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Time to fatigue on lactate threshold and supplementation with sodium bicarbonate in middle-distance college athletes

Prevalence and dynamic changes of vagotonic T waves during exercise in elite soccer player population

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Performance factors in Trail-running

Factores de rendimiento en carreras por montaña

Hugo Olmedillas

Departamento de Biología Funcional. Área de Fisiología. Universidad de Oviedo. Asturias.

Trail running (TR) has become extremely popular over the last few years. As a result, the interest of the participants themselves and that of the professionals responsible for their health and performance has progressively increased. The field of research has not remained indifferent; an increasing number of studies have principally aimed to answer the main questions raised from a physiological and biomechanical point of view. According to the Federación Española de Deportes de Montaña y Escalada (Spanish Federation of Mountain Sports and Climbing) (FEDME), the main entity responsible for regulating this discipline, trail running is a sport that can take place in High, Medium and Low Mountains, with a minimum distance of 21 kilometres, except in the case of the Vertical Kilometre, and with a minimum elevation gain of 1,000 metres. The course shall always be along non-asphalted tracks and pathways, with no more than 50% on tracks that can be used by vehicles. The main difference between these races and the most traditional asphalt races are the accumulation of uphill and downhill sections, which gradually create a specific profile for each unique competition. Of still greater importance, from a physiological point of view, is the exponential increase in the number of participants who, over the last five years, have taken an interest in the ultra- long trail races (>80 km). It is therefore extremely likely that these maximum efforts induce situations of extreme fatigue. The runner must overcome considerable elevation gains and this has a direct impact on continuous effort, intense concentric and eccentric muscle action of the lower limbs, generated by the ascents and descents respectively. In contrast, level asphalt races are characterised by repeated stretch-shortening cycles of the lower limb extensor muscles. This subtle difference results in biomechanical movements in the athletes' running pattern that are different from those observed in asphalt runners. The investigations, which have focussed on an analysis of fatigue, suggest a reduction close to 40% of muscle strength and a fatigue amplitude similar in the knee extensors and the plantar flexors, although the central or peripheral source of fatigue in these muscle groups has yet to be determined. Surprisingly, there is no linear relationship between the loss of strength in the knee extensors and plantar flexors (main muscles involved when running) and the duration of the ultra races. Scientific literature has revealed a reduction in the loss of strength in races of more than 166 km. Millet *et al*. suggests that this fact may be due to the runner's conservative pacing strategy in races of such a long duration, although this characteristic has been described for trail runs and for level asphalt running races alike. Running alterations occurring after an ultra race, regardless of whether it is TR or asphalt, are similar. This suggests that, rather than the biomechanical characteristics inherent in both disciplines, the duration of the race is the triggering factor in the modification of the running kinematics, possibly in order to reduce the eccentric load component characteristic of the running action and this could explain the non-linear performance of the loss of strength.

Despite the kinematic difference between both disciplines, it is true that the short races of TR <42 km are completed by the faster runners in times of less than 4 hours, establishing a certain similarity with the half-marathon and marathon asphalt races. Based on this distance-time factor for completing a race, it was suggested that the key determinants for performance in these endurance races could be explained by following the traditional model proposed by di Prampero *et al*. which is primarily based on physiological factors, including maximal oxygen uptake(VO_2max), the percentage of VO_2max (% VO_2max), and running economy (RE).

Numerous investigations have found that the greatest velocity that can be sustained during a race is directly related to increased % VO_2max and is inversely proportional to RE. Performance factors in trail running. In fact, the differences observed in RE can largely explain the differences observed in the performance of runners with a similar VO_2max. Moreover, an improvement in RE has been related to a reduction in the marathon times of elite runners. Although it is true that

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elite TR runners have high oxygen uptakes, similar to those observed for long-distance runners, particular attention should be paid to the detail that, when a group of well-trained trail runners perform incremental tests on treadmills with a slope of 0, 12.5 and 25%, no correlations were observed between the RE values on slope running with those for level running. Therefore, an initial approach to the study of these athletes must consider the use of evaluation methods that include protocols for inclined tests. On the other hand, the energy cost of running varied, depending on the slope gradient of the test. Therefore, runners with a low RE, when the test was conducted on the level, obtained high RE values when the test was conducted on greater gradients and vice versus. The fact that some runners increased their RE to a lesser extent than others when increasing the treadmill slope cannot be explained on this occasion, by one of the principal parameters that explains a lower RE between runners with similar anthropometric and physiological values, such as the elastic energy storage capacity, given the fact that with a 25% slope, the mechanical muscular work is principally positive. Recently, through a regression analysis, Ehrstrom *et al.* identified that the classic performance model used for resistance tests did not explain the success in races of <30 km for a group of TR runners. The authors found that the classic physiological factors explained around 50% of the performance variability, whereby the lower limb strength (50%), VO_2max (20%) and the RE evaluated in a test on a 10% slope (4.5%) were the main performance indicators. These variables explained 98% of the times obtained in a 27 km race with 1,400 positive metres.

We can conclude that, although it is true that classic physiological (cardiovascular) factors are crucial for differentiating the different levels of runners in the pack, the incorporation of investigations that provide an in-depth evaluation of the strength variable, that is maximal strength and also the variation in strength throughout the trail , could help explain the characteristics inherent in this discipline. Furthermore, it would be interesting to see how this could affect races with harder conditions, either due to the gain level or the distance of the race, or the different levels ranging from elite runners to runners with finisher ambitions. Unquestionably, the field of study that this novel discipline offers performance and sports care professionals is a factor that is in demand by the present and future society.

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The prevalence of adverse analytical findings in european anti-doping laboratories: monitoring and analysis in the Athens and London Olympic Games

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Summary

Introduction: Since 2003, the World Anti-Doping Agency (WADA) begins to provide annual public reports which informs about all the analysis performed and the adverse analytical findings (AAF) determined in the different accredited laboratories.
Objectives: To identify the European laboratories and the most used substances for doping purposes, in addition to relate the adverse analytical findings (AAF) in European laboratories over three different periods of time (pre-Olympics, Olympics and post-Olympics).
Methods: Cohort study, following the recommendations of the STROBE declaration of the reports collected by the WADA between 2003-2015. The data belong to 16 European laboratories accredited by the WADA distributed in 11 groups of substances considered as doping substances. Inclusion criteria: detectable substances through the urine. Exclusion criteria: laboratories that between 2003-2015 were temporarily or definitively suspended by the WADA or appearance after 2004. The variables of years were transformed into pre-Olympics, Olympics and post-Olympics of the Olympic Games of Athens (2004) and London (2012), because both competitions were carried out in Europe.
Results: In the last 12 years reported, the most detected substance by European laboratories has been anabolic substances (52.42%), being the laboratory of Moscow (Russia) which presents the highest detection rate of this substance (3 out of 4 AAF). It is related the increase in the detection of cannabis in the European laboratories with post-Olympics periods (p=0,0001).
Conclusions: The laboratory with the highest proportion of AAF reports is Ghent (Belgium). Anabolic steroids are the most commonly detected substance in all the laboratories. There is a relationship between the detection of adverse analytical findings of cannabis in post-Olympics periods and the detection of anabolic steroids in pre-Olympics and Olympics periods.

Key words:
Doping. Anti-doping control. Epidemiology. Medical statistics.

Prevalencia de los hallazgos analíticos adversos en los laboratorios antidopaje europeos: análisis y seguimiento en los Juegos Olímpicos de Atenas y Londres

Resumen

Introducción: A partir del año 2003, la Agencia Mundial Antidopaje (AMA) comienza a emitir anualmente informes de carácter público donde se informa de todos los análisis realizados y los hallazgos analíticos adversos (HAA) encontrados en los diferentes laboratorios.
Objetivos: Identificar los laboratorios europeos y las sustancias prohibidas mayormente reportadas, además de relacionar los HAA en los laboratorios europeos con tres periodos de tiempo diferentes (preolimpiadas, olimpiadas y postolimpiadas).
Métodos: Estudio de tipo cohortes, siguiendo las recomendaciones de la declaración STROBE de los informes reportados por la AMA entre los años 2003-2015.Los datos estudiados pertenecen a 16 laboratorios europeos y 11 grupos de sustancias consideradas dopantes. Inclusión: sustancias detectables a través de la orina. Exclusión: tantos los laboratorios que entre 2003-2015 fueran suspendidos temporal o definitivamente por la AMA en Europa, como los de aparición posterior a 2004. Se transformaron las variables de años en preolímpicos, olímpicos y postolímpicos de los Juegos Olímpicos de Atenas (2004) y Londres (2012), por realizarse ambas competiciones en Europa.
Resultados: La sustancia más detectada por los laboratorios europeos en los últimos 12 años reportados han sido los anabolizantes (52,42%), siendo el laboratorio de Moscú (Rusia) el que mayor detección en dicha sustancia presenta (3 de cada 4 HAA). Se relaciona el aumento de la detección del cannabis en los laboratorios europeos con periodos postolímpicos (p=0,0001).
Conclusiones: El laboratorio europeo que proporcionalmente detecta mayor número de HAA es Ghent (Bélgica). Los anabolizantes son la sustancia mayormente detectada en todos los laboratorios. Existe una relación entre la detección de HAA de cannabis en periodos postolímpicos y de anabolizantes en periodos preolímpicos y olímpicos.

Palabras clave:
Dopaje. Control antidopaje. Epidemiología. Estadística médica.

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Introduction

Each year increasingly sophisticated detection methods appear in the fight against doping, which, along with improvements in education and research, promote the anti-doping campaign and the harmful effects of doping on human health, integrity and the fundamental values of participating in sport[1,2]. For this reason, the WADA produces a list of doping substances, which is modified and re-edited each year due to constant research into substances, methods and technological advances that may alter the health of athletes[3].

The World Anti-Doping Agency (WADA) was created in 1999, and emerged as a private foundation subject to Swiss law. Its main objective is to promote and coordinate the fight against doping in sport on an international level. Since 1999 anti-doping controls have been regulated, but it was not until 2005 that a regulation protocol was created, validating the compulsory nature of the World Anti-Doping Code[4].

From 2003, the WADA began to distribute annual public reports, giving information about all the analyses carried out in all WADA-accredited laboratories. These reports can be obtained via the ADAMS IT programme (Anti-Doping Administration & Management System), which was created with the purpose of coordinating anti-doping control activities and managing the location of athletes, both in and out of competitions[5,6].

Due to the major social and economic involvement of sport in our society, success has become increasingly important for athletes, clubs and trainers, who aim to renew contracts and continue to participate among the sporting elite, and who often even turn a blind eye to established regulations[7,8]. The physical and mental demands of top-level sport mean that some athletes turn to the consumption of illegal substances in the quest to improve their physical performance. Considered the most important international competition for sport in general, the Olympic Games (OG) have become a unique scenario for investigating potential illegal substance abuse activities in professional sport.

Until now the relationship of AAF in high level competitions such as the OG has not been researched, as research targeting this kind of event is fundamentally based on the economic impact and repercussions in the different countries where these competitions are held[9-11], on socio-sanitary aspects such as the propagation of the Zika virus in the Rio de Janeiro OG in 2016[11], or on health risk factors in mass sporting events[12]. To develop new tools to detect illegal substances, it is important to know which are the most commonly used substances in doping, investigating new methods of fighting and detecting substances and illegal methods. To do this it is essential to know the prevalence of illegal substance abuse in sports as well as its geographic distribution. Identifying the most commonly used group of substances by athletes will enable us to discover the most frequent attitudes towards doping held by those that aim to deceive, and will give us a useful prevention tool. On the other hand, discovering the distribution of the different substances by years could be interesting, as we already know that in the years leading up to the Olympics, even the same year, classifying championships are held for participation in the OG. For optimum athlete performance, a good training planning is essential, based on objectives and the championships in which he/she wishes to participate[13]. This way, and knowing that anti-doping controls are more numerous in this kind of competition, we could find out if there is a relationship between the different years and the AAF in Europe.

Therefore, the study objectives are to describe the most detected WADA-banned substances; to identify accredited European laboratories that detect the largest number of AAF; and to find out the proportion of AAF in terms of European anti-doping controls between 2003 and 2015; as well as relating and defining the detection of AAF with pre-Olympic, Olympic and post-Olympic years in European anti-doping laboratories.

Material and method

Study design

An observational, analytical, longitudinal and retrospective cohort study was carried out - following the recommendations of the STROBE[14] statement - of the reports given by the WADA between 2003-2015[15-27].

Data extraction

The study data belongs to 16 WADA-accredited European laboratories on 11 groups of substances considered to be doping.

Process

In the WADA reports all the variables of interest were detected and codified, and were transferred to a 2010 Microsoft© Excel database for the initial data registration.

Substances that could be detected exclusively through urine were included in the study.

Laboratories that were either temporarily or permanently suspended by WADA in Europe between 2003-2015 were both excluded from the study, as well as those that appeared after 2004, for not providing enough information and with the aim of homogenising the sample.

Statistical analysis

All the analyses were performed with the IBM SPSS Statistics 21 programme.

For the study of the descriptive statistics, 16 accredited European laboratories were used, with the selected time period between 2003 and 2015.

The qualitative variables are expressed as counts and frequencies. The graphic summaries are expressed using bar charts and pie charts.

To study the difference between pre-Olympic, Olympic and post-Olympic periods, the year variables were transformed into pre-Olympic, Olympic and post-Olympic years of the OG of Athens (2004) and London (2012), as both were competitions held in Europe. The years corresponding to the Peking OG (2008) were therefore excluded. Data relating to 2006 and 2010 was also excluded so that the recoded variable in the post-Olympic year corresponded to a calendar year, just like the pre-Olympic and Olympic years. The AAF data was relativized

depending on the total analysis of each year to obtain a homogenous variable and so as to carry out the non-parametric tests.

After carrying out the normality tests, it was established that the data grouping was not homogenous, which is why non-parametric tests were carried out between two independent samples (Wilcoxon), with the CI being 95% (p = 0.05). The size of the effect was also calculated for the difference between the pre-Olympic, Olympic and post-Olympic time periods.

Results

Anabolic substances are those most frequently detected by European laboratories, followed by cannabis, glucosteroids and beta-agonists (Figure 1).

The European laboratories that proportionally detected the greatest number of AAF are Ghent (Belgium) (5.09%), Paris (France) (4.91%) and Madrid (Spain) (3.50%) (Table 1).

The proportion of AAF with regard to the anti-doping controls carried out between 2003 and 2015 in each laboratory barely exceeded 5% of all the samples analysed (Figure 2).

Detection of doping substances in the pre-Olympic, Olympic and post-Olympic years

The WADA reports were classified into time periods, cataloguing the years depending on their proximity to the OG: 2003 and 2011 were pre-Olympic years; 2004 and 2012 were Olympic years; 2005 and 2013 were post-Olympic years.

The data analysis displays the relationship between the detection of illegal substances in the different periods of time, with the presence of cannabis being particularly relevant in the post-Olympic period (Z = 4.397; p = 0.0001; SE = 0.63) and anabolic substances in the Olympic period studied (Z = 3.269; p=0.001; SE = 0.47) (Table 2).

Figure 1. Percentual representation of AAF in European laboratories between 2003 and 2015.

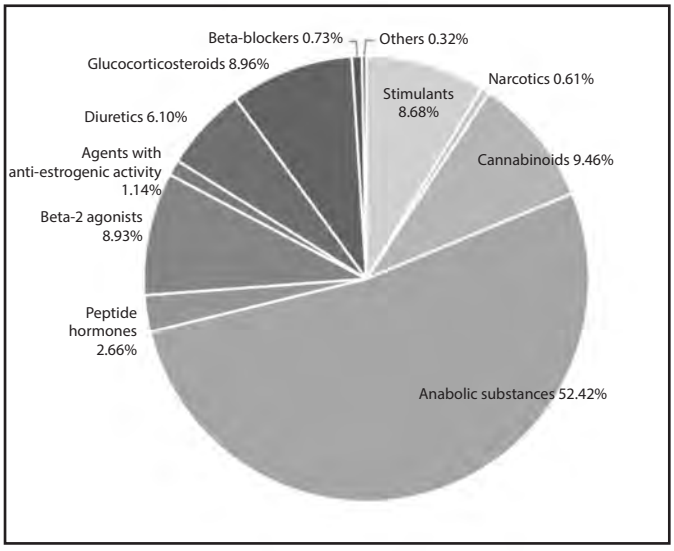
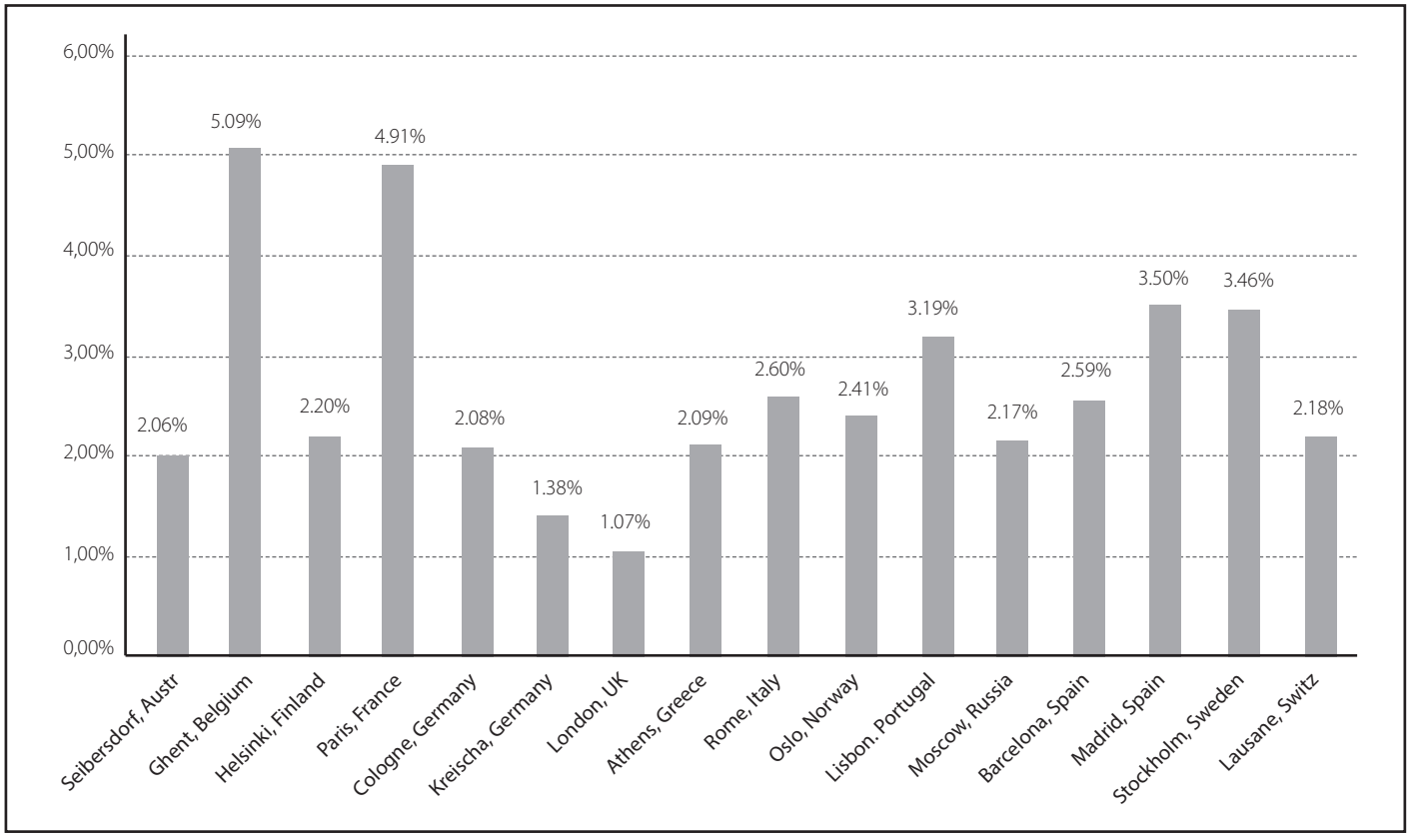


Table 1. AAF by substances reported in European Laboratories between 2003-2015.

