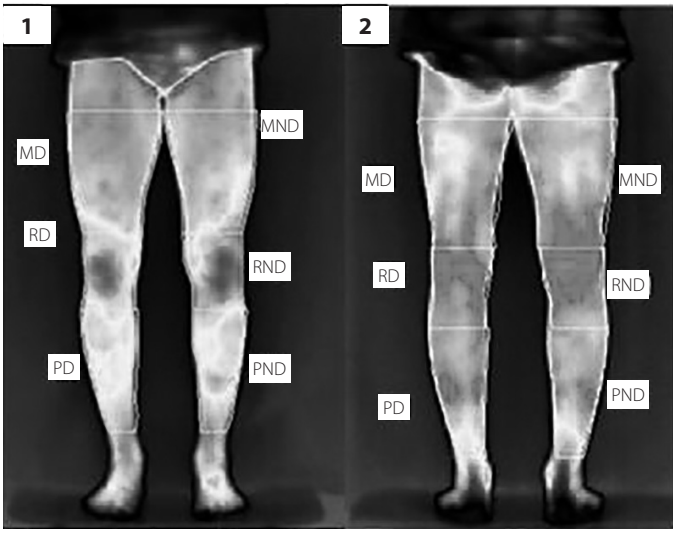
The body mass was measured through bioelectrical impedance with a Tanita TBF 300 (Tanita Corp., Tokyo, Japan), with an accuracy of 0.1 kg and a measurement frequency of 150 Hz. The participants, in their undergarments, stood on the metal strips on the scales. All the measurements were taken after standing for at least 10 minutes in order to minimise the potential errors of abrupt changes in fluid distribution. The laterality of the players was also recorded.

The variables relating to the infrared thermography were evaluated with a VarioCAM Hr® camera (Infratec GmbH, Dresden, Germany). The mean temperature range that can be recorded by the VarioCAM Hr® is between -40 ºC and 1,200 ºC with a measurement accuracy of 2%. The influence variables (physical activity or most recent physical treatment, shower or previous cream-gel-spray, intake of food, caffeine and medicine, consumption of tobacco or alcohol) were recorded in a questionnaire prior to the evaluation in order to ensure that there were no interference factors. The values for temperature (21 ºC), atmospheric pressure (954hPa) and humidity (49%) of the room, remained stable and within the ideal range for performing thermographic studies on humans[20,22]. The camera was positioned at a distance of three metres from the participant; this distance was selected as it was therefore possible to completely observe the lower limbs[23]. 4 images were taken during the evaluation (anterior and posterior lower limbs, for pre-training and post-training alike). For the analysis of the images, we used IRBIS3® software (Infratec GmbH, Dresden, Germany). For each dominant and non-dominant leg, 6 regions of interest were analysed, 3 in the posterior view and 3 in the anterior view, corresponding to the area of the thigh, knee and leg (Figure 1), recording the mean and maximum temperature for each area[24].

Statistical analysis

The statistical analysis was conducted using the SPSS v 22.0 software (SPSS Inc., Chicago, IL). The values are presented as mean values ± standard deviation. The Shapiro-Wilk test was used to check for the normal distribution of the dependent variables, which showed that all variables were parametrically distributed. A two-factor Anova was performed with repeated measurements in order to calculate the significant differences in the temperature-related variables; the first factor corresponded to the time at which the data were taken (pre-training or post-training), the second factor corresponded to the limb measured (dominant or non-dominant limb). Bonferroni was used as a post-hoc test. The magnitude of effect size was interpreted using the Cohen scale25: an effect size of less than 0.2 was considered to be small; an effect size of 0.5 was considered to be medium and an effect size was considered to be large when the result was greater than 0.8. The significance criterion was $p < 0.05$ for all statistical tests.

Figure 1. Regions of interest.



1. Anterior region; 2 Posterior region. MD: dominant thigh; MND: non-dominant thigh; RD: dominant knee; RND: non-dominant knee; PD: dominant leg; PND: non-dominant leg.

Results

Anterior region

The data for the pre and post-training thermographic evaluation of the anterior region of the lower limbs are included in Table 1. In the anterior view of the lower limbs, the mean temperature of the non-dominant thigh region increased by 1.08±2.06% (p=0.018; d=0.50) after training. Also in the anterior region, an increase in the mean temperature was observed for the regions of the dominant knee by 1.96±2.73% (p=0.003; d=0.85), non-dominant knee by 2.19 ± 2.60% (p=0.001; d=0.94), dominant leg by 2.14±2.26% (p<0.001; d=0.96) non-dominant leg by 1.77±1.50% (p<0.001; d=0.77). All maximum temperatures increased in the post-training. No differences were found in the comparison between the dominant and non-dominant limbs.

Posterior region

The data for the pre and post-training thermographic evaluation of the posterior region of the lower limbs are included in Table 2. In the posterior region of the lower limbs, the mean temperature of the non-dominant leg region increased by 1.14±1.76% (p=0.006; d=0.55). Also in the posterior region, an increase in the maximum temperature was observed in the regions of the non-dominant thigh by 0.93±2.26% (p= 0.045; d=0.48), dominant knee by 0.96±2.47% (p=0.049; d=0.46), non-dominant knee by 1.31±2.53% (p=0.018; d=0.67), dominant leg by 1.42±1.78% (p=0.001; d=0.81) and non-dominant leg by 1.50±1.55% (p<0.001; d=0.83). No differences were found in the comparison between the dominant and non-dominant limbs.

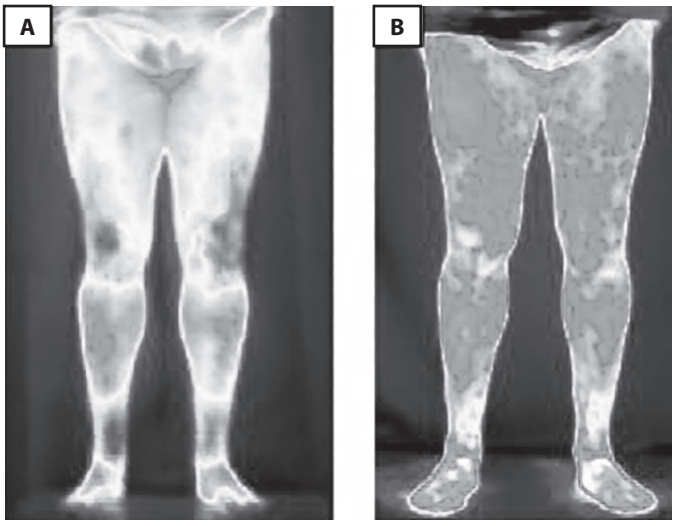
Table 1. Thermographic variables of the anterior region. Mean and standard deviation of all the thermographic variables of the anterior region of the lower limbs for pre and post-training conditions.

	Pre-training	Post-training	Δ (95% CI)
Mean temperature			
MD	32.24 ± 0.84	32.50 ± 0.53	0.27 ± 0.77 (0.04 to -0.57)
MND	32.15 ± 0.85	32.50 ± 0.52	0.35 ± 0.67 (-0.08 to -0.62)
Δ (95% CI)	0.09 ± 0.18 (0.17 to 0.00)	0.00 ± 0.27 (-0.13 to 0.13)	- 0.08 ± 0.21 (-0.18 to 0.02)
RD	31.52 ± 0.91	32.15 ± 0.51	0.63 ± 0.87 (-0.27 to -0.98)
RND	31.55 ± 0.91	32.26 ± 0.55	0.71 ± 0.84 (-0.38 to -1.04)
Δ (95% CI)	-0.03 ± (-0.15 to 0.09)	-0.11 ± 0.39 (-0.29 to 0.09)	- 0.08 ± 0.38 (-0.26 to 0.11)
PD	32.10 ± 0.75	32.81 ± 0.73	0.71 ± 0.75 (-0.41 to -0.91)
PND	32.22 ± 0.76	32.80 ± 0.74	0.59 ± 0.49 (-0.39 to -0.78)
Δ (95% CI)	-0.12 ± 0.35 (-0.29 to 0.05)	0.01 ± 0.28 (0.14 to -0.13)	0.13 ± 0.35 (0.30 to -0.04)
Maximum temperature			
MD	33.23 ± 0.82	33.79 ± 0.61	0.56 ± 0.84 (-0.23 to -0.89)
NDL	33.27 ± 0.85	33.74 ± 0.56	0.47 ± 0.70 (-0.20 to -0.75)
Δ (95% CI)	-0.04 ± 0.32 (-0.19 to 0.12)	0.05 ± 0.35 (0.22 to -0.12)	0.08 ± 0.42 (0.29 to -0.12)
RD	32.98 ± 0.78	33.65 ± 0.59	0.67 ± 0.89 (-0.32 to -1.02)
RND	33.05 ± 0.69	33.69 ± 0.59	0.64 ± 0.71 (-0.36 to -0.93)
Δ (95% CI)	-0.07 ± 0.36 (-0.24 to 0.10)	-0.04 ± 0.59 (-0.29 to 0.79)	0.02 ± 0.69 (0.36 to -0.31)
PD	33.35 ± 0.62	34.00 ± 0.68	0.66 ± 0.52 (-0.45 to -0.86)
PND	33.36 ± 0.68	34.03 ± 0.80	0.67 ± 0.42 (-0.50 to -0.84)
Δ (95% CI)	-0.01± 0.32 (-0.17 to 0.14)	-0.02 ± 0.37 (-0.20 to 0.16)	- 0.01 ± 0.32 (-0.17 to 0.14)

Table 2. Thermographic variables of the posterior region. Mean and standard deviation of all the thermographic variables of the posterior region of the lower limbs for pre and post-training conditions.

	Pre-training	Post-training	Δ (95% CI)
Mean temperature			
MD	32.14 ± 0.70	32.12 ± 0.64	0.27 ± 0.77 (-0.29 to 0.32)
NDL	32.10 ± 0.72	32.09 ± 0.60	0.00 ± 0.78 (-0.31 to 0.31)
Δ (95% CI)	0.04 ± 0.16 (0.12 to -0.03)	0.03 ± 0.23 (0.14 to -0.08)	-0.01 ± 0.22 (-0.12 to 0.09)
RD	32.52 ± 0.75	32.52 ± 0.60	0.00 ± 0.87 (-0.35 to 0.35)
RND	32.43 ± 0.84	32.51 ± 0.55	0.08 ± 0.86 (0.26 to - 0.42)
Δ (95% CI)	0.09 ± 0.23 (0.21 to -0.02)	0.01 ± 0.23 (0.12 to -0.10)	-0.08 ± 0.24 (-0.20 to 0-04)
PD	32.18 ± 0.71	32.44 ± 0.73	0.27±0.71 (0.26 to -0.42)
PND	32.13 ± 0.69	32.50 ± 0.65	0.37±0.58 (-0.14 to -0.60)
Δ (95% CI)	0.05 ± 0.17 (0.13 to -0.03)	-0.06 ± 0.25 (-0.18 to 0.06)	-0.11 ± 0.22 (- 0.21 to 0.00)
Maximum temperature			
MD	33.16 ± 0.73	33.41 ± 0.54	0.25±0.77 (0.06 to -0.56)
NDL	33.07 ± 0.70	33.38 ± 0.59	0.32±0.77 (-0.01 to -0.62)
Δ (95% CI)	0.10 ± 0.26 (0.22 to -0.03)	0.03 ± 0.32 (0.18 to -0.12)	- 0.06 ± 0.26 (-0.19 to 0.06)
RD	33.50 ± 0.75	33.83 ± 0.67	0.33±0.84 (0.00 to -0.67)
RND	33.46 ± 0.78	33.91 ± 0.55	0.45±0.86 (0.26 to -0.42)
Δ (95% CI)	0.04 ± 0.29 (-0.12 to -0.84)	- 0.08 ± 0.43 (-0.29 to 0.13)	-0.12 ± 0.41 (-0.31 to 0.08)
PD	32.98 ± 0.53	33.47 ± 0.67	0.48±0.60 (0.14 to -0.55)
PND	32.91 ± 0.64	33.42 ± 0.59	0.50±0.52 (-0.30 to -0.71)
Δ (95% CI)	0.07 ± 0.31 (0.22 to -0.07)	0.05 ± 0.36 (0.22 to -0.12)	-0.02 ± 0.35 (-0.19 to 0.15)

Figure 2. Pre-training and post-training thermography. Anterior view.



A. Anterior view pre-training; B. anterior view post-training.

Discussion

The aim of this study was to evaluate the effect of badminton training on the surface temperature of the lower limbs and possible asymmetries resulting from the unilateral nature of the sport. This is the first study with badminton players to evaluate the acute effects of practising this sport on the skin temperature of the lower limbs, which is a good gauge of the muscle activity performed[26]. The principal findings of this study were that the mean temperature of the anterior view increased in the regions of the non-dominant thigh, dominant knee, non-dominant knee, dominant leg and non-dominant leg, increases were also recorded for all the maximum temperatures. On the other hand, for the posterior view, the mean temperature increased for the region of the non-dominant leg and the maximum temperatures increased for the regions of the non-dominant thigh, dominant knee, non-dominant knee, dominant leg and non-dominant leg. Based on these results, badminton involves greater activity in the anterior region of the lower limbs in relation to the posterior region, in both extremities.

The mean temperature of the anterior region increased in the post-training measurement in relation to the pre-training measurement. Physical exercise is associated with important haemodynamic changes involving multiple regulatory processes[27]. Given the fact that exercise generates heat in the body and invokes skin thermoregulatory processes, this leads to alterations in the skin temperature[26]. During this compensatory mechanism, the skin blood flow may vary widely in order to provide heat dissipation or conservation, giving rise to marked variations in body temperature. Moreover, the areas responsible for removing the heat will depend on the type of exercise and its level of intensity[28]. In the case of badminton, an explosive, intermittent sport, the expected results are a continuous increase in body temperature, particularly in the area of the lower limbs, due to the increased physiological demand of movements such as lunging which account for 15% of the total actions made during a match[29]. We have found no studies that report the thermal behaviour of the upper limbs following unilateral physical activity, although there are studies that describe the thermal profile of the upper limbs in pre-competitive situations[24] or post-training of cyclic sports such as swimming[21]. Other investigations affirm that the temperature of the upper limbs drops when the activity performed involves a greater use of the lower limbs, such as for cycling[28].