Laboratory	Substances											
	Stim	Narc	Cann	Anab	Horm	Beta2	Antio	Mask	Gluco	Beta B	Others	Total AAF
Seibersdorf, Austria	102	1	128	922	34	91	24	135	58	10	0	1505
Ghent, Belgium	498	37	544	1932	65	312	58	195	240	23	0	3904
Helsinki, Finland	21	1	32	533	9	101	10	51	23	7	0	788
Paris, France	398	65	1030	1947	211	563	34	305	1181	49	10	5793
Cologne, Germany	372	26	194	2490	87	171	52	242	202	35	6	3877
Kreischa, Germany	88	10	86	748	17	180	22	96	88	16	4	1355
London, United Kingdom	251	9	102	437	39	51	20	53	17	7	1	987
Athens, Greece	160	1	105	680	21	42	12	96	75	3	0	1195
Rome, Italy	273	20	295	1514	164	352	15	206	263	26	36	3164
Oslo, Norway	105	6	77	830	17	145	10	60	100	5	31	1386
Lisbon, Portugal	114	3	216	649	30	62	8	98	133	38	6	1357
Moscow, Russia	259	8	114	2379	34	30	52	299	71	14	0	3260
Barcelona, Spain	68	4	83	603	47	189	31	115	73	6	3	1222
Madrid, Spain	219	19	258	1413	78	464	12	166	332	14	11	2972
Stockholm, Sweden	82	1	42	1024	8	379	23	37	287	2	0	1885
Lausanne, Switz	134	9	118	876	102	101	29	55	100	8	7	1539
Total	3144	220	3424	18977	963	3233	412	2209	3243	263	115	36189

Stim: Stimulants; Narc: Narcotics; Cann: Cannabinoids; Anab: Anabolic substances; Horm: Peptide hormones; Beta2: Beta-2 agonists: Antio: Agents with anti-estrogenic activity; Mask: Masking agents/Diuretics; Gluco: Glucocorticosteroids; BetaB: Beta-blockers; Other: others; Total AAF: total number of adverse analytical findings.

Figure 2. Percentual representation of the total AAF reported by the 16 European laboratories between 2003 and 2015.



However, the Wilcoxon test for related samples did not reveal differences in any of the periods analysed in terms of beta-agonist substances (pre-OG: Z = -0.507; p = 0.612. OG-post: Z = 1.7; p = 0.089. Post-pre: Z = 1.368; p = 0.171), anti-estrogenic substances (Z = 1; p = 0.317. OG-post: Z = 1; p = 0.317. Post-pre: Z = 0.378; p = 0.705), as well as diuretics and masking agents (Z = 1.375; p = 0.169. OG-post: Z = 1.663; p = 0.096. Post-pre: Z = 0.204; p = 0.839).

Discussion

The latest scandals called "State doping" in the McLaren report in Russia[28] are based on statements from Grigory Rodchenkov, the ex-director of the anti-doping laboratory for the Winter Olympics in Sochi 2014, in which Russia allegedly, concerned about its poor results in the Winter Olympics in Vancouver 2010, decided to initiate a process to conceal urine samples with traces of illegal substances, and allegedly provide doping substances and methods to athletes with the best chances of winning competitions. The scandal, which directly affected the participation of Russian athletes in the Olympic and Paralympic Games in Rio 2016, opens the debate about procedure and rigor in anti-doping controls. According to the information obtained in this study, the Moscow laboratory is the European laboratory with the second highest number of anti-doping controls over the past 12 years, but its AAF detection is very low (2.17% of almost 150,000 anti-doping controls). Despite this, it is the laboratory to detect the most anabolic substances in its AAF. It is worth highlighting that the data reported in this study belongs exclusively to the samples analysed by the different laboratories. WADA-accredited laboratories perform anti-doping controls on the athletes in their countries, and also analyse national and international competition samples, meaning that the samples from each laboratory are not necessarily samples from exclusively national athletes in the laboratory where the anti-doping control was carried out. This is one of the reasons why the aim is to compare the presence of the substance in the different Olympic time periods, thus ruling out laboratories as such. Initially it could be thought that in the years running up to the Olympics and during the Olympic year itself, there could be an increase of illegal substance detection, as this is the period when the most classifications for the OG take place. However, after analysing the results, it has been observed that significant differences can be seen between the three periods depending on the substances studied.

Anabolic substances

This kind of substance has been linked to sports with strength specialities - such as weightlifting and throwing - and to its high detection in laboratories in central and eastern European areas[29], as the main effect of

Table 2. Comparison between competitive periods and adverse analytical findings.

	Olympics[b] - Pre-Olympics[c]			Post-Olympics[b] - Olympics[c]			Post-Olympics[b] - Pre-Olympics[c]		
	SE	Z	p	SE	Z	p	SE	Z	p
Stimulants	0.35	-2.41[b]	**0.016**	0.34	-2.355[b]	**0.019**	0.46	-3.189[b]	**0.001**
Narcotics	0.20	-1.414[b]	0.157	0.29	-2[c]	**0.046**	0.14	-1[c]	0.317
Cannabinoids	0.13	-0.931[b]	0.352	0.42	-2.876[c]	**0.004**	0.63	-4.397[c]	**0.0001**
Anabolic substances	0.04	-0.28[b]	0.779	0.47	-3.269[c]	**0.001**	0.30	-2.045[c]	**0.041**
Hormones	0.17	-1.207[b]	0.227	0.39	-2.674[b]	**0.007**	0.41	-2.838[b]	**0.005**
Beta2-agonists	0.07	-0.507[b]	0.612	0.25	-1.7[b]	0.089	0.20	-1.368[b]	0.171
Anti-estrogenic	0.14	-1[b]	0.317	0.14	-1[c]	0.317	0.05	-0.378[c]	0.705
Masking	0.20	-1.375[b]	0.169	0.24	-1.663[c]	0.096	0.03	-0.204[c]	0.839
Glucosteroids	0.36	-2.474[b]	**0.013**	0.06	-0.411[c]	0.681	0.37	-2.554[b]	**0.011**
Beta-blockers	0.20	-1.414[b]	0.157	0.29	-2[c]	**0.046**	0.12	-0.816[c]	0.414
Others	0.29	-2.041[b]	**0.041**	0.00	0	1[c]	0.29	-1.983[b]	**0.047**

SE: size of effect based on r (r < 0.029 = small; r= 0.03 = medium; r > 0.031= large). Z: difference between the averages. p: value of p. [b]based on the positive ranges. [c]based on the negative ranges.

anabolic substances is to increase muscle mass and strength. Available literature usually relates the use of anabolic substances in combination with other illegal substances such as diuretics or beta-agonists, as they boost the anabolic effect or aim to mask its possible detection in anti-doping controls[30]. The information taken from this study reveals that there is greater detection of anabolic substances in the Olympic and pre-Olympic periods, but the same relation has not been found in the same periods for beta-agonists and diuretics.

Stimulants

The most used stimulants are ephedrine and cocaine. Their presence increases significantly in the post-Olympic periods studied (2005 and 2013), though this fact may be due to the use of stimulants as a social habit rather than as a substance to enhance sporting performance[31]. According to the 2015 official reports from the Spanish Observatory of Drugs and Addictions, in 2013 some 2.2% of the Spanish population claimed to have consumed cocaine at least once in the previous 12 months[32]. Cocaine remains detectable in urine for 3 to 5 days, but its metabolites can be detected for a long time afterwards. According to a study performed in the Rome anti-doping laboratory, the AAF discovered in athletes were metabolites with minimum amounts of this substance, relating more to social habits as opposed to doping in sport[34].

Narcotics

Narcotics are used in sport to speed up recovery time and/or to mask symptoms of an injury during competition[34]. In this study, it was revealed that in the years running up to the Olympics, European laboratories detected a greater presence of narcotics than at any other time. This phenomenon could be due to sporting activity for classification for the different OG sports.

Cannabinoids

The effect produced by cannabis and its derivatives on the body are usually used to reduce anxiety and as a relaxant before sporting competitions. On the other hand, there is certain controversy regarding its use as a doping substance, as physiological effects such as an increased heart rate and blood pressure, and reduced psychomotor activity are counter-productive effects in sporting performance[35,36]. In the results taken from this study, we can observe the strong link in pre-Olympic years compared to post-Olympic years, with pre-Olympic years producing the highest detection rate in European laboratories. In Spain, cannabis is the most frequently consumed illegal drug, especially among young people aged between 15-34 years[37], the age at which the majority of athletes develop their sporting careers.

Peptide hormones

This kind of illegal substances comprises a very heterogeneous group of substances, with the most common being erythropoietin. In recent years there have been various international scandals that have linked this kind of drug to sports like cycling, such as the infamous "Operación Puerto" in 2006, which broke up a doping network in Spain[38]. In this study a greater prevalence can be observed in the detection of hormones in the post-Olympic years than in the other periods. With a lack of data of the AAF in each sport, it is not possible to link the abuse of certain illegal drugs to specific sports[33].

Glucosteroids and other substances

Glucocorticoids have an effect on the central nervous system, reducing pain and increasing the state of euphoria, thus leading to an improvement in sporting performance. The results of this study reveal that glucocorticoids were mainly detected in Olympic and post-Olympic years.

During the OG of Athens 2004, 79 AAF were detected in glucosteroids, which were studied by the IOC as they were therapeutic use exemptions[39]. As the official reports given by the WADA only provide information about the AAF, it is not known whether these AAF were eventually considered TUE or not.

Beta-blockers

Beta-blockers are substances used to reduce the body's heart rate. It is a WADA-banned substance for just some sports, especially those that require precision or aim, such as archery, driving and motor sports. An increase of this kind of substance has been observed in the Olympic years compared to pre-Olympic and post-Olympic periods.

Study limitations

It is worth highlighting that the data reported in this study comes exclusively from the samples analysed by the different laboratories. Study limitations are the following:

- WADA-accredited laboratories perform anti-doping controls on athletes from their countries and also analyse samples from national and international competitions, which is why the samples from each laboratory are not necessarily exclusively samples from national athletes in the laboratory where the anti-doping control takes place.
- We can identify that existing data comes from official reports, but as these are illegal substances and methods, there is a black market behind all of these activities. There are studies that aim to explore this market, such as the research carried out in German anti-doping laboratories, which aim to link the AAF with the illegal drugs market, studying doping substances found in customs controls[40,41].
- There is heterogeneity between the first reports produced (2003-2005) and the latest ones (2012-2015), as the latter reports provide a larger amount of data.
- The sensitivity of the instruments used may vary between laboratories, as,given this is such specific machinery, the sensitivity in detecting different substances may be different.
- Furthermore, the data corresponding to the AAF reported by the laboratories has been studied, but many of the adverse analytical findings may correspond to TUE, which is why in principle they may appear as banned substances, whilst in reality they correspond to authorised pharmaceutical treatments for those athletes. This would translate as fewer athletes having truly used doping[42].

On the other hand, despite the large number of anti-doping controls carried out in the 2003 to 2015 period, the proportion of AAF per laboratory barely exceeds 5% of the total samples analysed. However, despite the AAF figures being low, sporting institutions must defend clean sport to eradicate doping altogether. Even so, Europe is the continent with the largest number of anti-doping sanctions to date[43]. In this respect, preventing doping should constitute a cornerstone in the sporting education of athletes, linked to ethical and social values that sport and competing represent[44,45]. If the most frequently used substances for doping are known, as well as the sports for which these illegal substances or methods are used the most, much more specific prevention campaigns can be carried out. With this aim, and for future research studies, it would be interesting to discover the geographical distribution and evolutionary trend of doping substances and their possible relationship with different sports, as well as studying the proportion of TUE connected to the AAF reported from each laboratory.

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Time to fatigue on lactate threshold and supplementation with sodium bicarbonate in middle-distance college athletes

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Summary

Introduction: There have been many researches that have attempted to improve sports performance based on supplementation with different buffer substances. Within this group of substances, sodium bicarbonate supplementation has been widely used in both cyclic and acyclic sports. In the case of cyclic sports, it has been tried to improve the performance of pedestrian races at different percentages of peak oxygen uptake. However, the results on intensity over anaerobic threshold have been contradictory.
Objective: To determine the performance variation based on execution in a endurance test after sodium bicarbonate administration. The second aim to evaluate the levels of blood lactate in the finish of endurance test.
Material and method: Five college athletes of middle-endurance and endurance race runners were subjects in the study. The variables measured were: effort maximum time (in seconds) measured through a endurance test, and maximum lactate post effort. All athletes were administered sodium bicarbonate (0.3 g•Kg^{-1} body mass) or a placebo (0.045 g•Kg^{-1} body mass) an hour before each endurance test. Student's t-test (lactate) and Wilcoxon (time) was used for the statistical analysis. The size of the effect was calculated with Cohen's d-test.
Results: The effort maximum time showed a significant increase ($P < 0.042$; size of the effect = 0.852) as well as lactate concentrations post effort ($P < 0.022$; size of the effect = 1.987).
Conclusions: The results of the study showed that the supplementation whit sodium bicarbonate generates an increase in the performance and lactate concentrations post effort, when the race speed surpass by seven percent the anaerobic threshold speed.

Key words:
Sodium bicarbonate. Lactate threshold. Athletes. Lactate.

Tiempo hasta la fatiga sobre el umbral láctico y suplementación con bicarbonato de sodio en corredores de medio fondo universitarios

Resumen

Introducción: Han sido muchas las investigaciones que han intentado mejorar el rendimiento deportivo en base a la suplementación con diferentes sustancias buffer. Dentro de este grupo de sustancias, la suplementación con bicarbonato de sodio ha sido ampliamente utilizada tanto en deportes cíclicos como acíclicos. En el caso de deportes cíclicos, se ha experimentado mejorar el rendimiento de carreras pedestres a diferentes porcentajes del consumo máximo de oxigeno. Sin embargo, los resultados a intensidades por sobre el umbral láctico han sido contradictorios.
Objetivo: Determinar la variación del rendimiento en base al tiempo de ejecución y producción de lactato post esfuerzo en una prueba de resistencia a una intensidad por sobre el UL posterior a la suplementación con bicarbonato de sodio.
Material y métodos: Cinco atletas de medio fondo y fondo universitarios fueron parte del estudio. Las variables medidas fueron: tiempo máximo de esfuerzo (segundos) evaluado a través de una prueba de tiempo límite y lactato máximo post esfuerzo. Una hora antes de cada prueba de tiempo límite los atletas fueron suplementados con bicarbonato de sodio (0,3 g•Kg^{-1} masa corporal) o un placebo (0,045 g•Kg^{-1} masa corporal). Para el análisis estadístico se utilizó la prueba *t* de Student (lactato) y Wilcoxon (tiempo). El tamaño del efecto fue calculado con la prueba d de Cohen.
Resultados: El tiempo máximo de esfuerzo tuvo incrementos significativos ($p < 0,042$; tamaño del efecto = 0,852), al igual que las concentraciones de lactato post esfuerzo ($p < 0,022$; tamaño del efecto = 1,987).
Conclusión: Los resultados del estudio mostraron que la suplementación con bicarbonato de sodio genera un aumento en el rendimiento y en las concentraciones de lactato post esfuerzo, cuando la velocidad de desplazamiento sobrepasa un siete por ciento la velocidad de umbral láctico.

Palabras clave:
Bicarbonato de sodio, Umbral láctico. Atletas. Lactato.

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Introduction

When generating an effort in an anaerobic threshold intensity or higher, the metabolism changes from an aerobic predominance to an anaerobic glycolytic metabolism[1]. Once this occurs, fast fibers start functioning to produce a higher ion hydrogen (H+) concentration, hence reducing blood pH[2]. Muscular acidity caused by H+ accumulation reduces the work capacity through the glycolytic way, causing a reduction in the muscular contractile capacity and preventing from maintain the effort intensity[3]. In order to work against the effects of the metabolic acidosis caused by the glycolytic metabolism, the body possesses physiological buffer systems that keep H+ production under control[4].

Among these natural buffer systems, sodium bicarbonate is considered as the most important compound to maintain an acid-based balance[5]. Drawn from this phenomenon, researchers have tried to determine whether the supplementation with buffering substances such as sodium bicarbonate[6], sodium citrate[7], b-alanine[8], or carnosine[9], can buffer to a larger extent the H+ in order to delay fatigue in athletes and improve their performance[10].

Based upon the foregoing, to exogenously increase sodium bicarbonate levels could reduce H+ levels generated in the anaerobic glycolytic metabolism, hence increasing the lactate flux in the muscles active to the extracellular medium[6]. In this way, the resynthesis of adenosine triphosphate (ATP) by glycolysis may be allowed to continue under more favorable conditions, delaying the onset of muscle fatigue in high intensity efforts[11]. Nevertheless, the physiological mechanisms directly responsible for performance augmentation in humans are unknown[12].