Badminton is characterised by the execution of sporadic movements of moderate and high intensity, related to repetitive actions of short duration but of a highly explosive nature[1]. In our study, the highest temperature increase occurred in the anterior area of the dominant and non-dominant knees (Figure 2). This is due to the increase in physiological stress in the area, primarily caused by the movements and the continuous semi-flexed position of the joint during the pause periods in order to keep the centre of gravity low and improve the speed of reaction[29]. Moreover, a significant increase in the mean temperature can also be observed in the region of the non-dominant leg in the posterior view. This temperature increase may be related to the unilateral eccentric movements made with the non-dominant limb when landing after the jump smash[30]. All these regions of the anterior part, except the dominant thigh, increased their mean temperature, which could be caused by the existence of a predominance of cutaneous vasodilator mechanisms that operate with a sympathetic impulse in this area during exercise and even after the gradual decrease in the core temperature following exercise, thereby causing the surface temperature to remain high after exercise[27]. Similar results were found in students performing repetitive jumps[31].

It should be mentioned in our study that no significant differences were found between the dominant and non-dominant sides, this is indicative of the absence of possible injuries in the regions examined, having regard to the studies that cite excessive thermal asymmetry between limbs as a key factor in the detection of injuries[18-20]. Therefore, this finding could indicate that, despite the unilateral nature of the movements, this is not sufficient to cause a greater physiological load on the dominant limb in relation to the non-dominant one, as far as thermal values are concerned. The literature indicates that a difference of 0.5ºC or more between the dominant and non-dominant sides could be a sign of injury[19,20], offering the case of the basketball player in the study by Sampedro *et al*.[24] as an example. At the time of measurement, he was suffering from Achilles tendinopathy, showing a difference of more than 2 ºC between the affected limb and the healthy one. By contrast, without describing it as pathological, the study of other athletes did show certain asymmetries in muscle groups as a result of practice[32]. It is therefore necessary to continue this line of investigation in order to improve the quantification of the training and competition loads on the different groups of muscles and make recovery strategies more effective.

Practical applications

To provide a tool that could improve the diagnosis of injuries in badminton players and, therefore, help structure the training and competition loads in order to keep them from excessive physiological stress and the overloads resulting from practising this sport. We would strongly recommend considering methodologies to evaluate muscle condition in order to provide guidance for recovery strategies. Despite the fact that the physiological aspects studied show a certain aptness between both limbs, the findings underlined the need to focus attention on the anterior region of both legs, particularly on the region of the knee. The results of this study appear to suggest that there is a greater physiological stress on the anterior region of both knees, which could be related to the characteristics of the game itself. This study can be used to help players and their team select the appropriate strategy to promote correct recovery after matches and training sessions.

Conclusion

In summary, the players taking part in the training experienced an increase in the mean temperature in the regions of the non-dominant thigh, dominant knee, non-dominant knee, dominant leg and non-dominant leg in the anterior view, and non-dominant leg in the posterior view in relation to the baseline condition at the pre-training measurement. We would therefore recommend focussing the recovery strategies on the anterior regions of both legs, particularly in the area of the knees, which experience the greatest temperature increase in the post-training.

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Recomendaciones para el ejercicio físico en deportistas con cardiopatías familiares (segunda parte)

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Received: 29.08.2017
Accepted: 15.12.2017

Summary

The safety of physical activity and sports in patients with inherited heart disease is not well established. The recommendations on physical exercise in these patients are usually quite restrictive without clear evidence for this, despite the fact that sport has shown important cardiovascular benefits. Participation in sports in adults with inherited heart disease is considered a relatively little known territory and many clinicians find it difficult to advise their patients. The development of current medicine has meant a significant improvement in the study of inherited heart diseases, as well as in their early diagnosis and treatment. In addition, genetic studies have assumed a fundamental aspect in the follow-up of these heart diseases, guiding more appropriately the therapeutic attitude that we must follow. Until recently, patients with such heart disease have been frequently disqualified from competitive sports, and in many cases, complete cessation of physical activity, including recreational sport, is recommended. However, current recommendations are less restrictive, insisting on individualizing the different cases depending on the type of pathology, the type of physical activity performed, whether they present the disease or are only carriers of causal genetic mutations, etc. Current research focuses primarily on the safety of physical activity in patients with inherited heart disease and the fear that the practice of competitive physical activity can significantly increase the risk of adverse events, especially arrhythmic events and sudden death. In this review, we analyzed numerous studies and clinical practice guidelines, in order to establish the recommendations of physical activity, as well as their restrictions depending on the different types of inherited heart disease.

Key words:
Sport cardiology. Inherited heart disease. Sporting activity. Cardiomyopathies. Channelopathies.

Recomendaciones para el ejercicio físico en deportistas con cardiopatías familiares (segunda parte)

Resumen

La seguridad de la actividad física y deportiva en pacientes con cardiopatías familiares aún no está bien establecida. Las recomendaciones sobre el ejercicio físico en estos pacientes suele ser bastante restrictiva sin que haya clara evidencia para ello, a pesar de que el deporte haya demostrado importantes beneficios cardiovasculares. La participación en deportes en los adultos con cardiopatías familiares se considera un territorio relativamente poco conocido y muchos clínicos se encuentran con dificultades en el asesoramiento a sus pacientes. El desarrollo de la medicina actual ha supuesto una mejoría significativa en el estudio de las cardiopatías familiares, así como en su diagnóstico precoz y tratamiento. Asimismo, los estudios genéticos han supuestos un pilar fundamental en el seguimiento de estas cardiopatías, guiando de manera más adecuada la actitud terapéutica que debemos seguir. Hasta hace poco tiempo, los pacientes que presentan dichas cardiopatías han sido descalificados de manera frecuente de los deportes competitivos y en muchas ocasiones, se recomienda el cese completo de la actividad física, incluido el deporte tipo recreacional. Sin embargo, las recomendaciones actuales son menos restrictivas, insistiendo en individualizar los diferentes casos en función del tipo de patología, del tipo de actividad física realizada, si éstos presentan la enfermedad o son únicamente portadores de mutaciones genéticas causales, etc. Las investigaciones actuales se centran fundamentalmente en la seguridad de la actividad física en pacientes con cardiopatías familiares, y el temor a que la práctica de actividad física a nivel competitivo pueda aumentar significativamente el riesgo de eventos adversos, especialmente de eventos arrítmicos y muerte súbita. En esta revisión, analizamos numerosos estudios y las guías de práctica clínica, con el fin de establecer las recomendaciones de actividad física, así como sus restricciones en función de los diferentes tipos de cardiopatías familiares.

Palabras clave:
Cardiología deportiva. Cardiopatías familiares. Actividad deportiva. Miocardiopatías. Canalopatías.

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Other genetic aortic diseases

As is well known today, high-intensity sports practice is associated with certain haemodynamic alterations, leading to increased aortic wall tension, thereby progressively increasing its dimensions. It has frequently been described that competitive athletes could have slightly larger aortic diameters, particularly with regard to the sinuses of Valsalva, than the general population. However, in recent literature, such as Boraita *et al*.[25], it is considered that significant aortic dilation is rarely due to a normal and physiological adaptation to high intensity training. We should therefore rule out a concomitant aortic pathology that may be exacerbated by continued physical activity. For this reason, different imaging techniques (transthoracic echocardiogram, computed tomography, cardiac magnetic resonance, etc.) should be used to make a proper study of the aorta and to rule out an underlying aortic pathology. Likewise, it is important to consider conducting a genetic study on those patients with aortic pathology, particularly at early ages, and also on those patients with a family history of aortic dilation, acute aortic syndrome (aortic dissection, aortic rupture, etc.), thoracic aortic aneurysm syndrome, etc.

For the aortic root study, it is recommended to make these measurements on the echocardiogram from inner edge to inner edge at the sinuses of Valsalva during the systole. Likewise, it is recommended to make measurements at different levels: ring, sinotubular junction, ascending aorta, etc. Moreover, other imaging techniques such as cardiac MR and CT will give greater spatial resolution and permit a more appropriate study of the thoracic and abdominal aorta. It is important to progressively analyse the increase in the aortic dimensions in relation to any prior checks made in previous years.

Typically, isolated measurements of the aortic diameters were used to make the diagnosis and monitoring of these pathologies. However, today, the criteria most commonly used to diagnose aortic pathology are the "Z-scores"[26] which include a number of variables such as body mass index, gender and age. In this way, it would be said that the aorta presents a slight, moderate or severe dilation depending on whether the Z-score is between 2-3, 3.1-4 or >4 respectively. However, it is recommended that any athlete with a marked aortic dilation (Z-score >2), should be assessed by doctors with experience in the field of aortic pathology in athletes.

Some years ago, the recommendations were quite restrictive in relation to competitive sports participation, restricting any athlete with "unequivocal aortic enlargement", defined as an aortic diameter >40 mm (or >2 standard deviations in children or young people, Z score >2) to participation in class IA competitive sports only. However, the American guidelines published in 2015[9] are less restrictive in the recommendation for sports activity for these patients:

- Today, athletes with aortic dimensions above the normal ranges (Z scores of 2 to 2.5 or aortic diameters of 40-41 mm in tall sportsmen or 36-38 mm in tall sportswomen, and with no signs that are compatible with Marfan syndrome, Loeyz-Dietz syndrome or familial thoracic aneurysm syndrome, should undergo echocardiographic or MR monitoring every 6-12 months, depending on aortic size and stability of measurements (Class I; level of Evidence C).
- Athletes with aortic dimensions above the normal ranges (Z scores of 2 to 2.5 or aortic diameters of 40-41 mm in tall sportsmen or 36-38 mm in tall sportswomen, and with no signs that are compatible with Marfan syndrome, Loeyz-Dietz syndrome, familial thoracic aneurysm syndrome, or bicuspid aortic valve, can participate in all competitive sports provided that a genetic study of gene FBN1 and other related genes has excluded a genetic aortic disease (Class IIb; level of evidence C).
- Athletes with aortic dimensions above the normal ranges (Z scores of 2 to 2.5 or aortic diameters of 40-41 mm in tall sportsmen or 35-37 mm in tall sportswomen, and with no signs that are compatible with Marfan syndrome, Loeyz-Dietz syndrome or familial thoracic aneurysm syndrome, should avoid intensive weight training (Class IIb; level of evidence C).
- Likewise, athletes with familial or non-familial thoracic aortic aneurysms or carriers of a known mutation related to thoracic aortic aneurysm syndrome must undergo echocardiographic monitoring (or CT or MR depending on the diagnosis) every 6-12 months to assess the progression of the aortic dilation or other vascular branches.
- It is reasonable for athletes with familial or non-familial thoracic aortic aneurysms or carriers of a known mutation related to thoracic aortic aneurysm syndrome to participate in class IA sports if they do not have ≥1 of the following characteristics (Class IIa; level of evidence C): aortic root dilation (Z score > 2, 40 mm or > 2 SD for children and adolescents under 15 years), moderate-severe mitral insufficiency, family history of aortic dissection, cerebrovascular disease and/or branch vessel aneurysm or dissection.
- It is reasonable for athletes with Loeys-Dietz syndrome or vascular Ehler-Danlos syndrome to participate in class IA sports if they have none of the following characteristics (class IIa; level of evidence C): aortic enlargement (score>2), dissection or branch vessel enlargement, moderate to severe mitral insufficiency and/or extracardiac involvement that may represent a risk.
- It is reasonable for athletes who have had surgery for aortic dissection or aneurysms and with no post-operational evidence of enlargement or dissection, to participate in class IA sports that do not include the risk of bodily collision (class IIa; level of evidence C).
- Athletes with Loeys-Dietz syndrome, Ehler-Danlos syndrome, familial or non-familial thoracic aneurysms or any other related disorder, should not participate in any competitive sports involving intense physical exertion or the potential for bodily collision (Class III; level of evidence C).

Channelopathies

Channelopathies are those genetic disorders caused by mutations in the genes of the different ion channels, causing various alterations

in their structure and function[27]. They are characterised by generally occurring in a structurally normal heart, and are responsible for most hereditary arrhythmias and a high percentage of sudden cardiac deaths that are not associated with structural cardiopathy. This term includes a number of pathologies, primarily Brugada syndrome, long and short QT and polymorphic ventricular tachycardia. These channelopathies have a number of characteristics in common:

- Phenotypic heterogeneity: The mutations in the same gene may give rise to different diseases and symptoms. For example, the mutations in the sodium channel may give rise to diseases such as long QT syndrome, Brugada syndrome, etc.
- Genetic heterogeneity: The mutations in different genes may give rise to the same disease. For example, the long QT syndrome may be caused by mutations in genes that encode different potassium channels or, on some occasions, affect the sodium channels.
- Clinical heterogeneity: Family members who carry the same mutation may have different phenotypes which, in the Brugada syndrome for example, range from normal electrocardiograms (ECG) to ST elevation and ventricular arrhythmias leading to sudden death.

According to recommendations of the American guidelines, a comprehensive study should be made of each particular case, differentiating between a symptomatic athlete and an athlete with concealed channelopathy, being aware of the difference between both terms. A symptomatic athlete is considered to be an individual who has suffered at least one adverse event (malignant arrhythmias, syncope, sudden death, etc.) that is related or probably related to a channelopathy. However the term "concealed channelopathy" is used to refer to a genotype-positive/phenotype-negative athlete. In other words, the athlete is a carrier or a specific mutation related to a channelopathy, and yet is completely asymptomatic, exhibiting no baseline electrocardiographic alterations or during exercise stress testing (ventricular arrhythmias etc.).

Described below are the principal channelopathies existing today.

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Long QT syndrome

This channelopathy has a prevalence of 1 in 2,000-3,000 persons[28], predominantly affecting young people or adolescents. It is characterized by prolonged ventricular repolarization with a QT interval prolongation, T-wave alteration, etc. These patients typically present potentially lethal arrhythmic events, predominantly in the context of polymorphic ventricular tachycardia or in torsade de pointes. There are different types of long QT syndrome, classified by the type of causal mutations as well as the activity triggering the arrhythmic events. For example, type 1 long QT syndrome, which is the most common, is the one that primarily needs to be ruled out in athletes, given the fact that the appearance of arrhythmias in this group is associated with physical exercise, frequently swimming. Type 2 LQTS arrhythmias are generally triggered by intense emotions or abrupt auditory stimuli (although the presence of arrhythmic events has also been described in these cases while sleeping with no excitation)[29], while type 3 LQTS is related to rest or sleep.

It is recommended to measure the QT interval at electrocardiogram leads II and V5. Given the fact that this interval varies in relation to heart rate, this should be corrected according to the patient's heart rate (QTc corrected). Given the fact that a significant proportion of athletes exhibit a tendency to bradycardia, if the QT interval duration is not corrected (through the Bazzet formula), then we would be faced with a high percentage of prolonged QT intervals that would be over-estimated and impossible to assess.

In general, long-QT is when the corrected QT (QTc) is >460 ms in minors under 15 years, >470 ms in adult women and >450 ms in adult men[30]. Today, the Schartz criteria are used (Table 1) to make the definitive diagnosis of long QT syndrome which, in addition to the prolongation of the QTc, also considers other clinical criteria such as family history, history of syncopes or sudden death, etc.

Therefore, this type of channelopathy should be suspected primarily in young people exhibiting syncopal episodes in relation to different stimuli such as exercise, intense emotion, swimming or abrupt auditory stimuli.

Since the start of the beta blocker treatment, the prognosis for this pathology has changed drastically[31], with a drop in overall mortality from 73% to less than 10%, particularly for those cases with a prior history of syncope. However, the administration of beta blockers is not recommended for patients with type 3 LQTS (it may even be contraindicated), given the fact that the arrhythmic events, as already observed, appear during sleep in the context of exaggerated sinus bradycardia. These drugs therefore promote the appearance of malignant arrhythmias.

Table 1. Schartz Criteria for the definitive diagnosis of Long-QT syndrome.

ECG Findings	**Points**
QTc (Bazett formula)	
• ≥ 480 ms	3
• 460-470 ms	2
• 450 ms (in males)	1
VT at *torsade de pointes*	2
Alternating T-wave	1
Coved T-waves in at least 3 leads	1
HR low for age	0.5
Medical records	**Points**
Syncope	
• With stress	2
• Without stress	1
Congenital deafness	0.5
Family history	**Points**
Relative with a diagnosis of congenital long-QT	1
Sudden death in a close relative under the age of 30	0.5

Low diagnostic probability ≤1 point
Intermediate probability 2-3 points
High probability ≥4 points

Nowadays, it is recommended that all patients with long-QT syndrome (except type 3), symptomatic or not, receive beta blocker treatment and avoid drugs that prolong repolarization. For those patients with long-QT syndrome and with a high risk of sudden death (documented ventricular tachycardia, family history of sudden death, excessively prolonged QTc of around 500 ms. etc.), ICD implantation should be considered. Likewise, athletes with a prolonged baseline QTc interval are advised to undergo a maximum stress test, endeavouring to analyse the shortening of the QTc with exercise at maximum rates, which would make this pathology more benign.

The 36th Bethesda Conference and the European Society of Cardiology of 2005 were extremely restrictive, recommending the disqualification of individuals with LQTS from all competitive sports, with the exception of low intensity sports (IA). However, there were discrepancies between the recommendations established by these two entities for the participation of genotype positive-phenotype negative athletes in sports activity; the ESC recommends complete discontinuation of competitive sports, while the Bethesda conference would permit participation in high level sports activity (except swimming for patients with type 1 LQTS). Today, numerous studies have established that the said guidelines are fairly restrictive and should be revised, given the low arrhythmic event rate of athletes with these channelopathies, when following appropriate guidelines.

According to the American guidelines[9] and the most recent recommendations, competitive sport participation may be considered for previously symptomatic patients or with electrocardiographic expression of LQTS, provided that they take appropriate precautionary measures and receive suitable treatment and that they have been totally asymptomatic for at least 3 months (class IIb, level of evidence C). For individuals with an ICD implant, the specific guidelines for performing sports with an ICD should be followed.

Likewise, if a patient has LQTS and has been previously symptomatic or electrocardiographically manifests LQTS (QTc > 470 ms in males or > 480 in females), competitive sports participation may be considered provided that the athlete is receiving suitable treatment and appropriate precautionary measures are taken, and that the said athlete has been asymptomatic on treatment for at least 3 months, except competitive swimming for those athletes with type 1 LQTS (class IIb, level of evidence C).

Short QT syndrome

This is a rare pathology that could predispose to the appearance of lethal arrhythmias, predominantly ventricular fibrillation[32]. Short QT is characterised by a persistent QTc<300 ms, predominantly associated with peaked, symmetrical T-waves. However, the finding of a short QTc interval on the surface electrocardiogram is not sufficient to refer to the presence of this syndrome, or the predisposition to lethal arrhythmias. This pathology should be suspected when, in addition to these electrocardiographic alterations, the patient exhibits palpitations, auricular fibrillation or syncopal symptoms, as well as a family history of sudden cardiac death. At present, only three causal mutations are known. It is therefore classified into three different types, depending on the mutation. An electrophysiological study is often recommended in order to induce arrhythmic events. Today, ICD implantation is the treatment of choice for the prevention of sudden death in high-risk patients. Although few studies have been made, quinidine could be used as a drug companion to prevent auricular fibrillation or recurrent ventricular tachycardias in patients with SQTS[33].

According to current guidelines, as is the case for athletes with long QT syndrome, competitive sport could be considered for previously symptomatic patients or with electrocardiographic expression of SQTS, provided that the precautionary measures indicated above are taken, that suitable treatment is received and that they have been totally asymptomatic for at least 3 months (class IIb, level of evidence C).

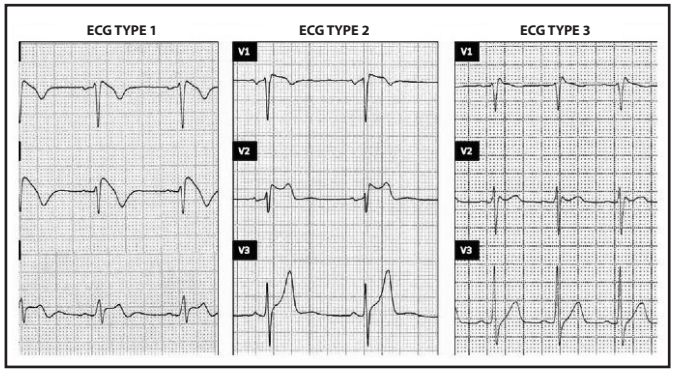
Brugada syndrome

This syndrome is characterised by a typical electrocardiographic pattern in the right precordial leads (V1-V3) often associated with right bundle branch block morphology and a predisposition to exhibit ventricular arrhythmias and sudden death.

Brugada syndrome is far more frequent in males (up to 75% of cases), with a mean age at diagnosis of around 40 years[34]. In general, the most frequent symptoms for these patients are syncope or sudden death in the context of polymorphic ventricular tachycardia or ventricular fibrillation, which most frequently occur during sleep or rest[35]. Today, the most frequent triggering events for this pathology are fever, heatstroke, certain drugs, etc. so that particular care should be taken in the event of any of these circumstances. For this reason, it is essential to establish early treatment for hyperthermia in febrile conditions and to avoid heat stroke during exercise. Likewise, particular care should be taken with the drugs triggering Brugada syndrome (anti-arrhythmic drugs, anti-depressants, etc.) in patients with this pathology. The complete list of these drugs can be consulted at www.brugadadrugs.org.

It has a global prevalence of 5 per 10,000 inhabitants, being more frequent in certain regions such as Southeast Asia. It is estimated that around 5-8% of the global cases of sudden death and 20% of sudden death without structural heart disease are due to this syndrome. In half the cases, the patients have a family history of this syndrome or of sudden death, however it is not unusual to come across sporadic cases. At present, when the diagnosis is made after syncope symptoms in a patient with a family history or following resuscitation from sudden death, management is more evident and the implantation of an ICD would be recommended. However, the treatment of asymptomatic sufferers, that is with a genotype positive-phenotype negative, is controversial. Today, an electrophysiological study with programmed electrical stimulation is recommended in order to identify those patients with the greatest risk of suffering arrhythmic events. However, there is evidence that the mere presence of a type 1 electrocardiographic pattern, even when other clinical criteria are not met, can be associated with death in long-term monitoring. It is thus necessary to consider at-risk patients as those with a type 1 electrocardiographic pattern. However, the management

Figure 1. Classification of the different electrocardiographic patterns established for the Brugada syndrome.



of asymptomatic patients has not yet been definitively established; this therefore requires exhaustive and prolonged monitoring in order to establish a specific therapeutic approach.

Three electrocardiographic patterns have been established for the Brugada syndrome (Figure 1):

Type 1: consisting in a coved ST segment elevation of ≥2 mm, followed by a negative T-wave, in more than one right precordial lead (V1-V3).

Type 2: this is also characterised by an ST segment elevation ≥2 mm in right precordial leads, but followed by a positive or biphasic T-wave, that results in a saddle-back configuration.

Type 3: any of the above two morphologies, but with an ST elevation of ≤1 mm.

At present, type 1 is the only diagnostic pattern accepted by the European Society of Cardiology[36]. Likewise, this pattern may be spontaneously evident in a baseline ECG or induced by a provocative drug challenge test with a sodium channel blocker (ajmaline or flecainide). However, in order to establish the definitive diagnosis, in addition to the electrocardiographic alterations, the patient must also present at least one of the clinical criteria (Table 2).

We should emphasise the fact that it is relatively frequent to find an incomplete right bundle branch block in high performance athletes; therefore both morphologies should not be confused. Likewise, the importance of the correct placement of the electrodes on the athlete (particularly for precordial leads V1 and V2 in the 4th right and left intercostal spaces respectively) has frequently been emphasised. This is because, if these are placed too high, then they can frequently simulate a Brugada pattern morphology, particularly for individuals with a greater body surface area[37].

According to current guidelines, competitive sport could be considered for previously symptomatic patients or with electrocardiographic expression of Brugada, provided that appropriate precautionary measures are taken (avoid triggering drugs, hyperthermia, dehydration, etc.), that suitable treatment is received and that patients have been totally asymptomatic for at least 3 months (class IIb, level of evidence C). For individuals with an ICD implant, the specific guidelines for performing sports with an ICD should be followed[34].

Table 2. Clinical criteria for the definitive diagnosis of Brugada syndrome.

ECG Findings
Elevation of the ST segment 2 mm with a coved slope in more than one precordial lead (V1-V3) either spontaneously or following provocation with a sodium blocker.
And one of the following:
Documented ventricular arrhythmia: a) Ventricular fibrillation b) Polymorphic ventricular tachycardia c) Ventricular arrhythmias induced following programmed electrical stimulation
Family history: a) Sudden deaths in individuals aged under 45 years b) Characteristic ECG in relatives
Symptoms related to arrhythmias: a) Syncope b) Nocturnal agonal respiration

Moreover, other possible causes of the ECG alteration should be ruled out.

Account should be taken of the fact that, nowadays, a routine genetic study is practically in place for those individuals suspected of having some type of channelopathy. Therefore, for most patients, an early, reliable diagnosis is made, even for those with a negative phenotype. Asymptomatic genotype positive-phenotype negative patients with Brugada Syndrome are permitted to participate in any competitive sport, provided that the recommended precautionary measures are taken into account (class IIa, level of evidence C).

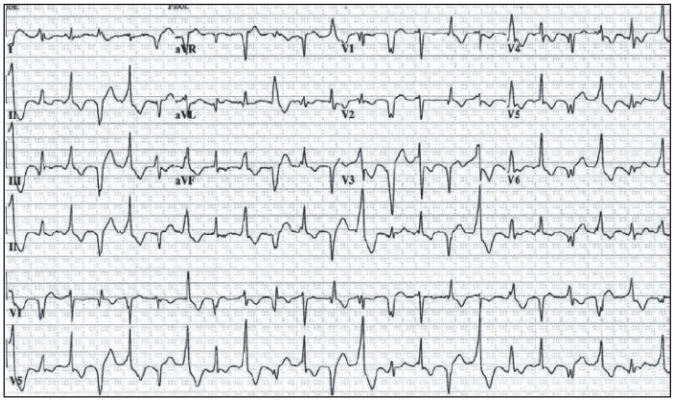
Catecholaminergic ventricular tachycardia

Catecholaminergic polymorphic ventricular tachycardia (CPVT) is a hereditary channelopathy (being the most common mutation located in the ryanodine receptor gene)[38] characterised by the appearance of syncopes or sudden death triggered during exercise or intense emotions in individuals without structural cardiopathy. Generally, the underlying cause of these adverse events is the appearance of potentially lethal arrhythmias, consisting in rapid episodes of bidirectional or polymorphic ventricular tachycardia (Figure 2).

The mean age for the commencement of symptoms is in childhood, between 7 to 12 years, although cases of late diagnosis of patients aged over 40 years have been reported. The diagnosis is generally delayed by 2 years, from the first syncope, which is generally labelled as vasovagal, neurally mediated syncope, etc. Furthermore, this diagnosis should also be considered for swimming-related syncopes.

It is considered to be one of the most aggressive and lethal channelopathies; it is estimated that around 30% of affected, untreated individuals experience at least one sudden death[38] and at least 80% exhibit at least one syncopal event. Unfortunately, on occasions, sudden death may be the first manifestation of the disease. We therefore need to be pay particular attention to those athletes with a family history or with suspicion of this pathology.

Figure 2. Electrocardiographic record of a patient with CPVT during a cardiac stress test, noting the presence of repeat bidirectional ventricular extrasystoles.



The baseline electrocardiogram does not generally prove useful in the diagnosis of this pathology[39], given the fact that, just like the echocardiogram and other imaging techniques, it does not generally show pathological alterations. For these patients, the exercise stress test is the key diagnostic tool. With this test, the clinician will endeavour to use an intense adrenergic discharge to evoke different malignant arrhythmias (bidirectional tachycardia, polymorphic ventricular tachycardia, etc.) (Figure 2). In the CPVT, these arrhythmic events during exercise generally appear at a threshold heart rate of 100-120 beats per minute, progressively worsening as the work load increases. For this reason, when an athlete is suspected of having this pathology, the cardiac stress test must be made following a protocol, with a gradual and progressive increase in the physical stress load, thereby avoiding sharp increases in the work loads. The diagnostic performance of the Holter monitor is lower than that of the exercise stress test. However, it could prove useful for persons with reduced mobility and small children who are unable to undergo a stress test.

Ventricular arrhythmias may become apparent with the adrenalin test. However, this diagnostic test is controversial, its diagnostic performance is extremely variable (2-50%) and it is only recommended in very specific cases[40]. Finally, we should mention that the genetic study has become a key element in establishing the definitive diagnosis of this channelopathy.

Given the lethality of this pathology and, as is the case for the rest of the familial cardiopathies, the genetic study should be recommended to first degree relatives of an affected individual, particularly if the specific causal mutation is known. Furthermore, a full cardiology study should be made on these relatives, including a baseline electrocardiogram, echocardiogram, cardiac stress test etc.