In this line of research, the response to the exogenous administration of sodium bicarbonate and physical performance in cyclic[13,14] and acyclic[15,16] sports have been studied. However, the results have been contradictory and they could not be directly related to the sodium bicarbonate supplementation but rather to the doses used, the level of training of the subjects, or the type of effort[14]. In the case of pedestrian races there are no reports of an increase in the performance after the intake of sodium bicarbonate in distances of 200 m or 400 m[17]. Nevertheless, some researchers have shown evidence of an increase in middle-endurance runners (800 m)[18]. An example was the study developed by Van Monfoort *et al*[19], where they reported an improved response to a sprint until exhaustion test using sodium bicarbonate in comparison to other buffer ergogenic aids. However, the scarce evidence related to the intake of sodium bicarbonate in intensities above lactate threshold (LT) generates questions towards the organic responses generated through the supplementation of sodium bicarbonate in intensities positioned in this intensity zone.

It is interesting then to study the acute response of sodium bicarbonate supplementation in endurance athletes in the aforementioned effort zone. Stimulating runners to real competition intensities by increasing the distance of training repetitions could be an efficient way to increase the performance of subjects. Consequently, will sodium bicarbonate supplementation improve the performance on a time limit test at an intensity higher than the LT in endurance athletes?

Objectives

To determine the performance variation based on execution in a endurance test after sodium bicarbonate administration. The second aim to evaluate the levels of blood lactate in the finish of endurance test.

Material and method

Experimental approach to the study. The sample for this study consisted of five male college students equivalent to the athlete population of middle-endurance runners of the University of Playa Ancha, Valparaiso, Chile. The inclusion criterion was to be a male athlete with a minimum of three years of experience in college endurance and middle-endurance athletic tests (1500 m a 10.000 m), the capacity to execute and maintain intensities above the lactate threshold and have the ability to execute the requested pace and cadence (Minimum lactate protocol and Endurance Test).

For the protocol application, a quasi-experimental cross-over intra-subject design was used. Each subject had to execute two endurance tests with 72 hours apart. The sodium bicarbonate intake and/or placebo was performed one hour before each endurance test. The administration of sodium bicarbonate and/or placebo was performed with a random double-blind method. Before commencing the study, each subject was measured for weight, height, 12-minute test, and lactate threshold. All participants of the study were told to not eat caffeine, drugs, or any substance that could increase their metabolism during the course of the experiment.

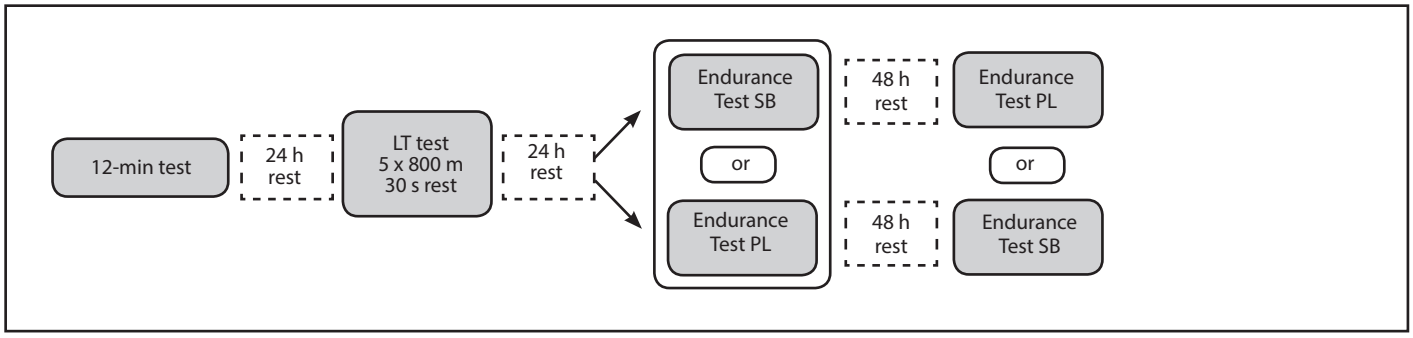
Subjects. Five male college athletes whit experience in middle-endurance and endurance races were part of the study. Age: 22.7 ± 1.95 years; weight 67.0 ± 5.3 Kg; height 173.0 ± 0.06 cm; bodily mass index 20.3 ± 2.6 Kg/m^2; peak oxygen intake 70.76 ±7.6 mL•kg^{-1}•min^{-1} (Table 1). All subjects were informed about the objective of the study and the possible risks of the experiment, all of them signed a written consent before the application of the protocol. The written consent, informative document, and the study were approved by the Committee of Bioetic of the University of Playa Ancha, Chile (register number 007/2016).

Table 1. Characteristics of the sample (median ± SD).

	Experimental Group (n = 05) (median ± SD)
Age (years)	22.7 ± 0.3
Height (cm)	173 ± 0.06
Weight (Kg)	67.0 ± 5.03
BMI (Kg/m^2)	20.3 ± 2.6
Test 12 minutes (m)	3750 ± 290.6
VO_2max (ml•Kg^{-1}•min^{-1})	70.76 ± 6.50

BMI (Bodily Mass Index); mL•kg-1•min-1 (milliliters of oxygen consumed by kilogram of bodily weight per minute); SD (standard deviation).

Figure 1. Methodological design of the treatment application with sodium bicarbonate and placebo.



12-min test: 12 minutes test; h: hours; LT: lactate threshold; Endurance Test SB: Endurance test with sodium bicarbonate intake; Endurance Test PL: Endurance test with placebo intake; SB: sodium bicarbonate; PL: Placebo.

Instruments. For the characterization of the simple, weight and height were measured with a (Health o Meter Professional®) scale and stadiometer.

Standard warm-up. For the test and post-test evaluation, the warm-up consisted of 10 minutes of articular mobility including circumduction movements, flexion and extension of the limbs, continuous jog of 10 minutes at 130 beats/minute (heart rate registry was performed with a Polar RS300 cardiac monitor was used), passive flexibility of eigth seconds for each muscular group, heel-stretching exercises, skipping, and three 80-meter ascension race.

Test and post test. Each athlete performed three evaluations. In the 12-minute test, all athletes were measured at the same time during the morning. For the lactate threshold, athletes were measured one by one consecutively during the morning. Finally, for the pre and post test through the aerobic resistance test, athletes were measured individually following the same order and the same starting time during the morning.

All three tests were performed every 24 hours, except for the two endurance tests that were performed every 48 hours. All tests were applied in a 400 m athletic court (Figure 1).

Evaluation 1 (Day 1). Peak oxygen uptake (VO_2max). The evaluation of indirect VO_2max was performed through a 12-minute test (Cooper). Before the evaluation, all subjects were requested to perform the longest distance possible for 12 minutes, and during the application of test the participants received oral cheers from the researchers. The distance each subject run was transformed into Km, and then the peak oxygen uptake was obtained with the following ecuation[20]:

VO_2max (ml•Kg^{-1}•min^{-1}) = (22.351 x distance in kilometers) – 11.288

Furthermore, the median velocity (Vm12-min) was used to determine the effort steps for the lactate threshold test.

Vm12-min (m/s) = (distance in meters performed in 12 minutes / 720 seconds)

Evaluation 2 (Day 2). Lactate Threshold (UL). In order to determine the LT all athletes were part of the minimum lactate protocol (LACmin) proposed by Tegtbur *et al.* (1993)[21]. In order to do so, athletes performed a maximum repetition of 500 m. Then, they performed a passive recovery of 8 minutes. From this minute on, athletes had to perform five repetition at 800 m at 75, 80, 85, 90, and 95% repetitions of Vm 12-min, with a 30-second pause. At the end of each repetition, a blood sample was taken from the earlobe. Lactate concentrations where entered into a registry form, and then put into graphs according to the visual inspection method of the curve to determine LT[22]. For blood lactate measuring, a (h/p/cosmos®) lactometer was used.

Table 2. Velocity of Treatment (UL+7% additional load).

Subject	LT (m/s)	Rhythm Km	LT + 7% (m/s)	Rhythm Km
1	5.5	3 m 02 s	5,9	2 m 49 s
2	4.8	3 m 28 s	5,2	3 m 13 s
3	4.5	3 m 42 s	4,9	3 m 26 s
4	4.5	3 m 42 s	4,9	3 m 26 s
5	4.9	3m 24 s	5,3	3 m 09 s

m/s (meters per second); Km (kilometer); LT (lactate threshold).

Evaluation 3 (Day 3). Endurance Test. In this evaluation, athletes must run for as long as possible at a LT +7% velocity of additional load of the LT velocity in m/s (Table 2). This test was executed with the supplementation of sodium bicarbonate or placebo (Figure 2).

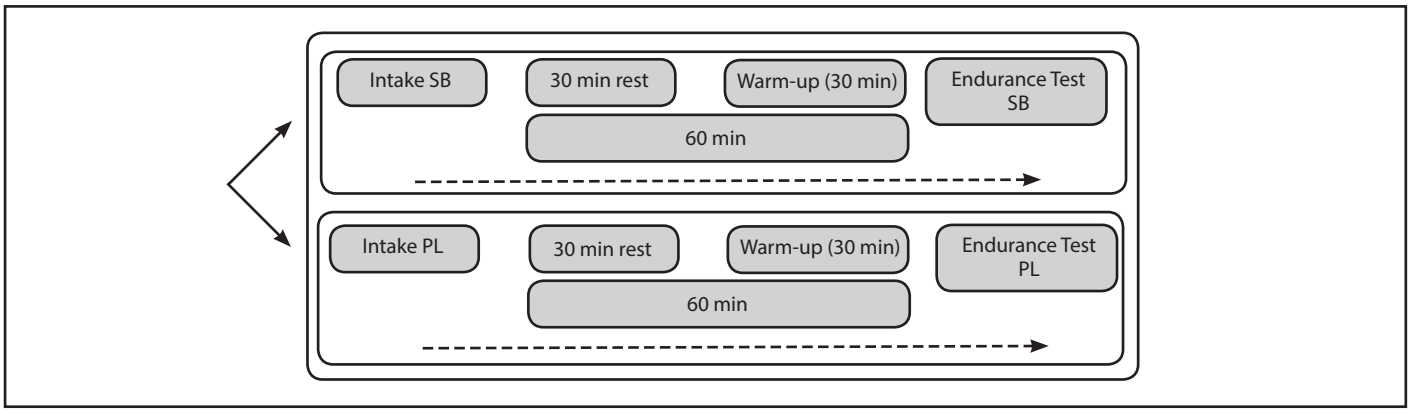
In the administration of endurance test, the race velocity was controlled every 100 m with a beep sound. When athletes did not reach the marked line by the time the beep was heard, the test was considered finished and the final time (s) and lactate (mmol•L) was measured.

Ergogenic aid. One hour after executing the Endurance test[21], all athletes ate a sodium bicarbonate solution or a placebo. The first solution had a concentration of 0.3 g•Kg^{-1} of bodily mass diluted in 300 mL of distilled water[6,23]. The second solution (sodium chloride) had a concentration of 0.045 mg•Kg^{-1} of bodily mass diluted in 300 mL of distilled water[24]. Considering the design used for the application of sodium bicarbonate or the placebo, a 48-hour difference was established between the second endurance test (Figure 1). The administration of the sodium bicarbonate solution or the placebo was at random with a double-blind protocol.

Statistical Analysis

Time and lactate variables were submitted to the Shapiro-Wilk normalcy test. If the variables showed a normal distribution, they were

Figure 2. Waiting time between sodium bicarbonate or placebo intake and the Endurance Test.



SB: sodium bicarbonate; PL: Placebo; Endurance Test SB: Endurance test with sodium bicarbonate intake; Endurance Test PL: Endurance test with placebo intake.

submitted to a Student's t test. If the opposite occurred, the Wilcoxon test was applied.

According to the foregoing, the behavior of the variables during the Endurance Test application was submitted to a Student t test in order to compare the final Lactate concentrations in the test and post test. Wilcoxon test was applied to compare the total time of the Endurance test and post test. The size of the effect (ES) for this analysis was calculated using Cohen's d test. This analysis considers an insignificant effect (d < 0.2), small (d = 0.2 to 0.6), moderate (d = 0.6 to 1.2), large (d = 1.2 to 2,0) or very large (d > 2.0). The level of significance for all statistical analysis was $P < 0.05$. The data analysis was performed with statistics SPSS software, version 12.0.

Results

Once the Students t test was applied, the final lactate produced in the endurance test supplemented with sodium bicarbonate presented a significant increase compared to the placebo supplementation ($P < 0.022$; TE = 1.987). Once the Wilcoxon was applied, the maximum time reached in the limit time test supplemented with sodium bicarbonate showed a significant increase in comparison to the placebo supplementation ($P < 0.042$; TE = 0.852). The results are presented in Table 3 and Table 4.

Discussion

In connection to the main goal of the study, supplementing sodium bicarbonate to college endurance race athletes and submit them to endurance test at an intensity higher than LT (LT velocity +7% of the LT velocity in m/s), a significant increase was shown in the performance when contrasting the maximum time of effort ($p< 0.05$). There was also a significant difference in the production of post effort Lactate ($p< 0.05$).

Recent studies suggest the need for individual analysis of the results given the high variation in the response that athletes may have to this type of supplementation protocol[25,26]. In relation to the above, all athletes were able to increase their maximum effort time and lactate concentrations post effort despite the individual differences in their lactate threshold and indirect peak oxygen uptake

In relation to the already existing researches on sodium bicarbonate supplementation, Peart *et al.* (2012)[27] performed a revision and analysis of 40 studies where the intention was to improve the performance based on the ergogenic aid. Of the aforementioned studies, only six presented a treatment based on endurance races with maximum distance of 1500 m.

Additionally, the authors concluded that the protocols used do not exceed 120 s in average. In the case of this study, the time of effort maintained by the athletes supplemented with placebo was 426.6 s in

Table 3. Lactate production and maximum time spent on the Endurance Test under sodium bicarbonate and a placebo supplementation.

	Lactate production on Endurance Test			
	Placebo median ± SD	**Bicarbonate median ± SD**	***t-Student test***	***d de Cohen***
Lactate (mmol•L)	13.32 ± 2.5	16.6 ± 0.8	*	1.987
	Maximum time spent on Endurance Test			
	Placebo median ± SD	**Bicarbonate median ± SD**	***Wilcoxon's test***	***d de Cohen***
time (s)	426.6 ± 66.6	486.8 ± 74.7	*	0.8520

s (second); SD (standard deviation); * p < 0.05; mmol•L (milimols per Litre).

Table 4. Delta of individual performances after placebo and sodium bicarbonate supplementation in relationship with lactate threshold

Subject	LT (m/s)	Time Pl (s)	Time Bic (s)	Δ (m)	Percent increment between Time Pl and Time Bic (%)
1	5.5	544	612	68	11,1
2	4.8	400	480	80	16,7
3	4.5	400	440	40	9,1
4	4.5	407	444	37	8,3
5	4.9	380	418	38	9,1

m/s (meters per second); LT (lactate threshold); Pl (placebo); Bic (Bicarbonate); (s) seconds; Δ (delta).

comparison to the athletes supplemented with sodium bicarbonate that was 486.8 s. The execution time experimented by the athletes supplemented sodium bicarbonate largely exceed the protocol of time employed in other sudies[3,5].

Miller *et al.* (2016)[28], used an intake protocol similar to that used in the present study, but used for the treatment of RSA (repeated sprint ability). Although the intensities differ with the present study (both are high) it was possible to establish that sodium bicarbonate supplementation allows a greater amount of work to be done to athletes, as well to the present study.

Siegler *et al.* (2016)[29] conclude that sodium bicarbonate supplementation may improve sports performance when the intensity of effort is in the anaerobic aerobic transition zone. In this study, the additional effort load (7%), enters the athletes in this area. Therefore, when observing the result of effort time allows to determine the effectiveness of this compound for such zone of effort.

In studies where sodium bicarbonate has been supplemented using continuous protocols but at LT intensities, there were only significant changes in the performance (race time increase of 17%) but not in lactate production ($p > 0.05$)[30]. In connection to this study, significant changes were shown in both the execution time and the lactate production with sodium bicarbonate supplementation in endurance test (presented in Table 3). Possibly, the race velocity used in this study – faster than the one used by George *et al.* (1988)[30] – lead to a larger lactate production. At the same time, the final lactate production found in this study can also be attributed to the increase of bicarbonate levels in the extracellular medium (ergogenic aid), since this compound favors the production of H+ and lactate from the active muscles into the blood stream[31].

In another study with continuum protocol, endurance race athletes had to run at a LT rhythm for 30 minutes. After this race time, athletes had to perform until exhaustion with a race intensity of 110% of LT. The results showed that sodium bicarbonate intake produced favorable metabolic conditions for 30 minutes of steady exercise at a LT rhythm; however there was no evidence of a significant improvement in the performance at 110% LT[32]. The present research showed significant differences to supplementation with sodium bicarbonate at intensities above the LT, with a more representative protocol to speed of competition in middle distance races.

Other studies that have searched an ergogenic potential of sodium bicarbonate in prolonged exercises of high intensity have showed diverse and controversial results. The former could be explained by the methodology used, the dosage of the compound, the post intake waiting time, the tests applied, the level of training of the athletes or the capacity of the subjects to generate large quantities of lactate with the selected exercise[5,31].

On a different scope of endurance training but with objectives similar to the ones of this study, cyclo-ergometers have been used in cyclists. In this area, Stephen *et al.* (2002)[33] reported that the administration of sodium bicarbonate does not improve the performance when working at 77% of VO_2max. The evidence shows that in order to generate an increase in performance it is necessary to select an adequate intensity that generates differences in blood pH[34]. For that matter, low effort intensities do not generate performance increase in tests with a glycolytic predominance considering that the acid-base balance during exercise in these characteristics is not modified and the sodium bicarbonate present in the body does not act as a buffer of the H+ that are released to the extracellular medium together with Lactate. According to the previously mentioned, it is important to mention that to have positive effects in sodium bicarbonate supplementation the race intensity must surpass LT[35], since it l from this point on that the anaerobic metabolism start to show predominance1, increasing muscular acidity.

An important variable in diverse researches is the intake time and the start of the treatment. Intake times fluctuating between 20 to 120 minutes have been found in literature[11,23]. Peart *et al.* (2012)[27] concluded that a 60-min intake time showed a greater buffer effect in the blood compared to shorter intake times.

The optimal time suggested for the intake of sodium bicarbonate with a 0.3 gr•kg^{-1} dosage is 60 minutes[23]. That is the time used in this study.

In connection to the sodium bicarbonate dose, there are studies from the 1980's[36] that have carried out tests with doses lower than the ones used in this study. In that research, 0.2 gr•kg^{-1} were used but there were no differences in the cyclists' performance that the researchers could observe. Several ulterior studies have suggested doses that range from 0.2 a 0.5 gr•kg^{-1}.