With regard to the treatment of these channelopathies, beta blockers are essential, given the fact that the channelopathies are generally induced by an important adrenergic discharge[41]. It is of interest to conduct periodical cardiac stress tests on these individuals, aiming to achieve a reproducible induction of the arrhythmia during exercise. This will permit a suitable assessment of the response to treatment as well as the monitoring of the effectiveness of these drugs. When faced with cases of incomplete protection with this medication (persistence of arrhythmias during exertion) then the addition of flecainide to the treatment should be considered[42]. Likewise, beta blockers are also suggested for primary prevention; in other words, those patients who are carriers of pathogenic mutations in CPVT associated genes, despite having a strictly normal cardiac stress test. This is due to the fact that, as mentioned above, on many occasions sudden death may be the first manifestation of this disease. Likewise, for these patients, consideration should be given to the implantation of an ICD in those cases in which episodes of sudden death or potentially lethal arrhythmic events have occurred, despite being under pharmacological treatment or for individuals that cannot take beta blockers. For patients with an ICD, it is recommended to maintain the above mentioned pharmacological treatment, thereby significantly reducing the number of device discharges. Furthermore, sympathetic denervation could be considered for those cases in which patients are refractory to other therapies, although it is not a widely recommended technique today, given its secondary effects, as well as the long-term recurrence of cardiological events.

Finally, we must insist on the importance of strict monitoring and a regular check-up by a cardiologist every 6 months approximately, in order to supervise adherence to treatment (cases of ventricular tachycardia have been described in which patients stopped their beta blocker treatment after just one day), as well as the response to the drugs. In order to recommend the intensity and limits of physical activity, the clinician can be guided by the objectified results of the cardiac stress test conducted in a hospital setting with the appropriate safety measures. Moreover, the use of different cardiac monitoring devices has been proposed in order to provide guidance for participation in sports, controlling that the athlete's heart rate is within the range considered to be safe for physical activity. However, given the risks involved, this is never considered as an alternative to strict monitoring and to suitable medical treatment.

According to current recommendations, an athlete with previously symptomatic CPVT or an asymptomatic CPVT athlete with ventricular contractions in bigeminy, couplets, or NSVT in the cardiac stress test, can only participate in class Ia competitive sports. A CPVT specialist cardiologist must be consulted for any exception (class III, level of evidence C).

In short, for athletes with channelopathies, the main recommendation has traditionally comprised avoiding all types of competitive sports. However, at present, some changes have occurred that make it possible to modify these recommendations. Over the last few years, in the United States, no event has been described related to competitive sport and attributable to channelopathy (provided that suitable precautionary measures were taken). Moreover, there are other registries, such as the North American ICD Sports Registry, that have shown a very low incidence of events for patients with channelopathies participating in competitive sport. All the same, even today, there is insufficient scientific evidence to determine the real risk for a competitive athlete with channelopathy and, therefore, the recommendations have a C level of evidence.

With regard to specific treatment, we need to bear in mind that this must be guided by the severity of the disease and not simply focus on the fact that we are dealing with an athlete. In other words, the implantation of an ICD in a patient with channelopathy would not be recommended simply because the patient is a competitive athlete.

Likewise, athletes with a suspected/diagnosed channelopathy, must be assessed by a cardiologist (arrhythmologist, experts in familial cardiopathies, etc. (class I; level of evidence C).

Moreover, it is recommended that symptomatic athletes with any suspected or diagnosed channelopathy should refrain from all competitive sports until evaluated by a specialist, the correct treatment program has been implemented, and the athlete has been asymptomatic on treatment for 3 months (class I; level of evidence C).

It is reasonable for an asymptomatic athlete with concealed channelopathy (genotype-positive / phenotype-negative) to participate in all competitive sports with appropriate precautionary measures, (class IIa, level of evidence C).

Conclusion

The development of present day medicine has led to a significant improvement in the study of familial cardiopathies, as well as early diagnosis and treatment. Likewise, genetic studies play a key role in the monitoring of these cardiopathies, providing the most appropriate guidance for the best therapeutic approach to be followed. Today it is considered that the advances in genetic studies will have an impact on prognosis and on a deeper knowledge of these diseases. However, on many occasions, genetics places us in a great dilemma when establishing recommendations for sports activities for causal mutation carriers with no phenotypic development of the disease. For this reason, extensive work is being conducted in this area.

We would therefore emphasise the importance of closely monitoring athletes who are carriers of pathogenic mutations with phenotype negative. It is evident that, depending on the penetration and expressiveness of each individual mutation, a percentage of these carriers will develop the familial disease. It is therefore important to develop individualised monitoring protocols in order to detect the appearance of phenotypic manifestations. These protocols are extremely useful in order to prevent these carriers from experiencing adverse events during sports activities.

At present, the permitted level of exercise for patients with familial cardiopathies represents a great challenge for clinicians. On the one hand, strenuous exercise could be harmful and could increase the risk of sudden death and other adverse events. However, the excessive restriction of physical exercise leads to physical inactivity and has an unfavourable impact on health and quality of life. Today, certain fitness programmes have been developed by a number of healthcare centres, directed at promoting safe exercise for patients with familial cardiopathies. These could be made available to different sports disciplines, while also offering the possibility of being easily implemented anywhere.

Therefore, there is a growing trend to be more permissive with these patients. Although current recommendations are progressively less restrictive, there are still restrictions in place in many of these cardiopathies. In order to obtain more reliable and specific findings, there is a need to have more evidence in extensive records of athletes with familial cardiopathies. Moreover, further studies are required in order to help us determine the real role of exercise in the phenotypic development of these diseases, in addition to the risk of sudden death that this entails.

In conclusion, the time has come to pay more attention to familial cardiopathies and to update their management, from the point of view of sporting activities, particularly due to the clear benefits that this can bring, while always acting with caution and basing our work at all times on two fundamental principles: safety and its benefits.

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Laboratory methodology for the histological study of skeletal muscle

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Received: 11.12.2017
Accepted: 15.02.2018

Summary

Skeletal muscle is a malleable and dynamic tissue capable of a high degree of plasticity in regards to its histological configuration. In this sense, microscopic study is an important and essential tool for the analysis of adaptive processes -such as hypertrophy or changes of fiber types- and the regeneration or repair of skeletal muscle after injury, in the fields of sports medicine and traumatology respectively. While light microscopy addresses the study of the different constitutive elements into the skeletal muscle and their relationships with each other that determine the organ histoarchitecture, with electron microscopy an ultrastructural analysis is carried out that allows to relate the structure and function of the individual cells. This article illustrates a pragmatic and practical approach, based on personal experience and a review of the literature, from the conditions in obtaining and sending samples of skeletal muscle to the laboratory to the procedures to prepare them for histological study (sections of cryostat, paraffin sections and electron microscopy). Especially we focus on the description of the processing by freezing and recommendations to follow, as this is the ideal method for this tissue. The aim of this article is to provide useful information on the management of skeletal muscle samples that are processed in the histology laboratory to achieve optimal and reliable results in microscopic analyzes and how to avoid methodological errors that lead to the appearance of artifacts that can get to hinder or invalidate the histological study.

Key words:
Skeletal muscle. Muscle histology. Muscle ultrastructure. Muscle biopsy. Frozen section. Electron microscopy.

Metodología de laboratorio para el estudio histológico del músculo esquelético

Resumen

El músculo esquelético es un tejido maleable y dinámico capaz de un alto grado de plasticidad con respecto a su configuración histológica. En este sentido, el estudio microscópico es una herramienta importante y esencial para el análisis de los procesos adaptativos –como la hipertrofia o los cambios de tipos de fibras– y la regeneración o reparación del músculo esquelético después de la lesión, en las áreas de la medicina deportiva y la traumatología respectivamente. Mientras que con microscopía óptica se aborda el estudio de los diferentes elementos constitutivos del músculo esquelético y sus relaciones entre sí que determinan la histoarquitectura del órgano, con microscopía electrónica se realiza el análisis ultraestructural que permite relacionar estructura y función de las células individuales. Este artículo ilustra un enfoque pragmático y práctico, en base a la experiencia personal y una revisión de la literatura, desde las condiciones en la obtención y envío de las muestras de músculo esquelético al laboratorio a los procedimientos para prepararlas para su estudio histológico (secciones de criostato, secciones de parafina y microscopía electrónica). Especialmente nos centramos en la descripción del procesado por congelación y recomendaciones a seguir, al ser éste el método ideal para este tejido. El objetivo de este artículo es proporcionar información útil sobre el manejo de muestras de músculo esquelético que se procesan en el laboratorio de histología para lograr resultados óptimos y fiables en los análisis microscópicos y cómo evitar los errores metodológicos que conducen a la aparición de artefactos que pueden llegar a dificultar o invalidar el estudio histológico.

Palabras clave:
Músculo esquelético. Histología muscular. Ultraestructura muscular. Biopsia muscular. Cortes congelados. Microscopía electrónica.

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Introduction

The microscopic evaluation of skeletal muscle is an essential part of the study of muscle histophysiology in sport and physical activity[1,2], muscle injuries in sport[3,4] and basic research in myology and experimental myopathology[5-7]. Knowledge of skeletal muscle histology allows us to understand the tissue, cellular and molecular mechanisms involved in the adaptive responses to exercise –hypertrophy, hyperplasia and remodelling of fibre types– and post-injury muscle regeneration[8,9]. It also allows us to know and understand the specific effects that certain types of exercises[10-12], substances[13], nutrients[14], drugs[15], rehabilitation strategies[16] and regenerative medicine therapies[17] have on the structure and function of muscle fibres, satellite cells, the extracellular matrix, innervation, vascularisation and myoconnective junctions.

The microscopic study of skeletal muscle requires magnification instruments such as *optical* and *electron microscopes*, and *techniques* which reveal the different components of its structure (Figure 1). *Histological* techniques are used to study the structural features of skeletal muscle, histochemical techniques are used to observe enzyme and non-enzyme activities which help to characterise the diversity and distribution of fibre types or identify certain substances; and antibodies and *immunohistochemical* techniques are used to study and locate specific cellular and extracellular protein components.

While optical microscopy with biopsy or muscle sample sections is used for the *histoarchitectural study or analysis of the whole* of all the elements that make up skeletal muscle as an organ, electron microscopy is used for the *ultrastructural study or individualised, detailed analysis* of each element[18]. Another methodology, involving the optical microscopy of individual muscle fibres, allows us to isolate muscle fibres to analyse the behaviour of elements such as myonuclei and satellite cells[19]. Although less used due to the limited information it has to offer, scanning electron microscopy is another very useful option for the three-dimensional examination of muscle fibres and their relationship with the nerve fibres at the level of motor end plates or the connective scaffold of skeletal muscle[20] (Figure 1).

In our opinion, anyone interested in conducting any kind of microscopic study of skeletal muscle must know the procedure or methodology to follow with the samples obtained, primarily because it is a tissue/organ that requires a very specific protocol for laboratory processing which needs to be strictly observed for optimal histological evaluation[21]. This article describes the procedure, the methodology and recommendations to ensure the proper specific preparation of samples, essential for an histological interpretation of skeletal muscle.

From which muscle, how much and how the sample should be taken

The laboratory procedure to follow is the same for human and experimental animal muscle, except when it comes to taking samples. In both cases, the essential requirements and conditions necessary to obtain the sample and send it correctly to the laboratory are the same and must be followed meticulously to ensure that the sample is not rendered entirely unusable.

There are two standardised procedures for human muscle: open biopsy and needle biopsy[22,23]. While both procedures are used for the diagnosis of neuromuscular diseases[24], the second is used to study athletes[10,25,26]. *Open biopsy* is carried out in the operating theatre without any special preparation beforehand (see special requirements in specialist literature)[22,27]. After local anaesthesia, a small incision is made to the skin (2-3 cm) over the muscle belly and a block of muscle tissue 0.5 cm in diameter and 1 cm long (equivalent to "a small olive pit") is removed (Figure 2). *Needle biopsy* requires an instrument -a modified Bergstrom needle- and a skin incision (1 cm) with local anaesthetic, inserting the needle to the muscular layer and extracting the muscle sample (see special requirements in specialist literature)[22,27,28]. There is a risk that the amount of muscle obtained will be insufficient for diagnosis and that the removal procedure will cause artefacts in the sample, in addition to making correct orientation very difficult when mounting. Certain muscles cannot be biopsied using this technique. The specimens obtained must be handled as little as possible, avoiding stretching and crushing. If the sample is bloodied, it should be rinsed rapidly in saline.

Figure 1. Range of microscopic studies for the analysis of skeletal muscle.

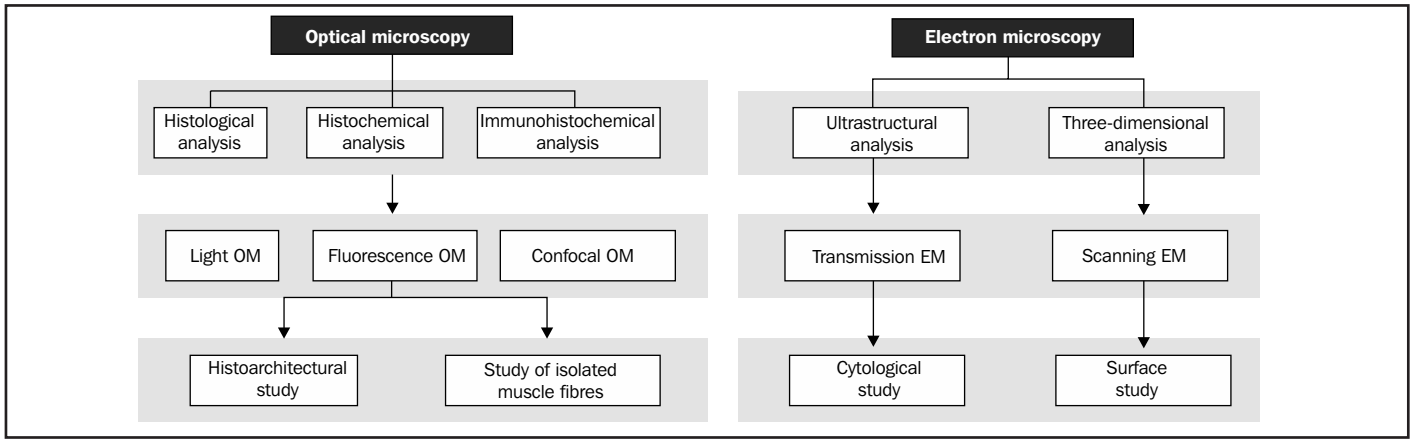
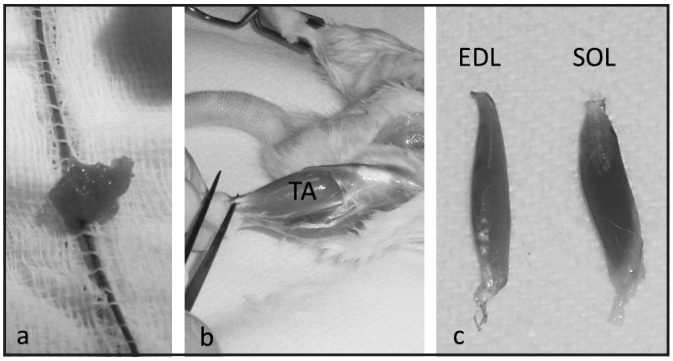


Figure 2. Macroscopic appearance of (a) a fragment of human muscle taken by open biopsy, and (b) complete tibialis anterior muscles in situ (TA), extensor digitorum longus muscle (EDL) and soleus muscle (SOL).