Mc Naughton *et al.* (1992)[37], a dose of 0.3 gr•kg^{-1} is used in cyclists under a long duration exercise, suggesting that this is the recommended dose in order to improve resistance in long-distance resistance tests, providing evidence about its usage in athletes with a large dose. Particularly in athletics, Bird *et al.* (1995)[38], used a dose of 0.3 gr•kg^{-1} in middle-endurance athletes. Jones *et al.* (2016)[25], concluded that bicarbonate concentrations and arterial pH increased significantly from the baseline after testing different doses, finding that the concentration of 0.3 gm•kg^{-1} showed the higger increments.

It can be concluded that supplementation with sodium bicarbonate has ergogenic effects for the distance. In recent studies, Carr *et al.* (2011)[39] concluded that, in connection to the values of arterial PH and arterial bicarbonate, the recommended dose is 0.3 gr•kg^{-1}, which was used in this study. The results showed statistical significant differences in the variables studied.

Conclusions

According to the results obtained, there is evidence that sodium bicarbonate supplementation can significantly increase the performance of endurance race athletes since they are capable of prolong their effort for a longer period of time at a seven percent intensity above LT velocity. Also, the intake of this solution generates a higher concentration of final lactate post effort, which demonstrates its efficacy when released to the blood torrent allowing the generation of more energy. All athletes were able to improve their performance despite having different levels of lactic threshold, even with a difference of 0.5 m•s.

Practical applications

The treatment used equals to a race intensity employed generally by athletes both in trainings and in competitions. Therefore, rhythm control by the subjects was no impediment to carry out the study, in addition to represent a competence situation provided by the surrounding and the race rhythm.

In connection to the dosage of sodium bicarbonate used, 0.3 g•Kg^{-1} bodily mass, it was observed that it was appropriate to increase the performance of athletes.

The administration of sodium bicarbonate in middle-endurance and endurance races with intensities below LT could have no beneficial effect for the performance of athletes because the natural buffering mechanisms of H+ and the lactate removal would function efficiently. In this case if a 5000 m runner shows a race rhythm lower than their LT, the sodium bicarbonate might not have any benefits in their performance.

Suggestions and limitations

Within the limitations for the realization of continuous protocols at intensities above the lactate threshold is the level of training of subjects. They must have experience at lactate threshold intensities or superior. The individual responses to intensities above the lactate threshold are highly variable, so many studies have very dissimilar results. According to the above, the samples of the studies are small because of the technical, psychological and physical specificity required to maintain an effort in those intensities. In addition, for lactate threshold protocol, it is necessary for athletes to have optimal rhythm control so that they can adequately complete the different steps of effort as it is the fundamental requirement for setting the pace of treatment.

It is suggested for future research to be able to determine the individual intake time before applying the protocol. This could lead to better results of the study, given that in this study a standard intake time was given to all athletes. The dosage used seems to be the most appropriate according to the literature. If possible, it could give greater support to the results found with some biomedical variables such as arterial pH and blood bicarbonate, as well as many studies cited.

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Prevalence and dynamic changes of vagotonic T waves during exercise in elite soccer player population

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Summary

Introduction: The characteristics of the athlete's electrocardiogram are still today the subject of multiple publications whose physiological meaning has been clarified as the different variants have been correlated with a sophisticated cardiological evaluation and a prolonged follow-up. There are different alterations of repolarization described in the sports population, among them the most frequently reported in the literature are: early repolarization, vagotonic T waves, ST-T alterations, etc. Vagotonic T waves are a common finding in the athlete population, although currently, the dynamic changes of this finding during exercise, have an uncertain meaning. The aim of our study was to determine its prevalence in a population of elite athletes and analyze their behavior at different stages of the exercise.
Methods: A population of 91 male, professional soccer players of a team of the first division of the Spanish football league (age 26 years ± 4.49 years) were analyzed. The presence of vagotonic T waves was assessed at baseline electrocardiogram and their association with different electrocardiographic and echocardiographic variables was also analyzed. The dynamic changes of the morphology of these waves were studied at different stages during a maximal effort trial.
Results: The presence of vagotonic T waves was identified in the baseline ECG in 14 (15%) subjects. In 13 out of 14 athletes (92%), a dynamic behavior of the vagotonic waves was observed. It had a progressive disappearance during exercise and it reappeared at the early stages of recovery, with similar voltages to that observed at the baseline electrocardiogram.
Conclusions: This study evidence that vagotonic T waves are mainly due to the predominance of parasympathetic tone. The exercise can be considered a useful strategy when study.

Key words:
Vagotonic T waves. Athlete. Electrocardiogram. Cardiology sport.

Prevalencia y cambios dinámicos de las ondas T vagotónicas durante el ejercicio en una población futbolista de élite

Resumen

Introducción: Las características del electrocardiograma del deportista son aún hoy en día objeto de múltiples publicaciones cuyo significado fisiológico se ha ido esclareciendo a medida que se han correlacionado las diferentes variantes con una evaluación cardiológica sofisticada y un seguimiento prolongado. Existen diferentes alteraciones de la repolarización descritas en la población deportista. Las ondas T vagotónicas son un hallazgo frecuente en esta población, aunque la dinámica de dichos hallazgos durante el ejercicio tiene actualmente un significado incierto. El objetivo de nuestro estudio fue determinar su prevalencia en una población de deportistas de élite y analizar su comportamiento en diferentes estadíos del ejercicio.
Métodos: Se analizó una población de 91 futbolistas profesionales varones de un equipo de la máxima categoría de la liga de futbol española (edad 26 años ± 4,49 años). Se evaluó en el electrocardiograma basal la presencia de ondas T vagotónicas, así como su asociación con diferentes variables electrocardiográficas y ecocardiográficas. Además, se estudió la dinámica de la morfología de estas ondas durante las distintas etapas de una prueba de esfuerzo maximal.
Resultados: Se identificaron 14 sujetos (15%) con presencia de ondas T vagotónicas en el ECG basal. En 13 de los 14 atletas (92%) se objetivó un comportamiento dinámico de las ondas, con desaparición progresiva durante el esfuerzo y posterior reaparición desde etapas precoces de la recuperación, con voltajes similares al electrocardiograma basal.
Conclusiones: Este estudio evidencia que las ondas T vagotónicas se deben fundamentalmente al predominio del tono parasimpático. El ejercicio puede considerarse una estrategia de gran utilidad a la hora de su estudio.

Palabras clave:
Ondas T vagotónicas. Atleta. Electrocardiograma. Cardiología del deporte.

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Introduction

Today, numerous publications have been released describing the characteristics of the electrocardiograms of athletes, the physiological significance of which has become clearer as the different variants have been correlated to a sophisticated cardiology assessment and extended follow-up. Despite having been described on numerous occasions in literature, current guides and criteria do not include vagotonic T waves as a physiological adaptation and variant of normality in athletes[1].

Diverse tests that include continuous electrocardiographic monitoring - both whilst resting and under stress - as well as image techniques (transthoracic echocardiogram, cardiac resonance, thoracic CT), have been extremely useful when discerning the physiological electrocardiographic variants in athletes from the presence of underlying heart disease. On the other hand, introducing the genetic study in groups of athletes with a suspected family history of cardiomyopathies or channelopathies has constituted an important step in deepening the aetiological study of athletes.

The global prevalence of repolarisation alterations in athletes is relatively frequent and variable in the different series published in literature[2]. Today, there are established criteria that are greatly useful when it comes to assessing when we should perform a more detailed study on an athlete that presents electrocardiographic alterations. Traditionally, the Seattle[3] criteria have been used, as well as the European Society of Cardiology Criteria[4]. In recent years, some unified criteria have been established – so-called refined criteria - which are more specific and sensitive when distinguishing the presence of cardiopathies in this population subgroup[5].

Different repolarisation alterations have been described in the athletic demographic, among which, those most frequently reported in literature are: early repolarisation, vagotonic T waves, U waves, elevation of the ST segment and negative T waves.

Vagotonic T waves are defined as high, symmetrical and narrow T waves, of more than 5 mm in limb leads or more than 10 mm in precordial leads6 (Figure 1), and are frequently observed in asymptomatic athletes subjected to high loads of physical activity. There is a prevalence of 14% among competing athletes6. These alterations usually disappear over time, when the high-intensity physical activity stops[1], though there is currently no thorough data regarding the frequency and dynamic in which these changes occur.

For this reason, the aim of our study was to establish the prevalence of vagotonic T waves in a population of elite athletes, as well as analysing their dynamic behaviour in different states of exercise.

Material and method

From June 2010 to June 2015, a medical team comprising sports doctors and cardiologists performed a thorough assessment of 91 professional male football players - all members of the Spanish First Division - prior to the start of the season. During this time, a study was carried out on all of them, including a detailed individual and family clinical history, a physical exploration, a 12-lead electrocardiogram, a 2-dimensional transthoracic echocardiogram, cardiopulmonary exercise test with oxygen consumption assessment (VO_2max), routine analysis, as well as an anthropometric study and collection of morphologic data.

This group of elite athletes is defined as professional football players whose main income is earned from their physical activity, and they compete in first or second division categories in the Spanish National Football League. They all have basic training requirements of over 10 hours each week.

An informed consent form was provided, agreeing to the sports assessment. A 12-lead electrocardiogram at 25 mm/s and 10 mm/mV was carried out on participants. All of the electrocardiograms were interpreted by two cardiologists with experience in the field of sporting cardiology. In the transthoracic echocardiogram analysis, the majority of the studies were performed using Siemens Vivid T7 ultrasound equipment. The ejection fraction was estimated using the Teichotz method. The diameter of both ventricles and the left atrium were measured, as well as the wall thickness in the long parasternal axis.

Cardio-pulmonary exercise testing was performed (Philips equipment) on 91 athletes, using a sporting protocol (4-minute warm-up, progressive increase of the exertion load, with an increase of 1 km/h each minute, maintaining a constant gradient of 1% and an active 3-minute recovery stage). The maximum oxygen consummation during the test was calculated for all of them, as well as the aerobic and anaerobic thresholds reached. The gases breathed were analysed using Ergometrix Cx equipment. In all of these tests, efforts were made to achieve maximal cardiac stress.

Likewise, to study the behaviour and dynamic pattern of the vagotonic T waves during exercise, we have established four different stages: basal, stage 5 of the exercise (speed 10 km/hour), stage 9 of the exercise (speed 14 km/hour) and the second minute of the recovery stage. To define the changes of these waves during the exertion, we have used the decline criteria of equal to or more than 50% of the voltage during the exertion in relation to the basal voltage.

Statistics

The average and standard deviation or the median and percentile 25 and 75 were calculated to describe the quantitative variables in accordance with the normality of the data. The Shapiro-Wilk test was used to check the normality of the data of the quantitative variables. The frequency and percentage in the qualitative variables were calculated. The student t test was used to compare the quantitative data, and in the cases in which the variable did not follow a normal distribution, the Mann-Whitney U test was used. To compare the qualitative data, we used the Chi-square test. A p-value < 0.05 was considered significant. The statistics programme used was R Core Team (2014).

Results

A thorough study was performed on the 91 athletes in our series. It is a demographic of athletes - mainly Caucasian (91.2%) - with an

average age of 26 years ± 4.49 years and a body mass index of 23.28 ± 1.62 Kg/m^2. The follow-up time was 36 ± 9 months. None of these athletes needed to suspend their physical activity as a result of pathological findings at the time of our assessment, or during the follow-up, and no cardiovascular incidents occurred during this time. A greater trend towards the presence of vagotonic T waves was detected in athletes that performed more hours of training (Table 1).

Electrocardiogram

With regards to the characteristics of the electrocardiogram, 98% of the subjects had a sinus rhythm, of these (the other two patients had a low auricular rhythm), 61% presented sinus bradycardia at the time of the assessment.

85 football players (93%) were identified with basal repolarisation disorders. The most frequently revealed disorder in our demographic of athletes was the presence of U waves in precordial leads (79 athletes (87%)). The second most frequent repolarization disorder was the presence of early repolarisation, identified in n=67 (74%). The following most frequently identified repolarisation alterations, in descending order, were: rise in ST n=24 (26%), vagotonic T waves n=14 (15%) and asymmetrical negative T waves n=7 (8%). As previously mentioned, the vagotonic T waves were identified in 15% of the subjects, whilst 77 athletes (85%) did not present this finding (Table 2).

The patients that presented these basal alterations, revealed a higher presence of right cardiac axis deviation on the surface electrocardiogram, as well as a greater tendency for sinus bradycardia, 1st degree AV block and signs of left ventricular hypertrophy (Table 3).

Echocardiogram

The echocardiographic study performed did not reveal the presence of structural heart disease in any of the patients that presented vagotonic T waves. Nor were significant differences identified between the different echocardiographic variables in both groups. All the echocardiographic parameters analysed in the study are included in Table 4.

Despite both the appearance of vagotonic T waves and the dilation of the right cavities being widely described discoveries in athletes, in this analysis it is observed that the right ventricle end-diastolic diameter (RVEDD) is lower in the group of vagotonic T waves (31 mm *vs.* 35 mm) with an almost significant *p* value (0.08).

Cardiopulmonary exercise testing

None of the stress tests exceeded an exercise time of 12 minutes, with these test practically all ending due to the exhaustion of the athlete.

Patients of the study sample performed a maximum oxygen consumption of 57 ± 6 ml/Kg/min (Table 5). Upon analysing the behaviour of the vagotonic T waves against the exercise during the maximal-type cardiopulmonary exercise tests, using the four previously described stages, their dynamic behaviour was identified (Figure 2). Their progressive disappearance was observed during the exertion as well as their later reappearance from the second minute of the recovery stage, with similar voltages to those of the basal electrocardiogram (Figures 3 and 4) in 93%

Table 1. Basal characteristics.

	Vagatonic T waves		
	Yes	No	*P* value
Age, years	28 (23.3 - 30)	26 (23 - 29)	0.36
BMI, Kg/m^2	23.05 (22.12 - 23.6)	23.08 (22.22 - 22.4)	0.9
HR, bpm	56 (50 - 60.8)	58 (52 - 68)	0.21
SBP, mmHg	125 (114 - 130)	125 (115 - 132)	0.73
DBP, mmHg	64 (59 - 76)	67 (60 - 72)	0.65
Time spent training weekly, hours	18.5 (15.75 - 21.25)	14 (12 -14)	0.38
CVRF	0 (0/14)	0 (0/77)	1
FA sudden death	0 (0/14)	0 (0/77)	1

BMI: body mass index. HR: heart rate. SBP: systolic blood pressure. DBP: diastolic blood pressure. CVRF: cardiovascular risk factors. FA: family antecedents.

Table 2. Prevalence of repolarisation alterations.

Repolarisation alteration, %	**93 (85/91)**
U waves	87 (79/91)
Early repolarisation	74 (67/91)
Elevation of the ST-T	26 (24/91)
Vagatonic T waves	15 (14/91)
Asymmetrical negative T waves	8 (7/91)

Table 3. Electrocardiographic variables.

	Vagatonic T waves		
	Yes	No	*p*-value
Sinus rhythm, %	100 (14/14)	97 (75/77)	1
HR < 60 bpm, %	71 (10/14)	60 (46/77)	0.55
Signs of LVH, %	64 (9/14)	43 (33/77)	0.16
PR, ms	144 (136 - 156)	156 (142 - 176)	0.15
QRS, ms	109 (104 - 113)	108 (100 - 114)	0.77
QTc, ms	408 (389,3 - 413,8)	404 (387 - 416)	0.79
1st degree AVB, %	14 (2/14)	5 (4/77)	0.23
Axis deviated to the right	71 (10/14)	36 (28/77)	0.04

HR: heart rate, LVH: left-ventricular hypertrophy. AVB: atrio-ventricular block.

Table 4. Echocardiographic variables

	Vagatonic T waves		
	Yes	No	*p*-value
EF of left ventricle, %	63 (59,3 - 66,3)	64 (60 - 68,3)	0,53
LVEDD, mm	53 (50 - 55,7)	53 (50,9 - 56)	0,42
LVESD, mm	33 (32 - 34,38)	34 (31 - 36)	0,53
IVS, mm	10 (9,25 - 10)	10 (9,38 - 11)	0,51
PLW, mm	10 (9 - 10)	10 (9 - 10)	0,98
LA diameter, mm	38 (36 - 38)	37 (36 - 38)	0,93
RVEDD, mm	31 (30 - 34)	35 (32 - 36,5)	0,08

EF: ejection fraction, LVEDD: left ventricle end-diastolic diameter, LVESD: left ventricle end-systolic diameter. IVS: interventricular septum. PLW: posterolateral wall. LA: left atrium. RVEDD: right ventricle end diastolic diameter.

Figure 1. ECG of an athlete presenting vagotonic T waves.

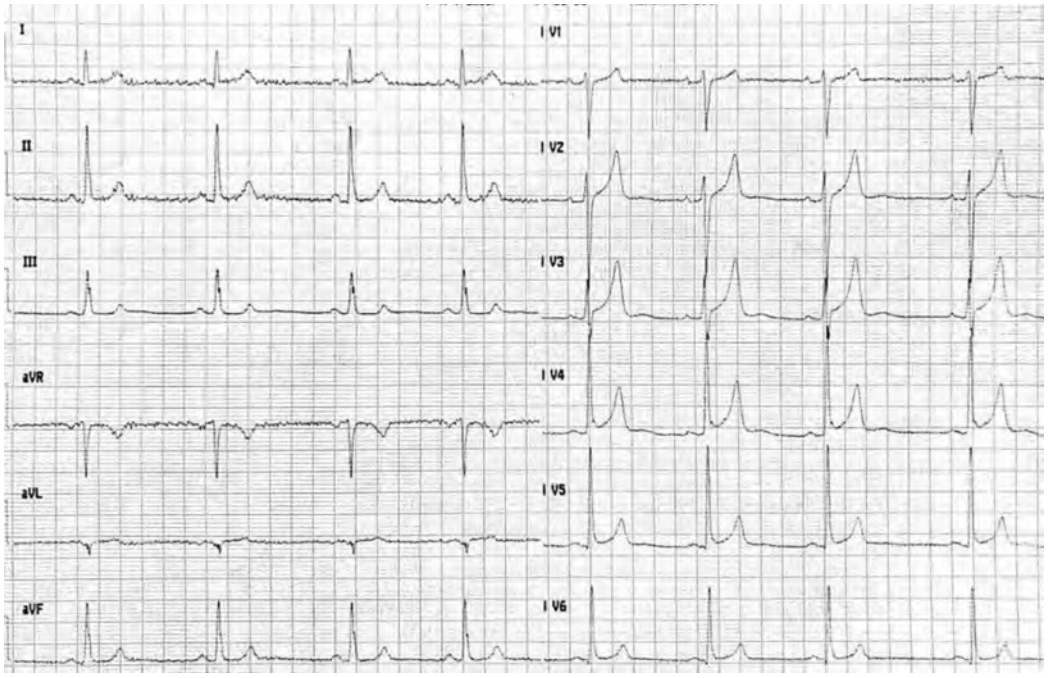


Table 5. Cardiopulmonary Exercise Stress Test variables.