With both biopsies and corpses, the sample must be taken from the muscle belly. The reasons are: a) this is where the muscle fibres have the largest cross-sectional area, which is essential to assess the sizes of the muscle fibres, and b) the area near the myotendinous region should be avoided (at least 2 cm away) (except when that area is the objective of the study) because, in addition to the muscle fibres decreasing in diameter at their termination, they also have histological features which, while normal, differ significantly from other muscle areas[29]. Muscles with recent trauma or injected with local anaesthetic or electromyography needles should not be biopsied either; in all events, the choice of the muscles for biopsy should be based on medical or scientific criteria depending on the desired objective. In studies with muscles from corpses, the procedures and recommendations are the same. It should be borne in mind both that the sample must be taken within 24 hours after death, because this post-mortem interval does not hamper histochemical analysis of the autopsied tissue[30], and that examination of autopsied muscle is not recommended with electron microscopy due to the effects of post-mortem autolysis[31]. The study of muscle samples from dead bodies already fixed in formalin is not recommended due to their great tendency to deteriorate, generating artefacts in the muscle fibres such as contraction and cracking, and even artefacts resulting from imperfect fixation[31].

In research with *experimental animals*, the muscles being studied are normally extracted completely (Figure 2), although again the muscle belly is used for actual analysis. Most of these studies are performed on the soleus and extensor digitorum longus muscles (typically red and white, respectively)[32], and on the tibialis anterior and gastrocnemius muscle, when a greater muscle volume which is easy to access for handling is needed for analysis[33].

How to send the sample to the laboratory

Regardless of the type of study to be conducted, once the sample has been taken, it must be sent to the laboratory immediately because cellular autolysis starts as soon as it is extracted. The indications for transportation are as follows:

- All efforts should be made to keep the samples cool and moist during transportation by placing them in gauze soaked in saline and then wrung out; under no circumstance should they be sent immersed (or previously immersed) in water, saline or fixation substances, because the excess moisture will subsequently generate artefacts during freezing.
- The time from collection to the beginning of the preparation process in the laboratory must be short. Delays of over 45 minutes before arrival at the laboratory may cause artefacts as a result of hypercontraction or dehydration of the muscle fibres[29]. Although a period of 4 hours should never be exceeded[34], a delay before freezing of up to 48 hours has no effect on enzyme histochemistry[35]. If the sample cannot be sent to the laboratory immediately, we recommend that it be kept in a refrigerator at 4°C. Another method is to transport skeletal muscle in ACTP (Aedesta™-cell/ tissue preservation media), as it preserves the sample better and results in fewer artefacts than muscle transportation by conventional methods[36].

How to process the sample in the laboratory

Once in the laboratory, the sample is divided into three fragments: two for analysis by *optical microscopy* and another for *electron microscopy* (Figure 3). It may also be necessary to take tissue for protein or DNA extraction in biochemical and/or genetic research; the fragment for these studies must be preserved at -70°C[29,37] and then subjected to different procedures to those for microscopic study. Consult these in the specific literature[19,21].

Preparation of samples for optical microscopy

The samples must be processed in such a way that it is possible to collect the greatest amount of information from all or most of the elements that constitute the skeletal muscle as an organ (Table 1). To ensure we actually "see" what we are looking for under the microscope, it is necessary to know the microanatomy of the muscle; otherwise, we could prepare the samples inadequately and render the study useless. For example, it is essential to understand the arrangement of the muscle fibres in order to orient the sample cross-sectionally or longitudinally, the motor line area to analyse motor end plates (in conjunction with electrophysiological studies)[29], the composition and distribution of the fibre types in a given muscle to evaluate their percentage variations correctly or the specific characteristics of the myoconnective junctions for proper assessment when dealing with injuries at this level.

Two fragments can be taken in the sample preparation procedure for optical microscopy, one for *fixation in 10% formalin and embedment in paraffin* and another for *freezing in isopentane cooled in liquid nitrogen*. However, the first type of fragment (the kind usually used for other sorts

Figure 3. Schematic overview of the three paths for processing skeletal muscle tissue.

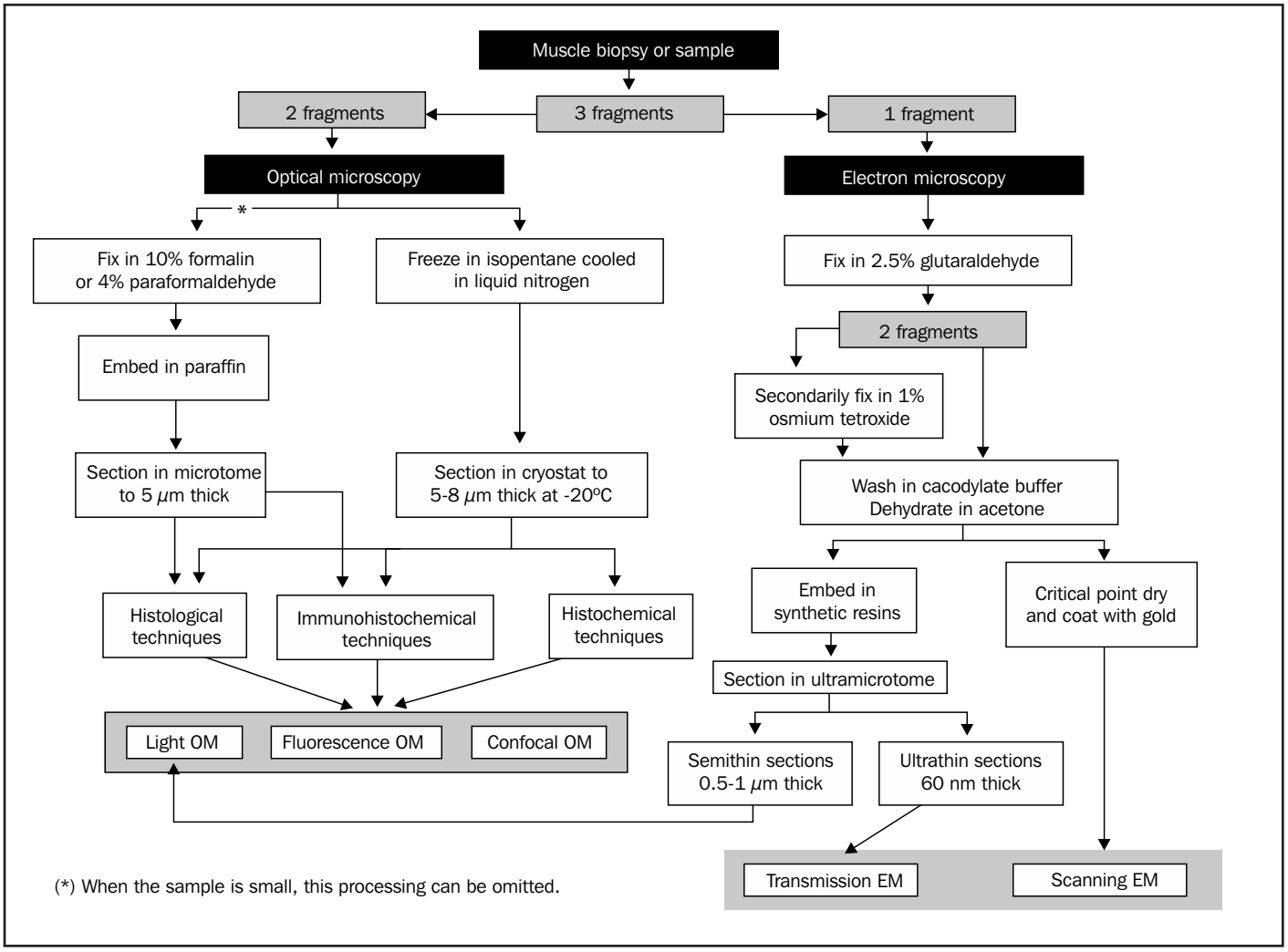


Table 1. Objectives of analysis of a histoarchitectural study.

Optical Microscopy: histoarchitectural study
General histological features of muscle fibres: - Shape and size. - Location of the myonuclei. - Fibre types: percentages and intramuscular distribution.
Satellite cells.
Organisation of and relationships between sheaths of connective tissue: - Endomysium. - Perimysium. - Epimysium.
Vascular elements and their distribution.
Nerve elements: - Nerves. - Neuromuscular junctions. - Neuromuscular spindles.
Myoconnective junctions: - Myotendinous. - Myofascial.

of tissue/organ) is of very limited value in the case of skeletal muscle. The reasons are: a) fixation in formalin and embedment in paraffin produces artefactual changes in the muscle structure which hinder correct microscopic interpretation[38], and b) certain cellular components (enzymes, lipids, etc.) are not preserved, thereby considerably limiting the classification of fibre types and impeding recognition of certain types of changes which cannot be seen in samples processed using the general histological technique[39]. However, we recommend that, whenever possible, a fragment be kept for the usual processing procedure.

Processing samples by freezing

This is the preferred method for the microscopic study of skeletal muscle because it preserves not only the microanatomy but also the antigenic structure and enzyme content of the tissue intact, as well as detaining autolysis and tissue putrefaction. The key to the correct fixation of tissue by freezing lies in doing it instantly, because slow cooling leads

to the formation of intracellular ice microcrystals which can aggregate with the passage of time and cause the tissue to break, hindering or completely impeding microscopic analysis. Problems of this kind are known as "freezing artefacts" and can be avoided by following certain recommendations: i. the sample size to freeze must be small (1.0 x 1.5 cm)[40], and ii. freeze using a mediator such as isopentane cooled in liquid nitrogen, because this speeds up freezing and prevents the formation of intracellular crystals which break the muscle fibres when the freezing process is slow or only liquid nitrogen is used[39]. The entire procedure is as follows and it should be stressed that extreme care must be taken when handling the sample so as not to generate artefacts:

1. Shaping and mounting (Figures 4a-f):
   - The muscle fragment or specimen should be approximately 4 mm in diameter and 8 to 10 mm long (Figure 4a). If it is too thick, the inside will not freeze optimally. For shaping, we recommend a razor blade split in half lengthways; while one half is used to hold the sample against the surface, the other is used to cut (Figure 4b).
   - A microscopic magnifying glass can be used to correctly orient the sample during shaping; this is necessary when the samples have been obtained by needle biopsy (Figure 4c).
   - The trimmed fragment is mounted on a small sheet of cork (on the base of which the sample is identified) using OCT Compound Tissue®, applied only to the cork mounting (Figure 4d) and being extremely careful not to smear or cover the muscle with OCT®, which would result in very severe freezing artefacts by acting as an insulator and preventing quick freezing[27,38].
   - During mounting, the correct orientation of the sample is fundamental to obtain cross sections (type of section which should be used to assess a muscle biopsy), which involves orienting the muscle fibres perpendicular with respect to the mounting surface (cork) and cutting surface (cryostat blade). Use fine tweezers and histological needles to orient the specimen, being careful not to damage the tissue (Figure 4e).
   - If the specimen is too long, it could curl, resulting in the muscle fibres skewing and losing their transverse orientation[41]. To avoid this in our laboratory, we stick a needle in the cork to act as a support, preventing the sample from falling in the moments prior to freezing (Figure 4f). When freezing has been completed, we remove the needle.
2. Freezing (Figures 4 g-l):

The freezing of skeletal muscle requires the use of isopentane (2 methylbutane) because it cannot be directly immersed in liquid nitrogen. This is due to the relative warmth of the tissue, which would cause the vaporisation of the liquid nitrogen next to it, acting as insulation against freezing and generating significant artefacts[38]. The solution is to freeze the specimen in isopentane cooled in liquid nitrogen, which does not penetrate the tissue or prevent or alter later staining processes.

The freezing procedure is as follows:

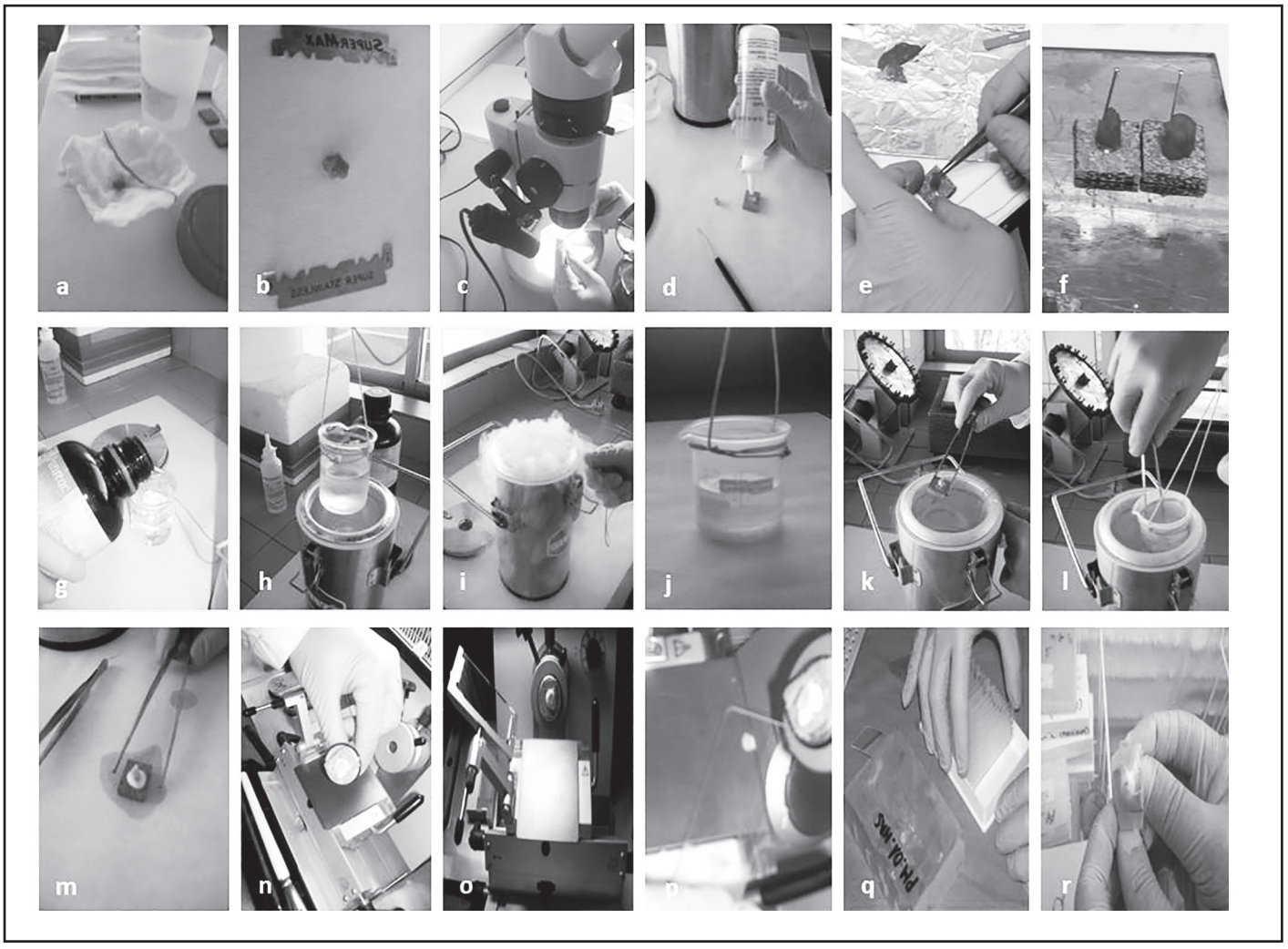
- Pour 80 cc of isopentane into a 100 ml beaker (Figure 4g).
- Suspend the beaker and immerse it in liquid nitrogen (-160°C) (without it overflowing from the vessel), ensuring that the nitrogen does not enter the isopentane (Figure 4h). The first time the beaker enters, there is still a large temperature difference between the two substances, causing the liquid nitrogen to vaporise a great deal and hinder vision of the vessel (Figure 4i). This phenomenon usually dies down in 2-4 minutes.
- When the isopentane freezes, a solid white coating starts to appear on the walls and bottom of the beaker, indicating that it has reached the temperature of the liquid nitrogen (Figure 4j). In our laboratory, we remove the beaker when this has happened and carefully scrape the base and walls until this coating disappears. We then repeat the process. After this, the beaker is ready to receive the sample.
- Re-immerse the beaker; the walls and bottom will solidify very quickly. Then use long tweezers to insert the sample into the isopentane on its cork base (Figure 4k).
- Keep the specimen in the isopentane for 20 seconds (Figure 4l) and then remove it (Figure 4m), transferring it immediately to the cryostat in order to section it.

The freezing time varies according to different authors (8 to 40 seconds), in some cases because they use a mediator other than isopentane, such as acetone and dry ice or Freon 22.

3. Sectioning in cryostat (Figures 4 n-p):
   - The ideal temperature for slicing skeletal muscle is -20°C, although -22ºC is better when the sample contains abundant adipose or fibrous tissue[40].
   - Place the cork mounting with the sample on it on the metal supports of the cryostat with OCT® and wait for it to solidify and stabilise (Figure 4n). After this, fit it on the specimen holder on the arm and orient it with respect to the blade (Figure 4o).
   - Then proceed to trim the surface being cut until it is smooth and uniform, and slice the muscle; the recommended thicknesses are 8-10 µm for histochemistry and 4-6 µm[41] or 5-7 µm[22] for immunohistochemistry. Sections of 2 µm are recommended for cytochemical studies of small structures, such as neuromuscular plates[35]. If the objective is to study the innervation of skeletal muscle with argentic impregnation techniques, the thickness of the sections should range between 50 and 100 µm[42].
   - The sections are collected from the surface of the blade by placing the slide, to which they adhere due to temperature difference, on top (Figure 4p). The slides are kept outside the cryostat and only enter it to collect the section, taking only those slices which are not wrinkled.
   - While obtaining sections, the slide boxes can be kept outside the cryostat to help the tissue on the slide dry and reduce the appearance of artefacts due to detachment when applying the techniques (especially histochemical techniques).
4. Storage of specimens and sections (Figures 4 q-r):

The slides are stored in boxes (containing 25 sections, a number sufficient for the different staining techniques) (Figure 4q) in a freezer (-20°C) prior to histological, histochemical or immunohistochemical

Figure 4. (a-f) Sequence of the procedure for mounting specimens for freezing. (b-l) Sequence of the procedure for freezing in isopentane cooled in liquid nitrogen. (m-r) Sequence for sectioning in cryostat and storage of slides and specimens.



staining. The slides should be dried at room temperature for about 30 minutes before staining the sections.

The frozen specimens on their cork mountings can be stored at -70°C for an unlimited period of time and can be sectioned again (for which they need to be acclimatised to the cryostat temperature, -20°C, for at least 20-30 minutes), retaining their aptness for staining with histological, histochemical and immunohistochemical techniques, and giving satisfactory results even decades after initial freezing[43]. In our laboratory, we store the specimens (both those kept at -20°C and those kept at -70°C) wrapped in Parafilm® to prevent them from drying out and allowing them to be sectioned in the cryostat at any time (Figure 4a).

What to do if you do not have the equipment and resources for processing by freezing?

In this case, the procedure to follow should be the general histological technique, as used for most histological studies. This basically consists of fixing the specimen by immersing it in a flask containing 10% formalin for 24 hours, embedding it paraffin and sectioning it (thickness 5µm) with a microtome. The sections, collected on glass slides, can be stored indefinitely before staining, for which they first need to be deparafined and hydrated.

Although this procedure generates important artefacts, it does not render the muscle sections entirely useless for histological analysis. While it does not permit enzyme histochemical techniques, it is possible to identify fibre types by means of immunohistochemical techniques using monoclonal antibodies against fast and slow myosins[44] .

Preparation of samples for electron microscopy

The main drawbacks of examination using electron microscopy are related to the great amount of work involved in preparing the samples and the high cost involved. These two reasons are given for

not using it and replacing the information it can provide with techniques through which to mark the different elements which make up muscle fibre and other elements. However, in our opinion, while the information obtained through ultrastructural study is no substitute for this information, it does complement and expand on it. This type of microscopy is used when it is necessary to analyse the subcellular or ultrastructural characteristics of the elements which make up skeletal muscle, especially in research which requires very precise views of the structures (Table 2). The procedure is as follows:

Shaping and mounting (Figures 5 a-f)

When the sample is received, a small fragment (no more than 5 mm thick) should be kept for processing using transmission electron microscopy. This fragment is inserted in a well with saline (or phosphate buffer) for 2-5 minutes to prevent artefacts in the myofibrils due to hypercontraction.

The fragment is cut into small cubes measuring 2 mm long by 1 mm wide (Figure 5a). These cubes are then transferred to a small tube in which they are covered with 2.5% glutaraldehyde (Figure 5b). The samples are so small in order to ensure that the fixative penetrates the tissue sufficiently. The samples must be fixed for at least 48 hours (maximum 2 weeks) and should be kept at 4ºC meanwhile. After this time, the fixative should be replaced with phosphate buffer (Figure 5c)

Table 2. Objectives of analysis of an ultrastructural study.

Electron microscopy: ultrastructural study
General cytological features of muscle fibres:
- Basal lamina and plasma membrane.
- Myonuclei.
- Myofibrils.
- Cytoskeleton.
- Mitochondria.
- Sarcoplasmic reticulum and T system.
- Inclusions: glycogen, lipid droplets.
- Specific areas:
• Motor end plate.
• Myotendinous junction.
Satellite cells.
Interstitium:
- Capillaries.
- Pericytes.
- Interstitial cells: histiocytes, fibroblasts.
- Nerve fibres.

and stored in a refrigerator (4°C, because such a low temperature slows down the cellular autolysis processes and anoxic changes which usually occur in the deeper parts of the sample before fixation[27]). The sample is then secondarily fixed with osmium tetroxide. The best way to send the samples is in Eppendorf tubes with hermetic lids.

Embedment in synthetic resins, preparation of blocks (Figure 5d)

Standardised procedures[22,38,45] are followed to embed the samples in synthetic resins such as araldite/epon. Following polymerisation and demoulding of the embedment capsules (Figure 5d), the specimens are trimmed prior to slicing.

Semithin and ultrathin sectioning (Figure 5f)

An ultramicrotome is used to obtain two types of section: semithin (0.5-1 micron) and ultrathin (50-60 nanometres). The former are collected on glass slides and stained with toluidine blue or p-phenylenediamine for prior evaluation under a light microscope; sections of this type provide a view similar to an electron microscope at very low magnification, with the advantage that they offer a much larger area of study than in transmission electron microscopy. This also allows us to select the sections and areas which interest us for later ultrastructural analysis[27]. These sections are collected on copper grids for contrasting (or "staining") with uranyl acetate and lead citrate. The ultrathin sections are then analysed under a transmission electron microscope; longitudinal sections are recommended for ultrastructural study.

Artefacts

Anyone setting out to perform a microscopic examination should be aware not only of the steps involved in handling and processing histological samples of any type of tissue or organ, but also of what we call artefacts (Figure 6). Artefacts are "errors" or "flaws" that appear in histological preparations as the result of an inappropriate methodology or misuse of the equipment or apparatus. Their appearance is quite common in histology and should be avoided because not only can they render a study unviable, they can also be misinterpreted as lesions or could conceal underlying pathological changes.

Figure 5. Sequence of the procedure for sample preparation for transmission electron microscopy.

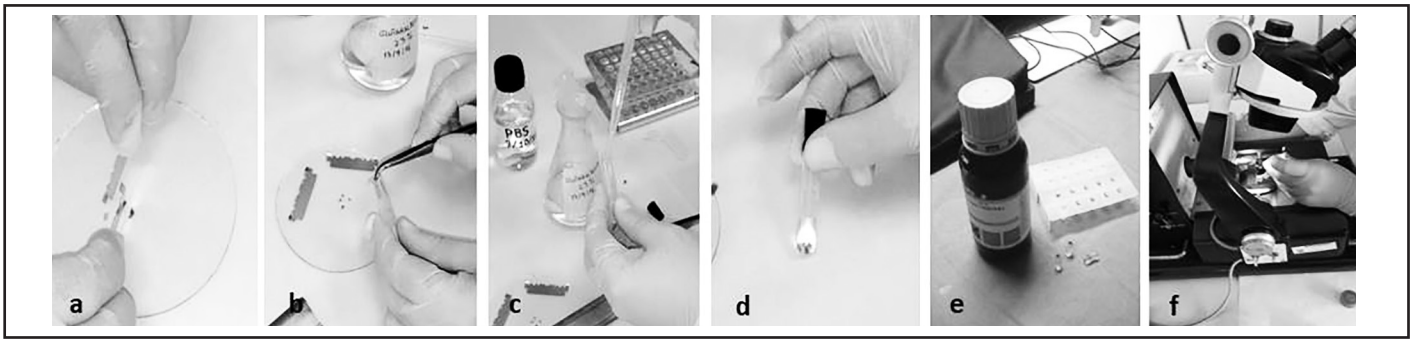
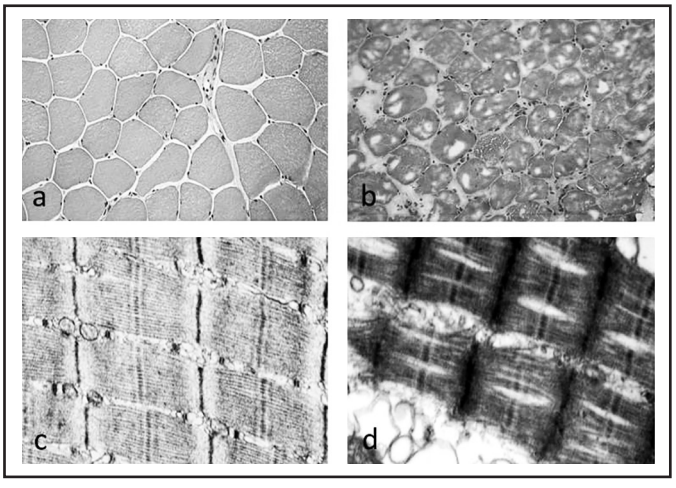


Table 3. List of recommendations to prevent the appearance of the most common artefacts due to errors in the method used to prepare skeletal muscle samples.

Point in the procedure	Don'ts	Consequences
Sample taking	Don't take samples from areas near to tendon	Overestimation of fibrosis and the percentage of nuclear internalisation
Sample taking	Don't take samples from areas previously: - Biopsied - Infiltrated with local anaesthetic - Used for EMG	Tissue necrosis, regeneration and repair may be observed as a result of previous damage
Send samples to the laboratory	Don't send samples in formalin	Histochemical techniques not possible Morphometric analysis not assessable
Processing by freezing	Don't embed the tissue in OCT	"Hole"-type artefacts appear in the more peripheral muscle fibres of the sample
Processing by freezing	Don't freeze the muscle sample directly in liquid nitrogen	Formation of ice crystals which break the muscle fibres
Storage	Don't store the samples in the freezer without protecting them with Parafilm®	The samples dry out and cannot be cut
Fixation for electron microscopy	Don't keep the muscle fragments in saline prior to fixation in glutaraldehyde	Hypercontraction of myofibrils
Fixation for electron microscopy	Inadequate fixation in glutaraldehyde: too much or too little	Mitochondrial breakage or swelling

Figure 6. Cross sections of human muscle stained with hematoxylin and eosin, showing (a) correct freezing and (b) freezing artefacts. Longitudinal sections of the inside of a muscle fibre under a transmission electron microscope, with (c) relaxed myofibrils showing their different bands and (d) myofibrils artefacted by hypercontraction.



In the case of skeletal muscle, artefacts are produced throughout the process, especially during freezing, possibly raising doubts about the reliability of the data obtained or even making study impossible. If this occurs, biopsies may need to be repeated or experimental animals may need to be used for study and both these solutions are ethically questionable. Knowledge of artefacts, how they are produced and how to solve them, therefore, is essential in order to obtain the best possible microscopic preparations and guarantee analysis of the highest quality (Table 3).

Conclusions

Knowledge of and adherence to the methodology for processing skeletal muscle samples for microscopic analysis ensures quality material and facilitates reliable results for trustworthy, precise evaluation. This sample processing by freezing methodology allows us to obtain samples suitable for a wide range of histological, histochemical and immunohistochemical techniques which, with the use of different types of microscopes, offer a more complete vision of muscle histology and, therefore, provide us with an essential aid to find out more about the responses of muscles in the field of medicine and sports traumatology.