	Vagatonic T waves		
	Yes	No	*p*-value
HR basal, beats/min	56 (50 - 60,75)	58 (52 - 68)	0,21
HR maxima, beats/min	181 (172,5 - 184,3)	185,5 (178 - 189,8)	0,19
SBP maximum, mmHg	169 (162,5 - 173)	174 (165 - 186)	0,1
DBP maximum, mmHg	71 (70 - 77,5)	80 (71 - 90)	0,05
METS	19,1 (18,3 - 19,4)	19,1 (18 - 20,1)	1
VO_2max, ml/Kg/min	56,7 (54,7 - 62,3)	57,8 (54,5 - 61,7)	0,9
VO_2max, ml/Kg/min	1,09 (1,04 - 1,12)	1,11 (1,09 - 1,14)	0,32

HR: heart rate, SBP: systolic blood pressure, DBP: diastolic blood pressure, VO2: oxygen consumption, RQ: respiratory quotient.

(n=13) of these athletes, with these changes reaching significant range in 11 (79%) of the footballers in our series (Tables 6 and 7).

Moreover, although both groups reached similar maximum oxygen consumption levels and workloads, the group of athletes that presented vagotonic T waves tended to present a maximal HR that was lower than the other athletes in our series (Table 5).

Table 6. Voltage of vagotonic T waves (mV) of the 14 football players in four different stages during the stress test: basal, stage 5 of exercise, stage 9 of exercise and recovery (at 2 minutes).

Athlete	Basal	Stage 5	Stage 9	Recovery (minute 2)
1	13	7	5	11.5
2	10	8	8	12
3	12	8.5	6	14
4	15	8	6.5	12.5
5	11	6	5	12
6	18	8	8	14
7	10	10	11	6
8	18	8	8.5	16
9	14	6	5	11
10	14	9	7	16
11	11	4	5	10
12	16	9	8	14
13	17	8	6	15
14	12	6	6.5	11

Discussion

In this study, after 5 years of follow up, none of the athletes have needed to stop their physical activity, reinforcing the banality of the frequently encountered electrocardiographic alterations found in this demographic.

Table 7. Heart rate (beats per minute) of the 14 football players in four different stages during the exertion test: basal, stage 5 of the exercise, stage 9 of the exercise and recovery (after 2 minutes).

Athlete	Basal	Stage 5	Stage 9	Recovery (minute 2)
1	49	130	160	106
2	90	164	192	139
3	43	121	162	115
4	61	119	174	130
5	58	148	172	132
6	50	155	172	121
7	70	137	177	131
8	54	139	157	105
9	52	130	164	112
10	60	147	181	130
11	47	138	170	120
12	64	154	186	134
13	55	155	178	124
14	50	124	150	101

Figure 2. Graph that displays the dynamic pattern of the vagotonic T waves (in the left column we can see the variation of the voltage of the T waves measured in mV) in the 14 athletes during the different stages of the cardiac stress test.

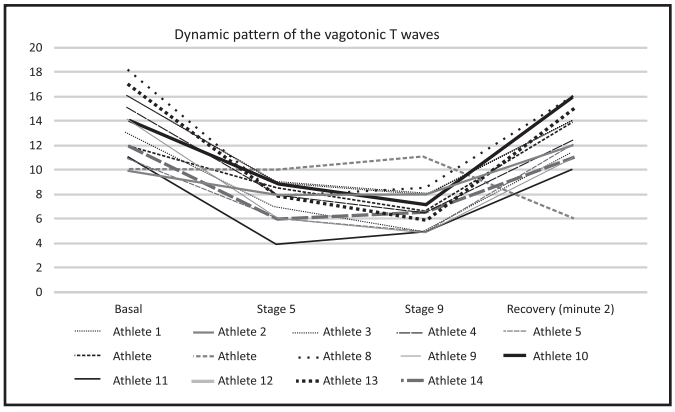
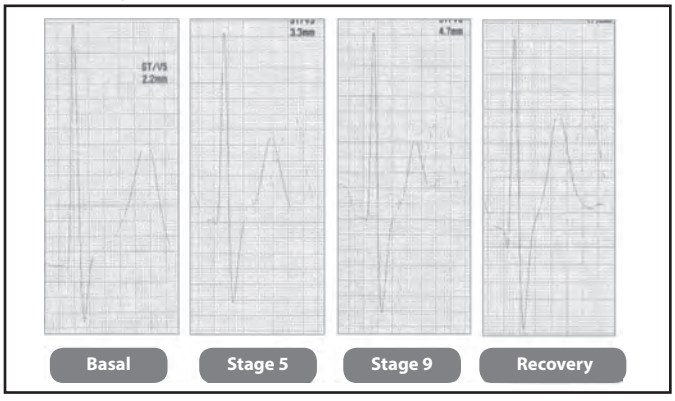


Figure 3. Dynamic changes of the vagotonic T waves during the cardiopulmonary exercise test. The dotted lines show the morphology of the basal vagotonic T waves.



The prevalence of vagotonic T waves in the basal ECG is 15% in our series, similar data to the prevalence obtained previously in the literature of other series[1].

The relationship is described between the vagotonic T waves and vagal hypertonia, and its association with other electrocardiographic findings typical among athletes. In our series, we discovered a certain association between the vagotonic T waves and the presence of sinus bradycardia, signs of ventricular hypertrophy, 1st degree AV block, etc., though without reaching statistical significance. Furthermore, it was observed that the athletes with vagotonic T waves were more likely to present deviation of the right axis, with both findings being relatively frequent among athletes.

However, significant differences were not identified between both groups regarding the echocardiographic findings that are common in the "heart of athletes" (dilation of right cavities, increase of wall thickness and/or dilation of the left atrium).

In the cardiopulmonary tests performed, the group of athletes with vagotonic T waves tended to display a lower maximal HR, despite reaching a similar workload and oxygen consumption level. This could be yet another finding that explains the predominance of the parasympathetic tone in this group of athletes.

In different publications, the presence of electrocardiographic changes is described - predominantly repolarisation alterations - which are induced with exercise and the increase of the heart rate, as well as the shortening of the QTc interval and the correction of T wave negativity[6].

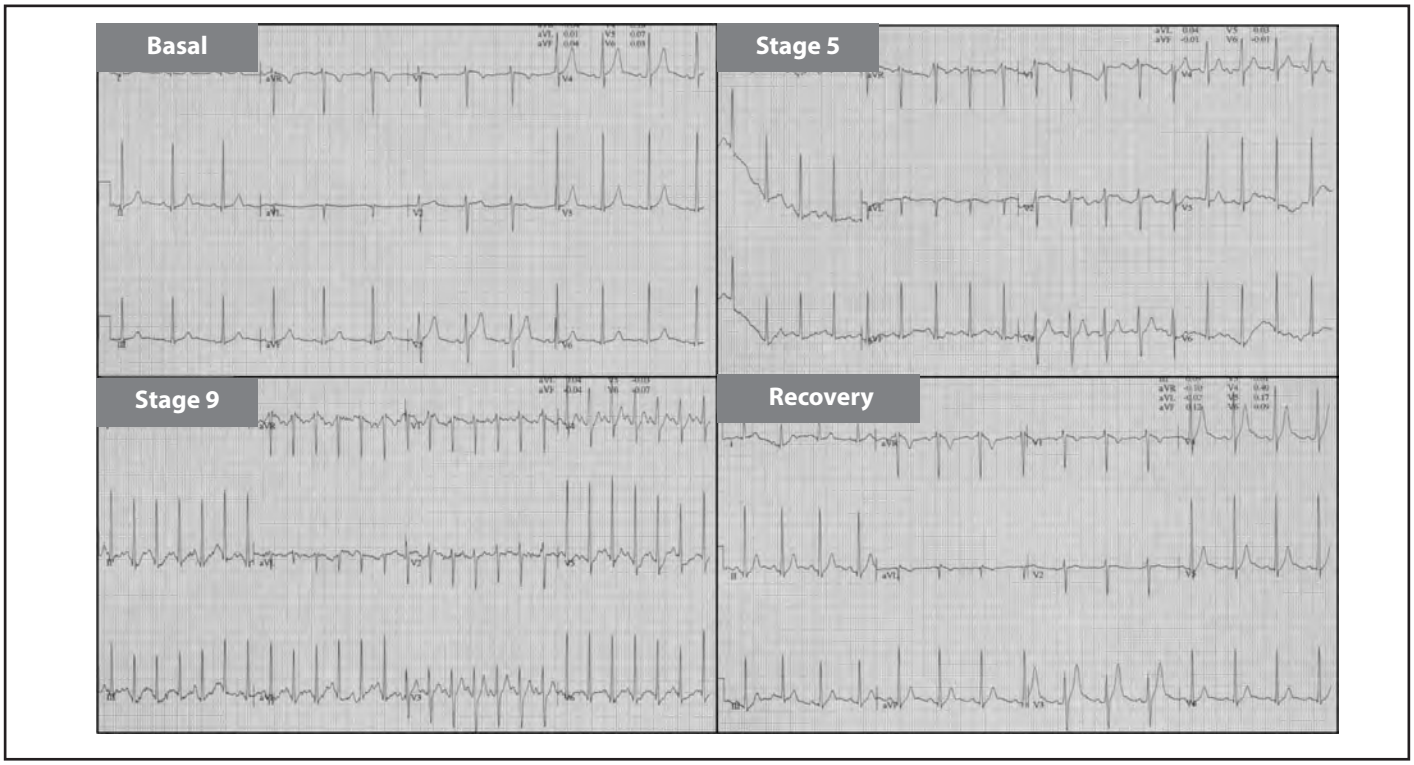
Typically, the disappearance of the vagotonic T waves has been described in the years following retirement from high-performance physical activity[7], with literature frequently reporting that the alterations in the morphology of the vagotonic T waves are related to the degree of training[8]. However, today there is little information regarding the dynamic electrocardiographic changes that occur in patients carrying vagotonic T waves during and after a protocoled exercise.

In this respect, our study reveals the existence of a dynamic pattern of the vagotonic T waves, which is repeated frequently among other athletes from our series, with a progressive disappearance of these waves during the exertion, as well as their later appearance in the early stages of recovery. This is probably due to the increase of the adrenergic stimulus during the successive stages of the exercise and the secondary reduction of the vagal hypertonia. When the predominance of the parasympathetic tone reappears, the vagotonic T waves return to their basal morphology. The observation of their attenuation during exercise, as well as their reappearance in recovery, help confirm the physiological variant character of the athlete's adaptation that has typically been conferred to this finding.

In terms of the study limitations, it is a descriptive study with a limited number of athletes that belong to the same sporting discipline.

In conclusion, these findings suggest that vagotonic T waves are related to a predominance of the parasympathetic tone, presenting dynamic behaviour during physical activity. These waves disappear in the majority of cases with exercise, and reappear in the initial recovery

Figure 4. Electrocardiogram of some of the athletes during the different stages of the stress test. Observe how the progressive disappearance of the vagotonic T waves can be seen during the exertion, and how it recuperates during the early recovery stages.



stages. In this respect, exercise could be considered to be a highly useful strategy when it comes to its study and stratification.

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Relationship between left ventricular hypertrophy and somatotype of high performance athletes using structural equations modeling

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Summary

Introduction: Sports induce morphological and functional adaptations in the human heart that directly relate to the type, duration and intensity of training and the years of practice. These changes are present in different ways in the electrocardiogram. A high QRS voltage is the most significant finding. Its correlation with left ventricular hypertrophy is low. In this study, the aim was to determine if a relationship exists between electrocardiographic alterations of left ventricular hypertrophy and somatotype in high performance athletes.

Methods: A retrospective, cross-sectional, quantitative, multiple correlation, observational and analytical study of a database of 180 resting electrocardiograms and anthropometric evaluations of men´s soccer, women´s soccer, swimming, cycling, basketball, and tennis athletes was performed. A database containing somatotype and Sokolow-Lyon electrocardiographic voltage criteria was created.

Results: The study group was composed of 83.3% men and 16.7% women. Age ranged from 10 to 51 years with a mean of 19.73 ± 5.8. Weight ranged from 35.90 to 122.3 kg with a mean of 66.98 ± 12.67 and height ranged from 143 to 213 cm with a mean of 174.11 ± 10.29 cm. Endomorphy for the entire group ranged from 1.0 to 5.7 with a mean of 2.5 ± 0.9. Mesomorphy ranged from 1.6 to 7.1 with a mean of 4.2 ± 0.95. Ectomorphy ranged from 1.1 to 5.8 with a mean of 2.9 ± 0.96. The structural equation model had a normal multivariable distribution of 3.161, reaching a Pearson of .26 for mesomorphy with a goodness of fit and a variance of 0% for mesomorphy and left ventricular hypertrophy.

Conclusion: Based on the findings, we can say that somatotype does not predict left ventricular hypertrophy in high performance athletes.

Key words:
Endomorphy. Ectomorphy. Mesomorphy. Structural equation model. Cardiac sudden death.

Relación entre la hipertrofia ventricular izquierda y el somatotipo en atletas de alto rendimiento utilizando modelamiento de ecuaciones estructurales

Resumen

Introducción: Los deportes inducen adaptaciones morfológicas y funcionales en el corazón humano directamente relacionadas con el tipo, duración e intensidad del entrenamiento y los años de práctica. Estos cambios se manifiestan de diversas formas en el electrocardiograma. Un alto voltaje del QRS es el hallazgo más significativo. Su correlación con la hipertrofia ventricular izquierda es baja. En este estudio, el objetivo era determinar si existe una relación entre las alteraciones electrocardiográficas de hipertrofia ventricular izquierda y el somatotipo en deportistas de alto rendimiento.

Métodos: Se efectuó un estudio transversal, cuantitativo, observacional, analítico retrospectivo de correlación múltiple de una base de datos de 180 electrocardiogramas en reposo y antropometría de atletas de soccer varonil, soccer femenil, natación, basquetbol, ciclismo y tenis. Se creó una base de datos con el somatotipo y los criterios de voltaje electrocardiográfico de Sokolow-Lyon.

Resultados: El grupo de estudio estaba compuesto por 83,3% varones y 16,7% mujeres. El rango de edad fue de 10 a 51 años con una media de 19,73 ± 5,8. El peso varió de 35,90 a 122,3 kg con una media de 66,98 ± 12,67 y la estatura varió de 143 a 213 cm con una media de 174,11 ± 10,29 cm. Endomorfia para todo el grupo osciló entre 1,0 y 5,7 con una media de 2,55 ± 0,9. Mesomorfia varió de 1,6 a 7,1 con una media de 4,2 ± 0,95. Ectomorfia varió de 1,1 a 5,8 con una media de 2,9 ± 0,96. El modelo de ecuaciones estructurales tenía una distribución multivariable normal de 3.161, alcanzando un Pearson de 0,26 para mesomorfia con una bondad de ajuste y una varianza de 0% para mesomorfia e hipertrofia ventricular izquierda.

Conclusiones: En base a los hallazgos podemos decir que el somatotipo no predice hipertrofia ventricular izquierda en atletas de alto rendimiento.

Palabras clave:
Endomorfia. Ectomorfia. Mesomorfia. Modelo de ecuaciones estructurales. Muerte súbita cardiaca.

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Introduction

Sports activity produces a series of morphological and functional adaptations in the human heart directly related to the type, duration, and intensity of the training and years of sports practice. These changes are seen in different ways in an electrocardiogram. A high QRS voltage is the most significant finding in male athletes. Its correlation with the presence of left ventricular hypertrophy is low[1].

The athlete's heart has intrigued physicians and scientists for over a century. Initial investigations date back to the late 1800s and early 1900s where an enlarged heart and bradyarrhythmias were documented in individuals with maximum oxygen consumption (VO_2) above normal, with no concomitant signs of cardiovascular disease[2].

In Europe, in 1899, the Swedish physician Henschen, using only his physical examination skills of auscultation and percussion, showed increased cardiac dimensions in elite Nordic skiers[3]. Similar findings were made by Darling[4] of Harvard University in college rowers. Later, White[5] described sinus bradycardia at rest in long distance runners and other athletes.

Since then, numerous studies using new methods have confirmed that the athlete's heart has manifestations of chronic adaptations to endurance training. The concentric growth observed is the result of an increase in the size of the heart chambers and the thicknesses of their walls. These changes were called physiological cardiac remodeling by Kindermann[6], Baggish and Wood[7] which refers to cardiac remodeling as a complex process influenced by multiple factors such as the athlete's age, gender, ethnicity, genetics, type of sport and body size[8,9].

Even though these changes are observed mainly in adult athletes, adolescent athletes who practice endurance sports also present greater left ventricular growth than non-athletes of the same age as demonstrated by Sharma[10].

Hypertrophic cardiomyopathy is a common cause of sudden death in apparently healthy athletes, and this condition is often a differential diagnosis with adaptive heart changes in athletes[11]. The importance of its early detection is one of the objectives of ergometric measurements, even if we do not yet have definitive diagnostic tests or gold standards as mentioned by Weinstock[12]. One of the most valid and reliable methods is the M-mode echocardiogram (ECHO) as reported by Devereaux *et al.*[13], despite considering that magnetic resonance imaging (MRI) has more than twice the accuracy over ECHO and being a more precise and reliable method for measuring LVH[14]. Even though these methods are more sensitive and precise, their high cost and limited availability provide an obstacle for routine use. Although an ECHO is less precise than MRI, an electrocardiogram (ECG) can serve as a less expensive, practical, and widely available alternative for LVH screening.

The ECG has the potential to accurately distinguish between physiological and pathological hypertrophy, since ECG abnormalities in hypertrophic cardiomyopathy slightly overlap with ECG voltage changes. In patients with hypertrophic cardiomyopathy (HCM), pathological hypertrophy of the left ventricle (LV) is associated with additional criteria, not only left atrial voltage and dilation, but also left axis deviation, and T wave, ST segment and Q wave alterations[15].

Kinanthropometry is a discipline that studies the size, shape and composition of the human body. Physical activity, nutrition, growth and race, among other variables, can alter an individual´s body composition[16]. For this, different measurements of size and proportions of the body are performed to determine body composition[17]. The Heath-Carter method is most frequently used to determine somatotype[18].