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TOLEDO18
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SEMED

XVII CONGRESO INTERNACIONAL DE LA SOCIEDAD ESPAÑOLA DE MEDICINA DEL DEPORTE

FUERZAS ARMADAS – SOCIEDAD
Una alianza a través de la actividad física y el deporte

Toledo - Hotel Beatriz Toledo Auditórium
29-30 de noviembre y 1 de diciembre de 2018

SMD
Sociedad Española de Medicina del Deporte

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	Ángel Sánchez Ramos
	José Luis Terreros Blanco

PROGRAMA PRELIMINAR

JUEVES, día 29

SESIÓN PLENARIA: El pasado y el presente de la traumatología del deporte.
Moderador: **José Cotarelo Perez**

José María Vilarrubias Guillamet
Mikel Sánchez Álvarez

PONENCIA OFICIAL de la Agencia Española de Protección de la Salud en el Deporte (AEPSAD): El Pasaporte Biológico del Deportista (PBD), presente y futuro.
Moderador: **José L. Terreros Blanco**

El PBD como herramienta en el control de dopaje
Jesús A. Muñoz Revilla

El PBD, una visión desde la Medicina del Deporte
Pedro Manonelles Marqueta

El PBD, una visión jurídica
Agustín González González

PONENCIA OFICIAL: Patología del pie en el deporte.
Moderador: **Ángel González de la Rubia Heredia**

Valoración de la morfología, rigidez y función del arco del pie en el corredor.
Luis Enrique Roche Seruendo

Talalgias en el deportista. Abordaje clínico.
Alfonso Martínez Franco

Dolor aquileo: las lesiones del tendón más poderoso.
Sergio Tejero García

PONENCIA OFICIAL: Probióticos y deporte.

SIMPOSIO SETRADE: Gestión de la información en las lesiones deportivas.
Presidente: **Antonio Carrascosa Cerquero**
Moderador: **Carlos Sánchez Marchori**

El menor deportista de élite. Cómo y a quién informar
Cristóbal Rodríguez Hernández

Ética en la gestión de la información
Tomás Fernández Jaén

El médico de equipo y su relación con los medios
Jordi Ardevol Cuesta

SIMPOSIO: Alimentación en situaciones extremas.

La alimentación del ejército en operaciones de campaña.
Juan Manuel Ballesteros Arribas

La alimentación en la travesía del Atlántico a remo.
Jorge Pena Mariño

La alimentación en altitud extrema.

TALLER: Taller de interpretación del electrocardiograma en el deportista.
Emilio Luengo Fernández

VIERNES, día 30

SESIÓN PLENARIA: El futuro del alto rendimiento deportivo/ *The future of high sports performance.*
Moderador: **José Naranjo Orellana**

El maratón en menos de dos horas:
The Sub2 Marathon Project: Galileo contra Goliat.
The Sub2 Marathon Project: Galileo versus Goliath.
Yannis Pitsiladis

Algoritmos de predicción de récords deportivos.
Sports record prediction algorithms.
John H. J. Einmahl

PONENCIA OFICIAL: El entrenamiento de la fuerza y la fatiga.
Moderador: **Fernando Alacid Cárceles**

Entrenamiento de fuerza y fatiga.
José Manuel García García

Entrenamiento adecuado para soportar la fatiga en colectivos especiales.
Nuria Mendoza Laiz

Alimentación adecuada para soportar la fatiga.
Antonio López Farré

PONENCIA OFICIAL: Actualización en deporte adaptado.
Moderador: **Antonio Sánchez Ramos**

Principales adaptaciones de los servicios médicos a la inclusión deportiva en el deporte federado.
Josep Oriol Martínez Ferrer

Baloncesto en silla de ruedas en España: aplicaciones inclusivas y de investigación.
Javier Pérez Tejero

Deporte terapéutico en lesionados medulares.
Ana Esclarín de Ruz

PONENCIA OFICIAL: Ejercicio físico en el ámbito militar.
Moderador: **Juan Ramón Godoy López**

Ejercicio físico en condiciones extremas en militares de operaciones especiales.
Claudio Nieto Jiménez

Hacia un nuevo modelo de preparación física militar.
José Francisco García Marco Reclamado

Entrenamiento físico del personal de vuelo.
Carlos Velasco Díaz.

SALA SEGUNDA
SIMPOSIO: Terapias no invasivas en la tendinopatía calcificante del hombro.
Moderador: **Miguel Del Valle Soto**

Electroterapia.
Juan Nápoles Carreras

Ejercicio.
Fernando Ramos Gómez

Ondas de choque.
Óscar Sanjuán Reguera

PRESENTACIONES

Documento de consenso de la Sociedad Española de Medicina del Deporte (SEMED-FEMEDE) sobre contraindicaciones para la práctica deportiva.

Documento de Consenso de la Sociedad Española de Medicina del Deporte (SEMED-FEMEDE) sobre lesiones y accidentes deportivos.

Documento de Consenso de la Sociedad Española de Medicina del Deporte (SEMED-FEMEDE) sobre ayudas ergogénicas.

TALLER: Taller de interpretación de la prueba de esfuerzo.
José Naranjo Orellana

SÁBADO, día 1

SESIÓN PLENARIA: ¿Hacia dónde se dirige la nutrición en el deporte y en la actividad física?

La alimentación en el deporte y el ejercicio / *Nutrition for sports and exercise*
Ron Maughan

El futuro de la nutrición en la actividad física.
Luis Moreno Aznar

PONENCIA OFICIAL: Ética y deontología en Medicina del Deporte: La clasificación deportiva de deportistas con diferencias en el desarrollo sexual.
Presentación: **Pedro Manonelles Marqueta**

La visión desde la Deontología Médica
Juan José Rodríguez Sendín

La visión desde la Medicina del Deporte
Fabio Pigozzi

REMISIÓN DE COMUNICACIONES CIENTÍFICAS

El Comité Científico invita a todos los participantes a remitir comunicaciones científicas (comunicaciones orales y póster-presentación interactiva) al XVII Congreso Nacional de la Sociedad Española de Medicina del Deporte.

Temas para presentación de Comunicaciones Científicas en el Congreso:

- 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.

Las Comunicaciones Orales se distribuirán en sesiones de los temas del Congreso. Por favor, escoja uno de los temas del listado como propuesta para realizar su presentación. El Comité Científico podrá reasignar el abstract en otro tema del Congreso.

Los trabajos deberán ser originales y no se habrán presentado en congresos anteriores o reuniones similares.

Las comunicaciones científicas admitidas, comunicaciones orales y pósters (presentación interactiva), serán publicadas en la revista Archivos de Medicina del Deporte.

Normas de remisión de abstracts

Por favor, preste atención a las siguientes normas de preparación del abstract de su comunicación científica (comunicación oral o póster: presentación interactiva), porque son de obligado cumplimiento:

- La fecha límite para la remisión de los trabajos científicos será el día **14 de septiembre de 2018**.
- Se remitirá la Comunicación Científica a la atención del presidente del Comité Científico, con el formulario debidamente cumplimentado, a la siguiente dirección de correo electrónico: **congresos@femede.es**.
- El abstract tiene que tener una clara relación con los contenidos del XVII Congreso Nacional de la Sociedad Española de Medicina del Deporte y, en definitiva, con la Medicina y Ciencias del Deporte.
- El Comité Científico podrá destinar el trabajo presentado a la forma de presentación (comunicación oral o póster: presentación interactiva) que considere más adecuada al tipo y contenido del mismo.
- El Comité Científico se reserva el derecho de rechazar los trabajos que no cumplan los requisitos indicados anteriormente por la calidad y temática que el evento científico requiere.

Forma de preparación del abstract

- Sólo se aceptarán las comunicaciones científicas presentadas en el formato electrónico que se encuentra en la página web del Congreso: http://www.femede.es/congresotoledo2018/ "Formato de comunicación científica".
- **Título:** El título deberá ser breve (máximo de 15 palabras) y específico. Debe reflejar el contenido de la presentación. No use abreviaturas en el título. Se escribirá en letras mayúsculas, usando el tamaño 12 del tipo de letra Arial.
- **Autores:** Se escribirá, en minúsculas, el apellido seguido, sin coma, de la inicial del nombre de cada autor, separados por comas.
- **Centro:** Indicar el centro de trabajo de los autores. Si son varios, indicar con un número superíndice.
- **Preferencia de presentación:** Seleccionar con un asterisco el tipo de presentación a la presenta la comunicación científica.
- **Texto:** La extensión máxima del texto es de 300 palabras o 3.000 caracteres. Se escribirá en minúsculas,

usando el tamaño 10 de la letra Arial. Se evitarán abreviaturas no explicadas. Se escribirá el contenido del resumen científico sin repetir el título de la Comunicación y ajustándose al siguiente esquema: introducción, material y métodos, resultados y conclusiones.

- Respetando la extensión máxima del texto se pueden incluir tablas, gráficos o imágenes.
- Es obligatorio indicar un máximo de **tres palabras clave**.
- Los abstracts deben incluir **información específica** sobre los resultados y las conclusiones de la investigación. No se aceptarán abstracts que establezcan que "se discutirán los resultados".

Notificación de la recepción de la comunicación científica

En el plazo de 15 días, Vd. recibirá la confirmación de recepción de la comunicación por parte de la Secretaría del Congreso. Si no la recibiera, no vuelva a remitir la comunicación y envíe un mensaje electrónico: congresos@femede.es.

Inscripción del responsable de la comunicación científica

- Cada persona puede presentar dos comunicaciones científicas como máximo (comunicación oral o póster: presentación interactiva). En caso de ser aceptadas ambas, sólo una de ellas podrá ser presentada como comunicación oral.
- Los autores (CADA UNO PUEDE PRESENTAR DOS TRABAJOS) que presenten una comunicación científica (comunicación oral o póster-presentación interactiva) y ésta haya sido aceptada, deben haberse registrado y **haber pagado los derechos de inscripción del Congreso antes del 25 de octubre de 2018**. En caso contrario su comunicación científica (comunicación oral o póster-presentación interactiva) será eliminada del programa y del libro de abstracts.
- Cada autor puede FIRMAR todos los trabajos que quiera.
- No hay limitación en el número de comunicaciones que puede aparecer una misma persona.

Presentación de la comunicación oral

- Las Comunicaciones Orales tendrán un **tiempo de presentación de 8 minutos.** Al final de cada sesión habrá un turno de preguntas.
- Todas las exposiciones orales se harán en **formato Powerpoint**, debiendo estar en posesión del responsable de las Comunicaciones de la organización el día anterior a la presentación de la misma.
- Se limita a un **máximo de 12 el número de diapositivas** de la presentación de powerpoint.

Póster (presentación interactiva)

Si su abstract se acepta, pero no se puede ajustar a una presentación en forma de Comunicación Oral, se le propondrá presentarlo en forma de póster-presentación interactiva, dándole un tiempo para su preparación.

Presentación del póster (presentación interactiva)

Para la elaboración del póster (presentación interactiva) debe seguir las siguientes instrucciones que son de obligado cumplimiento:

- Formato **Microsoft Powerpoint**.
- Hasta 12 diapositivas, de las cuales:
  - La primera: debe contener **título, autores, centro de trabajo**.
  - La última: debe contener **título** y la palabra **FIN** o expresión similar que indique que la presentación ha concluido.
  - La penúltima o las dos penúltimas deben contener las **conclusiones**.
- Fondo de diapositivas: color neutro y uniforme.
- Texto de diapositivas: color que **contraste** con el fondo.

- En lo posible evitar incluir vídeos en las diapositivas, si se hiciera debería ser en formato **.wmv** y se deberá incluir en un subdirectorio/carpeta que enlace automáticamente con la presentación remitida. Si el video no enlazara con la presentación, no se editará por parte de la organización para corregir el error.
- La organización se reserva el derecho de ocultar diapositivas que incluyan contenidos inapropiados o inadecuadamente referenciados.
- El uso de cualquier imagen que no sea de la autoría del/de los firmante/firmantes de la presentación deberá contener referencia a (y eventualmente permiso de) su autor en la misma presentación o bien podrá ser retirada de la misma y en todo caso la organización no se hará responsable en ningún caso de las consecuencias del uso inapropiado de aquellas.
- Se cuidará de igual manera de incluir las referencias bibliográficas oportunas en pequeño tamaño de letra, pero que sea legible.
- El abstract debe remitirse preparado tal como se indica anteriormente **(Forma de preparación del abstract)**.
- Una vez que se le confirme que su comunicación científica ha sido aceptada para ser presentada en forma de póster (presentación interactiva) debe enviar el documento electrónico **(.Ppt)**:
  - Trabajos destinados por el autor directamente a póster (presentación interactiva): **antes del 14 de septiembre de 2018**.
  - Trabajos destinados por el autor a Comunicación Oral y que el Comité Científico destina a póster (presentación interactiva): **antes del 20 de septiembre de 2018**.
- El documento electrónico **(.Ppt)**: debe enviarse a la dirección electrónica del Congreso: congresos@femede.es.

Certificaciones

Tras la presentación de la comunicación oral o la defensa del póster en el modo en que se indique se entregará un **único certificado** al responsable de la comunicación científica.

Publicación de los trabajos científicos

Los abstracts de los trabajos científicos (comunicaciones orales y póster) **aceptados y presentados** en el XVII Congreso Nacional de la Sociedad Española de Medicina del Deporte serán publicados en la revista ***Archivos de Medicina del Deporte***, publicación científica de esta especialidad y revista oficial de la Sociedad Española de Medicina del Deporte, que tiene una periodicidad de publicación bi-mensual.

Los inscritos en el Congreso que presenten comunicaciones podrán optar al Premio a la **Mejor Comunicación oral** del Congreso.

Para optar al premio **SE DEBE HACER CONSTAR EXPLÍCITAMENTE QUE SE OPTA A PREMIO** en carta dirigida al presidente del Comité Científico y adjuntar al Resumen remitido. En este caso, además de enviar el Formato del Resumen de Comunicación Científica, se debe de mandar el trabajo completo en el plazo de presentación de las Comunicaciones Científicas, presentado según las normas de publicación de la revista Archivos de Medicina del Deporte.

Los trabajos que se presentan en formato de póster (presentación interactiva) no optan a premio.

El trabajo que obtenga la segunda mejor puntuación, y supere en nivel de calidad exigible, será dotado con un accésit a la Mejor Comunicación del Congreso.

Dotación de los premios

Premio a la Mejor Comunicación Oral del Congreso:

- Dotación económica: 1.500 euros.
- Certificado acreditativo.
- Publicación en la revista Archivos de Medicina del Deporte con indicación del premio obtenido.

Accésit a la Mejor Comunicación Oral del Congreso:

- Dotación económica: 1.000 euros.
- Certificado acreditativo.
- Publicación en la revista Archivos de Medicina del Deporte con indicación del premio obtenido.

Los trabajos premiados serán publicados en la revista Archivos de Medicina del Deporte y se aceptará la revisión efectuada por el Comité Científico.