Hense *et al.*[19] demonstrated the influence of body composition on the size of the adult heart. The MESA (Multi-Ethnic Study of Atherosclerosis) study demonstrated a relationship between LV mass and end-diastolic volume with an increased body mass index, waist-to-hip ratio, waist circumference, and fat percentage; however, the ejection fraction showed no significant association with obesity measures[20].

Guerra *et al.*[21] studied 380 patients with essential hypertension, obesity and/or overweight and metabolic syndrome who suffered a problem with adequate control of their blood pressure. This study found that hypertensive patients with metabolic syndrome had a higher BMI and also a higher mean arterial and systolic pressure as well as greater thickness of the septum and of the interventricular wall together with an ejection fraction smaller than that of those without metabolic syndrome.

It is necessary to know the electrocardiographic manifestations of the athlete´s heart and determine if there is a direct relationship between the somatotype, the type of sport performed, and the electrocardiographic alterations of left ventricular hypertrophy. Therefore, the objective of this investigation was to determine if there is a relationship between electrocardiographic alterations related to left ventricular hypertrophy (LVH) and somatotype in high-performance athletes of various sports.

Material and method

This was a retrospective, cross-sectional, quantitative, multiple correlation, observational and analytical study of a database of resting electrocardiograms and anthropometrics evaluated in the Department of Sports Medicine and Physical Rehabilitation of men´s soccer, women´s soccer, swimming, cycling, basketball, and tennis athletes. Individuals with a history of previous heart disease and with electrocardiograms and anthropometric measures that were not legible were excluded from the evaluation. Athlete records that did not have anthropometry and/or an electrocardiogram were eliminated.

The measuring instrument for the dependent variable, left ventricular hypertrophy, was the electrocardiographic voltage criteria of the Sokolow-Lyon index for left ventricular hypertrophy[22]. These consist of the sum of the S wave in V1 and the R wave in V5 or V6 ≥ 3.5 mV (35 mm) and/or an R wave in aVL ≥ 1.1 mV (11 mm).

To measure the independent variable, somatotype, measures of weight, height, skinfolds, girth and breadth were obtained using the restricted profile of anthropometric measures in accordance with the recommendations of the International Society for the Advancement of Kinanthropometry (ISAK)[23].

Sample size

Structural models need large samples with more parameters to estimate those that work with larger samples (24). Some authors, such as Hu, Bentler, & Kano[25] and Schreiber, Nora, Stage, Barlow, and King[26]

propose as a basic rule the choice of 10 observations per indicator as a lower limit of sample sizes. Jackson[27] suggests a relation N:q, 20 to 1 where N equals 20 and q is the number of parameters in the model. However, it is important to mention that no rule can be applied to all cases and adequate sample size depends on many factors, including the psychometric properties of the variables, the strength of the relationships between variables considered model size, and the distribution characteristics of the variables. In the present research, we used the criteria proposed by Jackson. In this case there are 8: Endo, Meso, Ecto and SV1, SV2, RV5, RV5, RAVL, multiplied by 20 equals 160 participants.

For the statistical analysis, SPSS version 21 for Windows (IBM Corp., Armonk, NY) was used. For structural equation modeling, Amos 21 was used to verify the relationships between observed and unobserved (latent) variables and test the hypothesis and confirm relationships. Diverse statistical tests were performed as part of a multivariate analysis: determination of Mardia´s coefficient[28], which seeks multivariate normality, considered one of the most common assumptions of the distribution of normality in multivariate analysis, analysis of the Mahalanobis distance[29], multiple regression analysis, chi square analysis, and goodness of fit. The final sample consisted of 180 individuals.

Once the constructs were evaluated, SEM was used to quantify and test the validity of hypothetical assertions, possible interrelationships between constructs, and the relationship with evaluation measures (Figure 1).

Results

The study group was composed of 83.3% men and 16.7% women, with a mean Age 19.73± 5.8, weight ranged from 35.90 to 122.3 kg with a mean of 66.98 ± 12.67 and height ranged from 143 to 213 cm with a mean of 174.11 ± 10.29 cm.

Endomorphy of the entire group ranged from 1.0 to 5.7 with a mean of 2.55 ± 0.9. Mesomorphy ranged from 1.6 to 7.1 with a mean of 4.2 ± 0.95. Ectomorphy ranged from 1.1 to 5.8 with a mean of 2.9 ± 0.96. (Table 1).

Regarding left ventricular hypertrophy factors, S in V1 ranged from 0.0 to 25.0 mm with a mean of 9.3 ± 4.9; S in V2, ranged from 0.0 to 38.0 mm with a mean of 16.7 ± 7.3; R in V5 ranged from 1.5 to 32 mm with a mean of 16.1 ± 6.2; R in V6 ranged from 1.5 to 30 mm,

Figure 1. Proposed model to estimate LVH represented by SV1, SV2, RV5, RV6, RaVL, (endogenous variable) and Somatotype represented by endomorphy, mesomorphy and ectomorphy (exogenous variable), e (error).

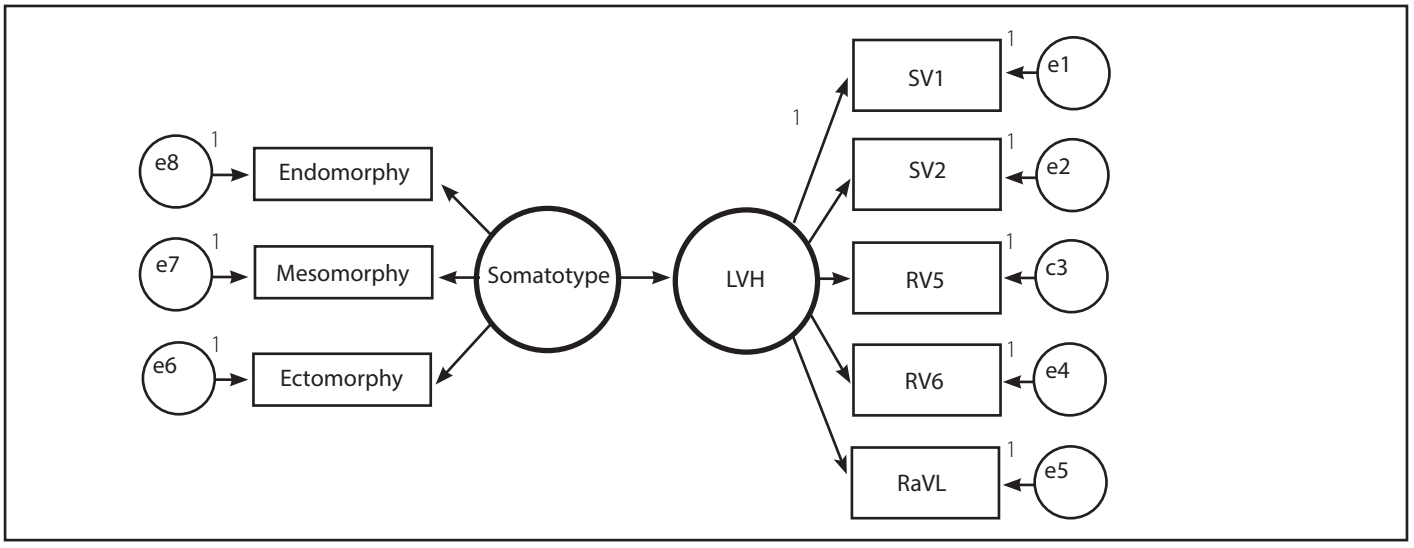


Table 1. Demographic characteristics of the athletes.

	Gender	Age, years	Body weight, kg	Height, cm	Endomorphy	Mesomorphy	Ectomorphy
Men	Mean	19.71	69.1645	176.257	2.416	4.387	2.986
N = 150	SD	5.912	12.30439	9.5152	.8557	.9036	.9525
Women	Mean	19.80	56.0667	163.397	3.207	3.530	2.830
N = 30	SD	5.242	8.14758	6.8107	.8741	.8272	1.0232
Total	Mean	19.73	66.9816	174.114	2.548	4.244	2.960
N = 180	SD	5.792	12.67829	10.2947	.9058	.9450	.9634

SD: standard deviation.

Table 2. Somatotype by sport.

	Sport	Endomorphy	Mesomorphy	Ectomorphy
Soccer	Mean	2.424	4.427	2.898
N = 126	SD	.8109	.8292	.8650
Cycling	Mean	3.720	4.200	2.220
N = 5	SD	1.0756	1.1000	.3834
Swimming	Mean	2.837	3.653	3.808
N = 19	SD	1.2868	1.0611	1.2640
Women's Soccer	Mean	3.106	3.522	2.600
N = 18	SD	.5846	.7256	.8007
Tennis	Mean	2.200	2.733	3.933
N = 3	SD	.8000	.9815	.7638
Basketball	Mean	2.022	4.911	2.844
N = 9	SD	.7345	.9239	1.0620
Total	Mean	2.548	4.244	2.960
N = 180	SD	.9058	.9450	.9634

SD: standard deviation.

Table 3. Presence of left ventricular hypertrophy (LVH) by sport.

Sport	Frequency	Percent	Cumulative Percent
Soccer	61	74.4	74.4
Swimming	14	17.1	91.5
Women's Soccer	4	4.9	96.3
Basketball	2	2.4	98.8
Cycling	1	1.2	100.0
Total	82	100.0	

Table 4. Presence of left ventricular hypertrophy (LVH) in athletes by age.

Age, years	Frequency	Percent with LVH	Cumulative Percent
15	12	14.6	14.6
18	12	14.6	29.3
17	11	13.4	42.7
19	9	11.0	53.7
13	5	6.1	59.8
16	5	6.1	65.9
24	5	6.1	72.0
14	4	4.9	76.8
20	3	3.7	80.5
30	3	3.7	84.1
12	2	2.4	86.6
26	2	2.4	89.0
27	2	2.4	91.5
10	1	1.2	92.7
11	1	1.2	93.9
21	1	1.2	95.1
25	1	1.2	96.3
28	1	1.2	97.6
33	1	1.2	98.8
51	1	1.2	100.0
Total	82	100.0	

Table 5. Regression Weights: (Group number 1 - Default model).

			Estimate	S.E.	C.R.	P	Label
LVH	<---	Meso	.263	.135	1.940	.052	par_3
SV1	<---	LVH	1.000				
RV5	<---	LVH	5.626	2.610	2.155	.031	par_1
RV6	<---	LVH	4.755	2.011	2.365	.018	par_2

SE: standard error; CR: critical ratio; P: bilateral asymptotic significance.

with a mean of 13.2 ± 4.7; and R in aVL ranged from 0.0 to 5.0 mm with a mean of 0.8 ± 0.98.

The sports and mean somatotypes of the sample for a total of 180 individuals are shown in Table 2. Of these, 82 (46.6%) had voltage criteria for LVH. The distribution of LVH by sport and age are shown in Table 3 and Table 4 respectively.

In Table 5, in the column critical ratio, it is seen that the loads of the indicators are significant. After evaluating several models, both the endogenous variable LVH and the exogenous variable somatotype, through a confirmatory factor analysis for LVH with the 5 factors shown in Figure 1, R in aVL and S in V2 were eliminated and a correlation between two residues was introduced to improve fit. In addition, the model had to be restructured because somatotype was not coherent as a construct in this study (Figure 2). Of all the models, it was this one that presented the best fit to the data and with this the maximum likelihood estimation (MLE) was performed.

Regarding standardized regression weights, mesomorphy positively impacts LVH with a regression of 0.259. S in V1 in relation to LVH has a weighted regression of 0.197 with a positive correlation and low weight. R in V5 in relation to LVH has a weighted regression of 0.868. R in V6 in relation to LVH has a weighted regression of 0.961 with a positive correlation and high weight.

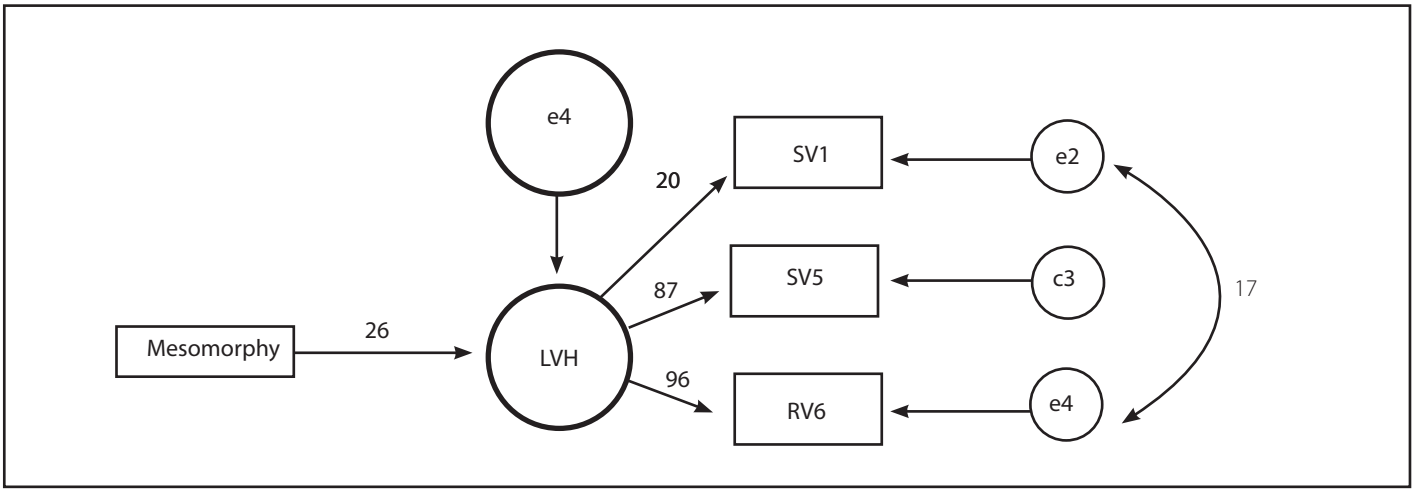
Discussion

The somatotype and its components, endomorphy, mesomorphy and ectomorphy, were not congruent as a construct in this study. Mesomorphy was the component that presented a direct and proportional relationship with LVH, without this being a statistically significant factor in the prediction of LVH in the study participants. In fact, somatotype was the most problematic factor, since it not only showed low loadings which caused a loss of endomorphy and ectomorphy; therefore, we could not speak strictly of somatotype.

The dominant component of this group was mesomorphy since all participants were athletes. The somatotype category for the female athletes was mesomorph-endomorph, and for male athletes it was balanced mesomorph. In relation with the sport 73.6% of the swimmers, 48% of the men´s soccer players, 22% of the women´s soccer players, 22% of the basketball players and 20% of the cyclists had LVH; 50% of LVH cases were younger than 18 years old.

The structural model reported a normal multivariate distribution of 3.161. As for the structural relationship between the exogenous and endogenous variables, the model reached a Pearson of 0.26 for meso-

Figure 2. Standardized regression weights: (Group number 1–Default model). The coefficient above each path is AMOS's maximum likelihood estimate of the effect size.



morphy. This is interpreted as a positive correlation of low weight with good goodness of fit and a proportion of explained variance of 0% for the relationship between mesomorphy and LVH indicating that no linear combination of the independent variables is a better predictor than the fixed mean of the dependent variable. The components that explained or diagnosed LVH were R in V5, 75.4%, and R in V6, 92.3%, while S in V1 only explained 6.9%.

As mentioned by Baggish and Wood and Escudero and Pinilla[7,30], cardiac hypertrophy is a combination of genetic, physiological and environmental factors. The underlying molecular mechanisms that induce physiological or pathological responses are not yet fully elucidated.

Unlike patients with hypertension in which a high correlation with body composition, BMI, and waist-hip ratio is observed, athletes do not have this relationship[19,21].

Conclusion

Mesomorphy was the dominant component and the one related to LVH. Based on the findings in this study we can say that somatotype has no utility in predicting left ventricular hypertrophy in athletes. Since 50% of LVH cases were under 18 years of age, we are obliged to continue with the ECG for the detection and subsequent study of these athletes to prevent possible complications in the long or medium term.

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Evaluation of aerobic endurance through time limit measured in the field in both sexes

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Summary

Introduction: The main objective of this paper was to compare the aerobic resistance in both sexes through the use of limited time (T-Lim) and the limit distance (D-Lim) measured in the field. In second place was to analyze the relationship between the VFA and the T-Lim.
Material and methods: 39 physical education students (27 men and 12 woman) were measured in 3 sessions. In the first session, anthropometric measurements were registered: size, body weight, perimeters and skin folds. In the second session the UNCa test was evaluated. This test was recently designed to estimate the maximum aerobic speed from the final speed reached (FSR). The FSR is defined as the speed reached in the last complete stage. In the last session, to measure the T-Lim the subjects ran to the endurance capacity in a track of 400 m next to a bicycle previously calibrated. The D-Limit refers to the total meters run during the T-Lim test. Differences between sexes were analyzed with the T test for independent samples. The relationships between FSR and T-Lim were determined using the Pearson correlation coefficient.
Results: In the UNCa test, FSR was was 14.8±1.4 km•h^{-1} and 12.0±1.0 km•h^{-1} for men and women respectively ($p<0.05$). The T-Lim was 385.0±99.3 and 351.0±79.6 seconds, without significant differences between groups. The D-Lim was 1589.5±485.7 meters for men and 1175.7±304.4 meters for women, being significant among groups ($p<0.05$). The correlations were: FSR and T-Lim; $R = 0.29$ ($p<0.035$) for all the cases, $r = 0.24$ ($p<0.112$) for males, and $r = 0.27$ ($p<0.196$) for females.
Conclusion: In physical education students, no significant differences were found among men and women as regards T-lim. The low correlation found between VFA and T-Lim leads us to conclude that both indicators define different variables.

Key words:
Aerobic training. Endurance capacity. Time limit. Maximal aerobics speed. Field test.