Los premios podrán ser declarados desiertos si no alcanzan el nivel de calidad exigible.

INFORMACIÓN GENERAL

Fecha

29-30 de noviembre y 1 de diciembre de 2018

Lugar

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C/ Concilios de Toledo, s/n. 45005 Toledo
Teléfono: +34 925 26 91 00
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Secretaría Científica

Sociedad Española de Medicina del Deporte
Apartado de correos 1207. 31080 Pamplona
Teléfono: +34 948 26 77 06 – Fax: +34 948 17 14 31
Correo electrónico: congresos@femede.es
Página web: http://www.femede.es/congresotoledo2018/

Secretaría Técnica

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

Idioma oficial

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

DERECHOS DE INSCRIPCIÓN

	Antes del 31/8/2018	Del 1/8/2018 al 8/11/2018	Desde el 9/11/2018 y en Congreso
Cuota general	350 euros	450 euros	500 euros
SEMED-FEMEDE	300 euros	400 euros	450 euros
Médicos MIR, doctorandos y becarios de investigación*	300 euros	400 euros	450 euros
Médicos MIR, doctorandos y becarios de investigación* que presenten comunicación científica	250 euros	400 euros	450 euros
Dietistas/Nutricionistas**	300 euros	400 euros	450 euros
AEF***	300 euros	400 euros	450 euros

*Es necesaria acreditación. Sin certificación se cobrará la cuota general.
**Dietistas-nutricionistas de asociaciones o colegios autonómicos de todo el territorio español. Es necesaria acreditación. Sin certificación se cobrará la cuota general.
***AEF: Asociación Española de Fisioterapeutas. Es necesaria acreditación. Sin certificación se cobrará la cuota general.

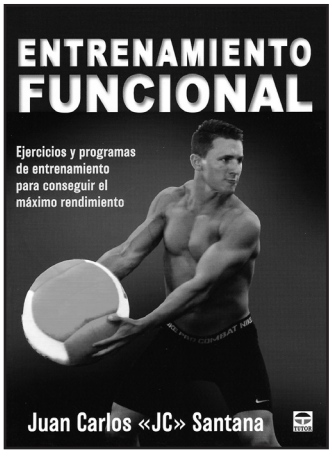
Cuota general, SEMED-FEMEDE, MIR, Dietistas/Nutricionistas, AEF. Incluye la asistencia a todas las sesiones científicas, la documentación del congresista, los cafés, las comidas de trabajo y la exposición comercial.

ENTRENAMIENTO PARA TRIATLÓN. TU PRIMER TRIATLÓN

Por: Linda Cleveland y Kris Swarthout
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, 264 páginas. P.V.P.: 21 euros

Natación, ciclismo y carrera a pie. Si la combinación de estos tres términos, emociona al lector entonces necesita este libro. Escrito por los expertos de USA Triathlon (USAT), la mayor organización multideportiva del mundo, este libro proporciona estrategias, secretos y consejos con los que prepararse para el primer triatlón de distancia *esprint* o de distancia olímpica.

No es otro programa generalista aplicable a todos los casos y sin especificidad alguna, se trata de un entrenamiento global. El libro ha sido concebido para que el deportista se centre en el entrenamiento que más necesita. Se establece un nivel de partida en cada una de las tres modalidades: natación, ciclismo y carrera a pie. Se exponen los niveles de entrenamiento de bronce, plata y oro para cada modalidad, que además se combinan y adaptan a la medida de sus necesidades, objetivos y estilo de vida.

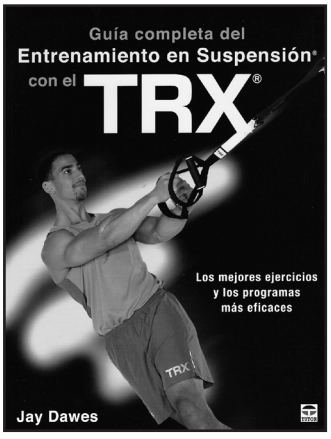


ENTRENAMIENTO FUNCIONAL

Por: Juan Carlos Santana
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, 296 páginas. P.V.P.: 29,95 euros

El autor presenta un enfoque revolucionario de los métodos de entrenamiento y acondicionamiento físico que, seguro, mejorarán la capacidad funcional en cualquier actividad física o deporte. Este libro aborda los últimos avances, un gran número de ejercicios y los programas de eficacia probada que pueden seguirse o incorporarse al plan de entrenamiento. Ofrece una programación con ejercicios de fuerza, resistencia, potencia y ejercicios para deportes específicos; es una excelente obra completa para cualquier deportista, entrenador o preparador físico.

El libro abarca los conceptos, los ejercicios, las progresiones y la secuenciación sobre los que se basan los programas de entrenamiento funcional, cubriendo las necesidades de once deportes, y presenta 135 ejercicios empleando el propio peso corporal, bandas elásticas y poleas, mancuernas y *kettlebells,* balones medicinales y balones de estabilidad. Por medio de evaluación y análisis, se identifican los movimientos y músculos implicados en los distintos deportes, para así seleccionar los mejores ejercicios y programas basándose en los resultados que se desean y en los objetivos marcados para el rendimiento.



GUÍA COMPLETA DEL ENTRENAMIENTO EN SUSPENSIÓN CON EL TRX

Por: Jay Dawes
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, 224 páginas. P.V.P.: 29,95 euros

El entrenamiento en suspensión es excelente para aumentar la fuerza, la potencia, la estabilidad del core, la flexibilidad y el equilibrio. Es el método empleado por los mejores entre los mejores: desde los preparadores físicos hasta los deportistas de élite con los que trabajan, el entrenamiento en suspensión es un componente apreciado y esencial de los programas de acondicionamiento físico. Ahora, el mayor experto en este tipo de entrenamiento comparte con los lectores los ejercicios y programas de entrenamiento en suspensión más actuales.

Este libro es la guía autorizada sobre el entrenamiento en suspensión. Esta obra es tan completa que se ha ganado el respaldo de TRX. Este es un recurso único en su género, diseñado para llevar los programas de entrenamiento hasta niveles nunca vistos. Incluye instrucciones completas de 117 ejercicios, con secuencias fotográficas, variantes y recomendaciones de seguridad.

2018		
8th International Posture Symposium	9-12 Septiembre Smolenice (Eslovaquia)	web: http://www.posture.sk/
XXXV Congreso Mundial de Medicina del Deporte	12-15 Septiembre Rio de Janeiro (Brasil)	web: www.fims.org
59º Congreso Peruano de Ortopedia y Traumatología	13-15 Septiembre Lima (Perú)	www.spotrauma.org/
28º Congress European Society for surgery of the shoulder and the elbow (SECEC-ESSSE)	19-22 Septiembre Ginebra (Suiza)	web: www.secec.org
XI Congress Société Française de Médecine de l'Exercice et du Sport (SFMES)	20-22 Septiembre Le Havre (Francia)	web: www.sfmes.org
10th edition of the IOC Advanced Team Physician Course	25-27 Septiembre Marrakech (Marruecos)	web: www.ioc-preventionconference.org/atpc2018/
55 Congreso SECOT	26-28 Septiembre Valladolid	web: www.secot.es
International symposium on Preventing Childhood Obesity in Preschoolers	27-28 Septiembre Salzburgo (Austria)	web: http://www.salto-salzburg.at/english/symposium/home.html
5th International Scientific Tendinopathy Symposium (ISTS)	27-29 Septiembre Groningen (Países Bajos)	web: http://ists2018.com/
EFAD (European Federation of the Associations of Dietitians) Conference	28-29 Septiembre Rotterdam (Países Bajos)	web: http://efadconference.com/
14th TUSYAD (Turkish Society of Sports Traumatology, Arthroscopy and Knee Surgery)	2-6 Octubre Antalya (Turquía)	web: www.tusyad2018.org/en.html
VII Congreso Iberoamericano de Psicología del Deporte	3-5 Octubre Las Condes (Chile)	web: www.postgradounab.cl/actividades/vii-congreso-iberoamericano-de-psicologia-del-deporte/
XXVIII Congreso AMLAR 2018 - Asociación Medica Latinoamericana de Rehabilitación	3-6 Octubre Guayaquil (Ecuador)	web: http://amlar2018.com/
49 Congreso Nacional de Podología	5-6 Octubre Santiago de Compostela	E-mail: comiteorganizador@49congresopodologia.com E-mail: podologia2018@compostelacongresos.com
II Congreso de Alimentación, Nutrición y Dietética	5-6 Octubre Madrid	web: http://www.congresoand.com/2018/
Strength Sports Conference	8-11 Octubre Stellenbosch (Sudáfrica)	E-mail: mimibotha@sun.ac.za
7th International Society for Physical Activity and Health Congress (ISPAH)	15-17 Octubre Londres (Reino Unido)	web: www.ispah2018.com/
XLI Congreso de la Sociedad Ibérica de Biomecánica y Biomateriales	19-20 Octubre Madrid	web: https://sibb2018.wixsite.com/madrid

II Jornadas de cirugía del pie y tobillo: pie plano del adulto	19-20 Octubre Murcia	web: www.clinictrauma.es
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XXIX Congreso Mexicano de Ortopedia y Traumatología	24-27 Octubre Merida-Yucatán (México)	web: http://www.femecot.com/
VII Congreso Internacional de Entrenadores de Piragüismo de Aguas Tranquilas y I Congreso Internacional de Slalom	26-28 Octubre Catoira (Pontevedra)	web: www.congresocatoira.es
55º Congreso Argentino de Ortopedia y Traumatología	1-4 Noviembre Rosario-Santa Fe (Argentina)	web: http://congresoaaot.org.ar/
VII Congreso Asociación Hispanoamericana de Médicos del Fútbol	3-4 Noviembre Lima (Perú)	web: http://hispamef.com/
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7º Congreso Mundial del Deporte Escolar, Educación Física y Psicomotricidad	8-10 Noviembre A Coruña	web: www.sportis.es/congresos
CIENMEDE 2018 - Ciencias Aplicadas a la Medicina del Deporte	12 -15 Noviembre La Habana (Cuba)	web: www.cienmedecuba.com/
XVIII Congreso latinoamericano de Nutrición (SLAN) 2018	11-15 Noviembre Guadalajara (México)	web: www.slaninternacional.org
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XVII Congreso Nacional de la SEMED-FEMEDE	29 Noviembre-1 Diciembre Toledo	web: www.femede.es
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2019		
BKAM 2019: Barcelona associated Knee Meeting	6-9 Febrero Barcelona	web: www.bkam.info
XVI Congreso Nacional de Psicología de la Act. Física y del Deporte	13-16 Marzo Zaragoza	web: www.psicologiadeporte.org

XXXVI Congresso FMSI: "Età biologica, età anagrafica"	27-29 Marzo Roma (Italia)	web: www.fmsi.it/
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VIII Congreso Iberoamericano de Nutrición	3-5 Julio Pamplona	web: http://www.academianutricionydietetica.org/congreso.php?id=7#
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13th Congreso Mundial de la International Society of Physical and Rehabilitation Medicine	9-13 Julio Kobe (Japón)	web: http://www.isprm.org
9th VISTA Conference	4-7 Septiembre Amsterdam (Países Bajos)	web: www.paralympic.org/news/amsterdam-host-vista-2019
14th International Congress of shoulder and elbow surgery (ICSES)	17-20 Septiembre Buenos Aires (Argentina)	web: www.icses2019.org
5th World Conference on Doping in Sport	5-7 Noviembre Katowice (Polonia)	web: http://www.wada-ama.org/
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IOC World Conference Prevention of Injury & Illness in Sport	12-14 Marzo Mónaco (Principado de Mónaco)	web: http://ioc-preventionconference.org/
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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
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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/

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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

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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"

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1. Klein G, Kullich W. Reducing pain by oral enzyme therapy in rheumatic diseases. Wien Med Wochenschr 1999;149(21-22):577-580,2. Gregory, S, Kelly, ND. Bromelain: A Literature Review and Discussion of its Therapeutic Applications. Alt Med Rev 1996;1(4):243-257. 3. Roep BO, van den Engel NK, van Halteren AGS, Duinkerken G, Martin S. Modulation of autoimmunity to beta-cell antigens by proteases. Diabetologica 2002;45(5):686-692. 4. Klein G, Kullich W, Schnitker J, Schwann H. Effi cacy and tolerance of an oral enzyme combination in painful osteoarthritis of the hip. A double-blind, randomised study comparing oral enzymes with non-steroidal anti-infl ammatory drugs. Clin Exp Rheumatol 2006;24(1):25-30. 5. Ueberall, M. A., Mueller-Schwefe, G. H., Wigand, R., & Essner, U. (2016). Efficacy, tolerability, and safety of anoral enzyme combination vs diclofenac in osteoarthritis of the knee: results of an individual patient-level pooledreanalysis of data from six randomized controlled trials. Journal of pain research, 9, 941.6. Wittenborg A, Bock PR, Hanisch J, Saller R, Schneider B. Comparative_epidemiological_study in patients with rheumatic diseases illustrated in a example of a treatment with non-steroidal anti-inflammatory drugs versus an oral enzyme combination preparation. Arzneimittelforschung._2000;50(8):728-38. 7. May C, Smola M, Ruda C, Scharnagl E. Randomized open controlled clinical study on the efficacy and tolerance of an oral enzyme preparation in lymphadenectonomy patients. International Journal of Immunotherapy. 2001; XVII (2/3/4):149-152. 8. Akhtar N, Naseer R, Farooqi A, Aziz W, Nazir M. Oral enzyme combination versus Diclofenaco in the treatment of osteoarthritis of the knee- a double-blind prospective randomized study. Clinical –rheumatology. 2004;23:410-415. 9. Masson M. Bromelain in blunt injuries of the locomotor system. A study of observedapplications in general practice. Fortschr. Med. 1995;113:303-6. 10. Kerkhoff s GM, Struijs PA, de Wit C, Rahlfs VW, Zwipp H, van Dijk CN. A double blind, randomised, parallel group study on the effi cacy and safety of treating acute lateral ankle sprain with oral hydrolytic enzymes. Br. J. Sports Med.2004;38:431-5. 11. KamenícekV, Holán P, Franêk P. Systemic enzyme therapy in the treatment and prevention of post-traumatic and postoperative swelling. Acta Chir. Orthop.Traumatol. Cech. 2001;68:45-9. 12. Wittenborg A, Bock PR, Hanisch J, Saller R, Schneider B. Comparative epidemiological study in patients with rheumatic diseases illustrated in a example of a treatment with non-steroidal anti- inflammatory drugs versus an oral enzyme combination preparation. Arzneimittelforschung 2000;50:728-38.

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