Evaluación de la resistencia aeróbica a través del tiempo límite medido en campo en ambos sexos

Resumen

Introducción: El propósito principal fue comparar la resistencia aeróbica entre los sexos a través del tiempo límite (T-Lim) y la distancia límite (D-Lim) medido en campo. En segundo lugar se analizó la relación entre la VFA y el T-Lim.
Material y método: 39 estudiantes de educación física (27 hombres y 12 mujeres) fueron medidos en 3 sesiones. En la primera sesión se registraron medidas antropométricas: talla de pie, masa corporal, perímetros y pliegues cutáneos. En la segunda sesión se evaluó el UNCa test. Este fue confeccionado recientemente para estimar la velocidad aeróbica máxima a partir de la velocidad final alcanzada (VFA). La VFA es definida como la velocidad alcanzada en la última etapa completa. En la última sesión, para medir el T-Lim los sujetos corrieron a la VFA en una pista de 400 m junto a una bicicleta previamente calibrada. La D-Lim es la cantidad total de metros recorridos durante la prueba de T-Lim. Las diferencias entre sexos fueron analizadas con la prueba T para muestras independientes. Las relaciones entre la VFA y el T-Lim fueron determinadas con el coeficiente de correlación de Pearson.
Resultados: La VFA en el UNCa test fue de 14,8±1,4 km•h^{-1} y 12,0±1,0 km•h^{-1} para hombres y mujeres respectivamente ($p<0,05$). El T-Lim fue de 385,0±99,3 y 351,0±79,6 segundos, sin diferencia significativas entre los grupos. La D-Lim fue de 1589,5±485,7 metros para los hombres y 1175.7±304,4 metros para la mujeres, siendo significativa la diferencia entre los grupos ($p<0,05$). Las correlaciones encontradas entre la VFA y el Tlim fue: para el grupo total $r=0,29$ ($p>0,035$), para los hombres $r=0,24$ ($p>0,112$) y para las mujeres $r=27$ ($p>0,196$).
Conclusión: En estudiantes de educación física no se encontraron diferencias significativas en el T-Lim entre hombres y mujeres. La baja correlación encontrada entre la VFA y el T-Lim nos lleva a concluir que ambos son indicadores de variables diferentes.

Palabras clave:
Entrenamiento aeróbico. Resistencia aeróbica. Tiempo límite. Velocidad aeróbica máxima. Test de campo.

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Introduction

Maximal oxygen uptake (VO_2max) has traditionally been used to study the cardiorespiratory component of fitness in different health- and sport-related populations[1]. VO_2max can be improved in both men and women through aerobic training programmes[2]. Improvements depend on multiple factors: level of the subject, initial VO_2max, duration of training (weeks, months, years), training load (intensity, volume of work, frequency, density), sex, age, genetics, etc.[3,4]. Increases in VO_2max, however, have a genetic limit[4,5] and even in highly trained individuals run performance improves without observing increases in VO_2max[6]. It is, therefore, important to monitor other variables related to the cardiorespiratory component[7], such as maximal aerobic speed (MAS) and time to exhaustion (T-Lim).

Billat defines T-Lim as a subject's ability to sustain exertion at 100% MAS for as long as possible. The interest in studying T-Lim lies in validating a criterion for aerobic endurance[8]. The parameter expresses the amount of work carried out over time (seconds or minutes) and also in metres, called distance to exhaustion (D-Lim). The two variables (T-Lim and D-Lim) have shown themselves to be acceptably reproducible in testing and retesting (r=0.86), and there is great variability between subjects, even when VO_2max and MAS are similar[9,10]. According to a review of the literature, field-measured T-Lim averages between 5 and 7 minutes[9-16], regardless of MAS and VO_2max, although the value ranges from 3 to 10 minutes, and even greater times have been registered in some cases[9].

Another aim of T-Lim is to establish a framework with which to choose the duration of training at and near VO_2max. This means that the trainer can dose training volumes more precisely, obtaining improvements in VO_2max, MAS, high-intensity submaximal aerobic capacity, the anaerobic threshold and run performance[9,12-14].

The literature includes two studies which measured T-Lim in men and women[15-16]. Demarie *et al.*[15] measured T-Lim in both sexes, although mean values were presented in their results without differentiating between the two. Bherthoin *et al.*[16] compared the sexes, but the subjects in the study sample were children and adolescents aged between 6 and 17. The authors found differences in T-Lim from 12 years of age up to 17, inclusive.

Several studies have observed differences between men and women when measuring, directly or indirectly, VO_2max and MAS[4,17-20], but whether the same occurs with T-Lim in adults is unknown.

The main purpose of this study was to field-evaluate T-Lim to identify differences in endurance capacity between young physically active male and female adults. The second aim was to analyse the relationship between Final Speed Reached (V(max)) and T-Lim.

Material and method

All the evaluations were conducted in the morning between 9 and 11 a.m., with two hours without food intake. The UNCa test[21], recently validated through the final field speed reached (V(max)), was used to estimate MAS. The measurements were taken in three sessions. Anthropometric measurements were taken in the first session. In the second session, field measurements were taken using the UNCa test. The evaluations were carried out with groups of up to 6 subjects. In the third session, T-Lim was measured grouping the subjects together by speed, regardless of sex, with a maximum of 6 subjects. There was a rest period of 120 hours between the 2nd and 3rd sessions. The subjects wore the same clothes and footwear in all the evaluations. The evaluations were conducted in the field on natural grass. The subjects did not do any exercise in the 48 hours prior to the evaluations.

Subjects

39 voluntary subjects, all physical education students (27 men and 12 women), were evaluated. The general characteristics of the sample are shown in Table 1. The following were excluded from the study: a) under-18s, b) subjects with any type of neuromuscular lesion and/or cardiorespiratory disease, c) subjects without experience in the two field tests (UNCa test and T-Lim) and d) those who did less than 1 hour of physical activity at least three times a week. Before signing the informed consent form, the subjects were informed about the procedures involved in the study and the benefits and risks of taking part in it both verbally and in writing.

Procedure

Anthropometry: Body mass, standing height, 3 girths (relaxed arm, minimum waist and maximum calf) and 3 skinfolds (triceps, abdomen and cal f) were measured. The skinfolds were measured using Rosscraft

Table 1. Characteristics of the sample and field-measured variables.

	All N= 39	Men N= 27	Women N= 12
Anthropometric variables and indexes			
Age (years)	24.5 ± 6.4	25.4 ± 7.3	22.9 ± 4.1
Height (m)	1.70 ± 0.08	1.76 ± 0.05	1.60 ± 0.07#
Body mass (kg)	71.2 ± 11.2	77.6 ± 9.2	63.7 ± 8.2#
CG Arm (cm)	24.0 ± 17.6	27.4 ± 2.3	21.3 ± 3.4#
CG Waist (cm)	70.9 ± 7.7	75.9 ± 6.5	67.0 ± 6.2#
CG Calf (cm)	32.3 ± 5.2	34.9 ± 2.3	30.4 ± 6.0#
BMI (kg/m^2)	24.6 ± 3.1	25.2 ± 2.8	23.9 ± 3.2
Σ 3 skinfolds (mm)	46.7 ± 17.6	36.5 ± 14.7	54.6 ± 15.8#
Fields variables			
V(max) (km•h^{-1})	13.9 ± 1.8	14.8 ± 1.4	12.0 ± 1.0#
T-Lim (s)	374.5 ± 94.0	385.0 ± 99.3	351.0 ± 79.6
D-Lim (m)	1462.2 ± 475.0	1589.5 ± 485.7	1175.7 ± 304.4#

CG: corrected girth. BMI: body mass index. Σ: Sum of 3 skinfolds (triceps, abdomen and calf). V(max): final speed reached in the last complete stage of the UNCa test. T-Lim: time to exhaustion. D-Lim: distance to exhaustion.
# p< 0.05 significant differences with respect to the male group.

Slim Guide callipers and the girths with a Lukfin metal tape measure. The measurements and calculations of the body mass index and corrected girths were made according to the guidelines of the ISAK (International Society for the Advancement of Kinanthropometry)[22].

UNCa Test: The subjects run the perimeter of a hexagon. Each side of the hexagon is 20 metres long (Figure 1). Each interior angle is 120º. The speed is set by a beep. At each vertex of the hexagon, there is a 2-metre area where the subject should be located when the beep sounds (Figure 1). The initial speed in the test is 8.0 km•h^{-1} and the stage lasts 3 minutes. It then increases to 10.0 km•h^{-1} for 2 minutes. The aim of these first two stages is to standardise a specific warm-up. Without a break, the speed then increases by 1 km•h^{-1} every 1 minute until exhaustion.

Given that a portable gas analyser was not used, the Final Speed reached (V(max)) was monitored in the last complete stage as recommended in the literature[23].

The audio was downloaded from: http://g-se.com/es/entrenamiento-en-rugby/blog/audio-del-unca-test[24].

Time to exhaustion (T-Lim). A 400-metre athletics track was used. A bicycle with a digital speedometer was used to register the speed of the subjects. The speedometer was calibrated as explained in the manual: the circumference of the tyre and the radius need to be loaded into the device. As a second method of calibration, the speed recorded by the speedometer was compared with the speed determined by the UNCa test audio over a distance of 100 metres with cones every 20. The warm-up consisted of 10 minutes at 60% V(max) in the UNCa test. Then there was an active 10-minute break for joint mobility, flexibility and hydration. Immediately afterwards, the runner started to run alongside the bicycle, always between its two wheels and on the inside lane of the athletics track. When the speed corresponding to 100% V(max) in the UNCa test was reached, the stopwatch was started and that speed was maintained for as long as possible. The test ended when the subject could not maintain the speed imposed by the bicycle (between its two wheels) or when he/she stopped through exhaustion. This method to field-measure T-Lim is described in the literature[11].

Distance to exhaustion (D-Lim). This is the number of metres covered in the T-Lim test.

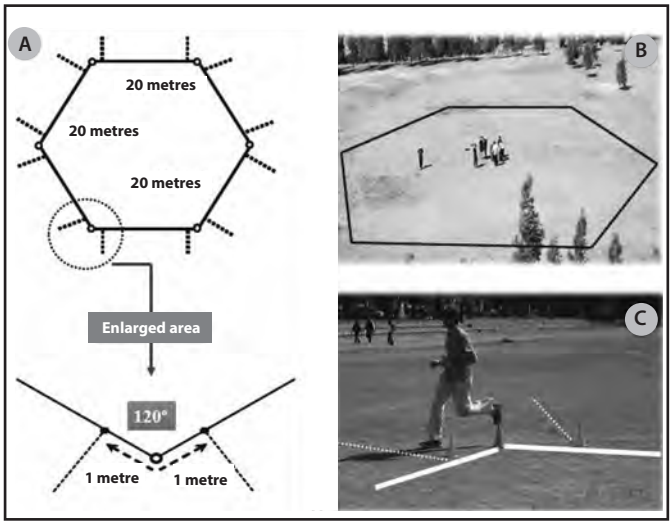
The distance is obtained by multiplying the time to exhaustion in seconds by the speed in metres per second.

$$\text{D-Lim} = \text{T-Lim (s)} \cdot \text{Speed (m} \cdot \text{s}^{-1}\text{)}$$

Statistical Analysis

The data are presented as mean values with standard deviation, unless otherwise specified. They were analysed using SPSS 18.0. The Kolmogorov-Smirnov test and Levene's test were used to test the normality and homoscedasticity of the study sample. After corroborating the normality of the data, the independent samples t-test was used to determine statistically significant differences between the sexes in terms of V(max), T-Lim, D-Lim and other descriptive variables. The relationships between T-Lim, D-Lim and V(max) were calculated using the Pearson correlation coefficient, applying the following criteria: 0.1 very low; 0.1-0.3, low; 0.3-0.5, moderate; 0.5-0.7, good; 0.7-0.9, very good; and 0.9-1.0, perfect[25]. An alpha level of p <0.05 was accepted in all cases..

Figure 1. UNCa test; a) graphic design of the hexagon, with one of its vertices enlarged. b) Aerial photograph of the hexagon. c) One of the vertices of the hexagon.



Results

Table 1 shows the characteristics of the sample and the field values obtained. In the male group, V(max) ranged between 13 and 18 km•h^{-1}, for T-Lim from 213.0 to 661.0 seconds, and D-Lim between 828.3 and 3121.0 metres. In the female group, V(max) ranged between 10 and 14 km•h-1, for T-Lim from 217.0 to 523.0 seconds, and D-Lim between 769.4 and 1743.3 metres.

Statistically significant differences were observed between the sexes in all the variables measured except age, body mass index and T-Lim (Table 1).

The correlations found between V(max) and T-Lim were: for all the cases r= 0.29 (p>0.035), for the men r= 0.24 (p<0.112) and for the women r= 0.27 (p<0.196). The correlations found between V(max) and D-Lim were: for all the cases r= 0.64 (p>0.001), for the men r= 0.53 (p<0.002) and for the women r= 0.56 (p<0.027). The correlations found between T-Lim and D-Lim were: for all the cases r= 0.92 (p>0.001), for the men r= 0.95 (p<0.001) and for the women r= 0.95 (p<0.001). Such a high correlation is because D-Lim is dependent on T-Lim; the longer the subjects kept running, the greater the distance covered, regardless of V(max).

Figure 2 shows the individual values of V(max) and T-Lim. Several subjects share the same V(max), but differ in terms of T-Lim. The same can be observed between D-Lim and V(max) in Figure 2.

Discussion

The main purpose of this study was to examine gender differences in endurance capacity through field-evaluated T-Lim in physically active

Figure 2. Individual values:T-Lim vs. V(max).

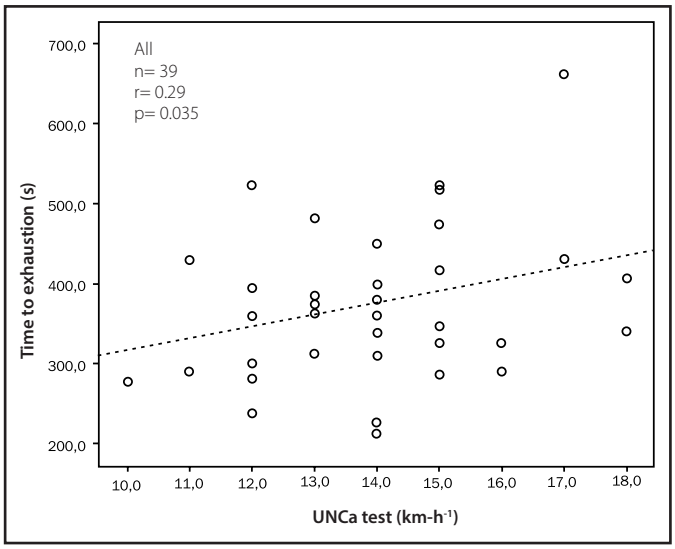


Figure 3. Individual values: D-Lim vs. V(max).

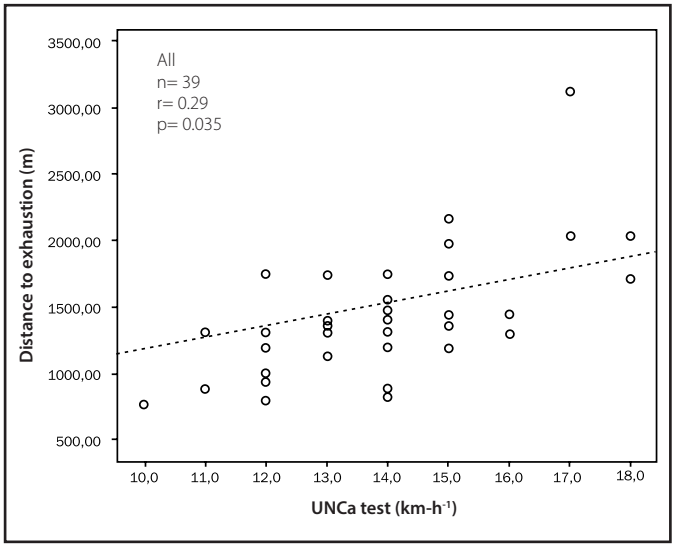


Table 2. Summary of research which has field-measured T-Lim using V(max) or MAS.

Author	n=	Sex	MAS (km•h-1)	V(max) (km•h-1)	Evaluation Protocol	TLim (s)
Billat V. *et al.*[9]	10	M	21.6 ± 1.2	-	3 min * 1 km•h^{-1}	371.0 ± 120
Billat V. *et al.*[11]	7	M	-	20.1 ± 0.7	2 min * 1 km•h^{-1}	355.0 ± 55
Kachouri M. *et al.*[28]	14	M	-	17.8 ± 1.5	2 min * 1 km•h^{-1}	483.,0 ± 213.0
Berthoin S. *et al.*[29]	74	M	-	14.1 ± 1.6	2 min * 1 km•h^{-1}	365 ± 102
	65	W	-	11.4 ± 1.1	2 min * 1 km•h^{-1}	325 ± 93
Billat V. *et al.*[30]	6	M	17.0 ± 1.1	-	4 min * 2 km•h^{-1}	
					(1 min pausa)	333.0 ± 116
Demarie *et al.*[31]	15	M-W	16.6 ± 1.1	-	3 min * 1 km•h^{-1}	
					(20 s. pausa)	307.0 ± 183
Millet G. *et al.*[10]	8	M	19.9 ± 0.9	-	1 min * 0.5 km•h^{-1}	235.6 ± 49.2
Millet G. *et al.*[32]	7	M	19.8 ± 0.9	-	1 min * 0.5 km•h^{-1}	243.7 ± 39.5
Heurbert *et al.*[33]	8	M	16.1 ± 1.4	-	1 min * 3 km•h^{-1}	373 ± 111
Dupont G. *et al.*[34]	10	M	17.5 ± 1.3	-	2 min * 2 km•h^{-1}	350.3 ± 68.5
Dupont G. *et al.*[35]	9	M	16.7 ± 1.3	-	1 min * 1.5 km•h^{-1}	362.0 ± 109.0
Chtarra *et al.*[36]	10	M	-	16.1 ± 1.1		312.2 ± 68
	9	M	-	16.1 ± 0.5		280.9 ± 55
	10	M	-	16.2 ± 1.0	1 min * 0.5 km•h^{-1}	274.9 ± 63
	10	M	-	16.2 ± 0.9		312.7 ± 57
	9	M	-	16.1 ± 0.8		253.9 ± 51
Chaouachi *et al.*[37]	41		-	16.2 ± 1.0	1 min * 0.5 km•h^{-1}	307.2 ± 79.5
Presente	27	M	-	14.8 ± 1.4	1 min * 1 km•h^{-1}	385.0 ± 99.3
Trabajo	12	W	-	12.0 ± 1.0	1 min * 1 km•h^{-1}	351.0 ± 79.6

MAS: maximum aerobic speed. V(max): final speed reached. TLim: time to exhaustion. s: seconds. M: men. W: women. min: minutes.

young adults. The results showed that there existed no difference in T-Lim between men and women in a sample of physical education students. Due to the greater V(max) registered by the males, higher D-Lim for this group was to be expected. The low correlations between T-Lim and V(max) would seem to indicate that there is a very poor relationship between these two aerobic performance variables. This highlights the fact that subjects who reach higher speeds are not always those who can maintain or sustain those speeds the longest.

Table 2 shows how little research has involved female subjects. The table only shows research which field-measured T-Lim and excludes studies conducted with treadmills, because MAS and/or V(max) may be affected by the protocol and the place where measurement is taken (field or treadmill)[11,21,26,27]. Table 2 also shows how speed was arrived at in the different studies: by finding MAS directly (gas analyser) or using an indirect test to estimate MAS through V(max).

The T-Lim values registered in this study were similar to those reported in Table 2. The running speeds (MAS or V(max)), however, were appreciably lower. These differences may be due to the type of sample used. In most cases, the subjects were trained or highly trained. The only study which gave speeds similar to those in our study was that of Berthoin *et al*, although it should be pointed out that the sample consisted of 17-year-olds[16].

On analysing our subjects' physical performance and comparing it with the other studies, both differences and similarities in terms of aerobic performance can be observed: the former regarding "aerobic power", in this case determined by running speed, and the latter regarding "aerobic capacity", which has to do with the condition or ability to sustain the final speed reached in the test continuously until exhaustion, represented by T-Lim.

The most significant differences, therefore, are concerned with speed and not T-Lim. In other words, we can say that our subjects differ from those in other studies when aerobic power, expressed as speed, is compared, but give similar values when aerobic capacity, expressed as time, is compared.

Another point for discussion concerns the applicability of T-Lim in aerobic training. If the aim is to stress the cardiorespiratory component at and near VO_2max, Billat suggests that repetitions should last 60% T-Lim[8]. This means that if the subject keeps running for 200 seconds during the T-Lim test, the training repetitions should last 120 seconds. This is an interesting idea for trainers and fitness coaches. In both continuous and intermittent sports, the distances covered at high intensities of MAS or V(max) define the calibre of the athlete; if a long-distance runner can sustain a pace close to his/her aerobic maximum over the competition distance, this is a good indicator of success. Likewise, if a footballer or rugby player has a total volume at high intensity, even when each repetition involves no more than 30 metres, this too is a good indication of success in his/her discipline. This proposal should not, therefore, be ignored.

To illustrate Billat's recommendation better, in Table 3 we have taken three male examples who obtained the same V(max), 15 km•h^{-1}, in our study.

The three subjects have the same field V(max) (15 km•h^{-1}), but differ in T-Lim. Subject 2 kept running for 90 seconds longer (27%) than subject 17, but 105 seconds less than subject 3 (-25%). Subject 3 kept running for 195 seconds more than subject 17 (60%). Given this variability, Billat suggests that the run be designed according to T-Lim. As can be observed in Table 3, each subject has a personal training distance. Any other training design, such as 10 repetitions of 400 metres, would only have running speed and not endurance capacity in mind. Billat's approach, therefore, should be taken into account because it means that the workload is individualised more specifically, particularly for high-intensity runs (near VO_2max). It also provides the fitness coach with another work methodology, bringing diversity to aerobic training.

Table 3. Example of repetition design based on T-Lim for 3 male subjects with the same V(max).

Subject	V(max) (km•h^{-1})	TLim (s)	DLim (m)	Repetition (m)	(60% TLim) (s)
2	15	416	1733.3	1040	250
3	15	521	2170.8	1302	313
17	15	326	1358.3	815	196

s: seconds. m: metres.

Other authors have come up with alternatives based on Billat's proposition. Millet *et al.* used the total duration of T-Lim to design variable continuous runs[10]. Esfarjani *et al.* also designed 2 modalities based on T-Lim, with intensities between 100 and 130% MAS. After 10 weeks of training, they observed improvements in MAS, the threshold speed, run performance (3,000 metres) and T-Lim[14]. Smith *et al.* compared the effects of training on 2 groups using 2 different approaches: one group did repetitions based on 60% T-Lim, while the other worked with 70%. The latter group registered greater improvements[12]. Heubert *et al*. used different percentages of T-Lim to design exercise repetitions (25%, 50% and 75%), ranging intensity from 90 to 115% MAS[13].

The different proposals cited above demonstrate that T-Lim is a valid criterion to establish individual volumes of work near VO_2max, meaning that trainers should not rule out this idea for aerobic training, while also measuring endurance capacity using other variables related to aerobic power (VO_2max and MAS).

On the basis of the results obtained, it can be concluded that, for the sample analysed, there is no difference in T-Lim between the sexes and the correlation between V(max) and T-Lim is low. Great variability in terms of T-Lim was also observed between subjects with the same V(max). This shows that T-Lim is an important indicator when it comes to individualising training volumes in sessions. This study should be replicated with sportspeople to see if the same difference exists between men and women.

Practical applications

T-Lim can be used to measure individual aerobic endurance capacity and fractionate workloads to bring diversity to aerobic training near VO_2max. Although the indirect method may constitute a constraint, it is the one used by the vast majority of trainers and fitness coaches to prescribe training workloads; hence its usefulness.

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Recommendations to the Medical Services in Spanish federations by sport, for the inclusion of athletes with disabilities (first part)

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Inclusion. Sport integration. Adapted sports. Disabled athlete. Person with disability. Sport federations (conventional). Federation medical services.

Summary

The inclusion process in adapted sport, affects at several levels on the Medical Services in Spanish Sport Federations (SMF), due to the presence of disabled athletes. This is a first part of the article titled *Recommendations to the Medical Services in Spanish federations by sport, for the inclusion of athletes with disabilities.* New significant aspects related with specific and differential adaptations on physiological control and sports control, are presented: medical and functional recognition, sports performance tests, sports-medical examination, functional classifications and assessments. Subsequently, nutrition, hydration and ergogenic supplements specific aids are explained. Finally, specific aspects of anti-doping control in disabled athletes are discussed: therapeutic uses exemption and specific adaptations to the sample collection techniques.
The second part, in a second article, will deal with other specific actions in the SMF and with other actions and adaptations that guarantee equality of conditions among athletes.

Recomendaciones a los Servicios Médicos de federaciones españolas unideportivas, para la inclusión de deportistas con discapacidad (primera parte)

Palabras clave:
Inclusión. Integración deportiva. Deporte adaptado. Deportista con discapacidad. Persona con discapacidad. Federaciones unideportivas (convencionales). Servicios médicos federativos.

Resumen

El proceso de inclusión del deporte adaptado repercute a diversos niveles de los Servicios Médicos Federativos (SMF), que deben de adaptarse a la presencia de los deportistas con discapacidad en las federaciones unideportivas españolas. En esta primera parte de las "Recomendaciones a los Servicios Médicos de federaciones españolas unideportivas, para la inclusión de deportistas con discapacidad" se presentan las bases en que fundamentar las necesarias adaptaciones, desde un modelo general de inclusión – integración, desde la dimensión del deportista, con diversos tipos de discapacidad, y de la modalidad deportiva. Se presentan los aspectos más significativos a tener en cuenta por los SMF en el proceso de inclusión de los deportistas con discapacidad, referidos a las adaptaciones específicas y diferenciales sobre el control fisiológico y el rendimiento deportivo: reconocimiento médico y funcional, pruebas de rendimiento deportivo, reconocimiento médico-deportivo, valoraciones y clasificaciones funcionales, y nutrición, hidratación y ayudas ergogénicas. Finalmente, se comentan aspectos específicos del control antidopaje en deportistas con discapacidad: autorizaciones de usos terapéuticos y adaptaciones específicas en las técnicas de recogida de muestras.
La segunda parte, en un segundo artículo, tratará de otras acciones específicas en los SMF y otras acciones y adaptaciones que garanticen la igualdad de condiciones entre los deportistas.

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Introduction

The inclusion of people with disabilities is a priority focus in social development policies in Spain, Europe, and the rest of the world, with physical and sporting activities, as well as competition sport, constituting an important means of achieving social inclusion targets[1]. Adapted sport is undergoing a historical moment around the world in terms of favouring the inclusion of its athletes, with the key objective being the promotion of performing sporting modalities, whatever the physical, psychic, mental or sensorial characteristics of the individuals undertaking them. This process represents a challenge that will mark the future of sporting modalities and competition sport in the 21st century.

Suggestions for driving forward inclusion/integration processes of adapted sport in Spain propose situations that require responses, for example:

- Structural and organisational adaptations,
- Aspects related to the promotion and initiation of sport, not just for people with disabilities but also for the wider population
- Aspects related to the guidance and training of sports managers and technicians, support for athletes, competition personnel, judges or referees
- The development of interdisciplinary teams that include adapted sport as an objective
- The development of adapted sport projects and programmes included in general sports programmes
- Sporting legislation applicable to the development of the process, agreed upon by single-sport federations.

Consequently, Federated Medical Services (FMS) should not be exceptional within this context of federative inclusive adaptation, and adaptation to these new needs emerging from the presence of athletes with different disabilities and their sporting modalities should be carried out. In this first part of the review, along with the FMS inclusion process of single-sport federations of athletes with disabilities, we will present the need to adapt the basic services offered, focusing on a level of physiological control and sporting performance, nutrition, ergogenic support, and as a result of this, anti-doping control.

Moving towards completing the inclusive process

It is important to highlight that the ultimate goal of the process is to achieve the inclusion of athletes with disabilities in single-sport federations. Yet it is also obvious to observe that not all athletes with disabilities - and their corresponding sporting modalities - will have the same possibilities of achieving this objective of maximum inclusion. Some will probably only be able to achieve – now and in the near future – levels that could fit within integration; thus the phrase "inclusion/integration" (Martínez-Ferrer, 2016)[2], which is often used as a premeditated fact for better understanding. Possessing sufficient normalisation criteria is a fixed requirement, which should show respect towards the diversity of all athletes in the single-sport federation at all times. In each case, the level or levels of normalisation and socialisation that these athletes and their modalities can achieve must be identified[2].

We are going to define these levels of the inclusive dimension through the characteristics of the athletes' disabilities and of the sporting modality, with this differentiation proving very useful for single-sport federation, which must later implement the participation and representation of the adapted sport within the federation itself, particularly in its sporting competitions. The dimensions are:

a) *Dimension of the athlete with disability*: in this case the athletes with disabilities can achieve the following levels:

– Included individual athlete: when his/her functional and competing capacities do not differ from those shown by other athletes at his/her sporting level within this sporting modality. An example could be an athlete with the ramifications of a forearm amputation, in a middle-distance athletics race.

Integrated individual athlete: when his/her functional and competing capacities are not comparable to those of other athletes at his/her sporting level within this modality. In this situation he/she must compete with athletes with a similar disability, applying the functional classification criteria of the sporting modality in question. An example could be a swimmer with the ramifications of complete paraplegia from the twelfth dorsal level, in a free-style swimming competition.

Adapted individual athlete: when his/her competitive capacity cannot be compared to those of other athletes at his/her sporting level because this modality or competitive characteristic does not exist in the single-sport federation. In this situation he/she must also compete with athletes with a similar disability, applying the functional classification criteria of the sporting modality in question. An example could be a visually impaired cyclist in tandem cycling mode, with a sighted guide.

Inclusive team athlete: when his/her functional and competitive capacities do not differ from those of the rest of the athletes in the team in that sporting modality, or are counterbalanced by small regulatory changes. An example could be a basketball player with a hearing impairment, with combined refereeing using a whistle and green and red lights.

Adapted team athlete: when his/her competitive capacity cannot be compared to that of other athletes at his/her sporting level because this modality or competitive characteristic does not exist within the single-sport federation. In this situation he/she must also compete in teams comprising athletes with similar disabilities, applying the functional classification criteria of the sporting modality in question. In this case, an example could be a football player with the ramifications of infantile cerebral palsy with hemiparesis with manifest spasticity, on a seven-a-side football team.

b) *Dimension of the sporting modality*: in this case the modality could achieve the following levels:

Inclusive modality: when the athletes have a similar functional and competitive level, for example, archery.

Integrated modality: when the modality is the usual one and within the same competitive setting, but not all the athletes have a similar or standard functional level and in the competition they must be classified in specific classes. An example would be table tennis for people with intellectual disabilities.

- Adapted modality: when the modality in question must have technical variations to allow it to be practiced by some athletes with disabilities. An example would be adapted curling.
- Assimilated modality: when the modality is not a true reflection of the standard modality and similar modalities have been developed to be performed by some athletes with disabilities, such as wheelchair rugby modality.

c) *Special dimension*: We should not forget that some sports carried out by people with disabilities do not have real inclusive capacity. There is a simple explanation, as there is not an established single-sport federation. An example of this is *Boccia* for athletes with physical disabilities, or *Goalball* for blind and visually impaired athletes. These sports should be established as single-sport federations on a national level with the support of the Spanish Superior Sports Board (SSB), as they already are on an international level.

The inclusion/integration of this special group within the federated Spanish sport will not be on a federative level, rather on a level of its equal interrelation in supra-federative organisations such as the Spanish Olympic Committee (SOC) or the Spanish Paralympic Committee (SPC), where it should occupy a newly created and represented space, in this case as "Paralympic Specific Sport Federations".

We must also consider the inverse possibility – integrated – in which people without disabilities perform any speciality of the adapted sport within the integrated modality, such as the incorporation of seated volleyball players without disabilities.

This historical time of including adapted sport into the sporting world is the latest challenge faced by sporting federations and competitive sport in the first quarter of the 21st century.

Basic adaptations of the federated medical services

The aim of this review is to present a proposal of general adjustments and adaptations of Spanish FMS, derived from the inclusion proposal within the Spanish Sporting Federation: *"Inclusion protocol of competitive sport for people with disabilities in conventional sporting federations – single-sports – in Spain"*. This study corresponds to a qualitative and far-reaching doctoral thesis[2], which proposes following a methodical research-action methodology that brings us closer to existing knowledge about the inclusion of adapted sport within sporting federations via their managers, technicians and athletes, comparing knowledge from different adapted sport federations and single-sport federations. The participative discussion Focus Group methodology was applied[3] in order to put forward the foundations of an intervention model that may be useful for transforming the setting into inclusive, framed within the criteria agreed upon in *"Good Inclusive Practices"*[4]. This review includes the main actions needed to transform FMS, especially those used generally by all federations, which will evolve towards specific actions depending on the sporting modality, as well as the type of disability and the degrees of disability in each single-sport federation.

Adaptations of medical and functional examinations

Medical and functional examinations must adapt to the needs and characteristics of the specific sport and of the athletes with disabilities that perform them, whether physical, sensorial or intellectual disabilities. These adaptations stem from the criteria established by the International Paralympic Committee Medical Code *(IPC Medical Code,* 2011)[5], which establishes all general criteria of medical assistance, the preservation of athletes' health and the ethics and confidentiality of the services provided.

Sporting performance tests

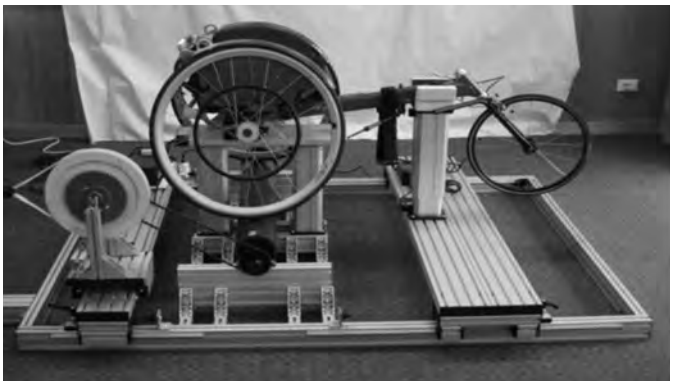
In order to perform a good follow-up of the training of athletes with disabilities, they must overcome some tests for physical condition, just like other athletes. These tests will assess different capacities and physical conditions, the most important of which are aerobic capacity, muscle strength and body composition. Also, depending on the type of sport and the disability, agility, speed, balance, flexibility and coordination can also be assessed.

Often, before carrying out the tests, one or more familiarisation sessions are required, in particular with athletes that have intellectual-type disabilities. It should be considered that, for some of them, the material and the equipment, as well as the execution techniques, are new, and we must ensure a minimum level of learning and confidence for the test to be valid.

With regards to the material and equipment, we must make some adaptive considerations. Some may be common for athletes with and without disabilities, but their assessment via the applied formulas may vary depending on the disability. This occurs, for example, when we want to obtain body composition via skin fold tests, or dynamometric indices via isometric dynamometers. Other pieces of equipment and machinery are specific to some of the disabilities. For example, in the case of wheelchair users, the use of a handbike is necessary. A sufficiently wide treadmill would also be useful, upon which a wheelchair could be placed, with fixtures to keep it on the belt. A third option would be to use mechanical rollers, requiring good fixture to the wheelchair to prevent possible accidents, particularly at moments of fatigue or claudication of the athlete (Figure 1). Another recommendable aspect, in the case of very reduced mobility, would be to have a belt with unloading harnesses for athletes with major walking limitations.

It is important to apply a specific protocol with loads and intensities that are customised to each athlete and his/her disability and sport so as to carry out an appropriate follow-up of his/her training, as there can be different physiological responses that can appear when exercise is performed with some kinds of disability. For example, in the case of Down syndrome, it is important to be aware of the chronotropic incompetence presented, with maximum heart rates being lower than those of the population in general for the same age (Guerra M. *et al,* 2003)[6]. Or, in the case of cerebral palsy, the thermo-regulation alteration due to an alteration of sweating, also significant in athletes with the symptoms of spinal cord injury[7,8]. Furthermore, in the case of field tests, it will be

Figure 1. Athletics wheelchair mounted on a treadmill for a study. A fixing device has been fitted to avoid possible accidents during the tests (authors' private photographic archive).



necessary to perform the corresponding adaptations, or simply create new tests that assess the elements we wish to control. In any case, it will be necessary to previously validate these tests for the corresponding demographic group.

Taking into account the heterogeneity of athletes with disabilities, and the large amount of sports that they can perform, it is difficult to establish specific protocols for assessing this demographic, which is why individualisation is so paramount.

It is therefore necessary to consider that before performing any test, general reference values should not be used to establish their current level of physical condition. We must always compare each individual with him/herself, and analyse improvements or changes for the worse that may occur in order to adapt training in the quest for satisfactory performance.

Medical-sporting examinations

In this section the characteristics and functionalities of the disability presented will be taken into account, in relation to the risk of practicing competitive sport. To do so, the official certifications held by the athlete with a disability should be considered, and the international criteria established in the International Paralympic Committee Classification Code (*IPC-Classification Code*)[9] - also approved in 2011 - in which eligibility criteria are established depending on the degree of disability and functionality for performing the specific sport. These criteria also establish which athletes may be eligible to partake in competitive sports, from levels that vary from maximal handicap[9] – an athlete that cannot be chosen given the risk that participating in the sport may have on his/her health and safety – to minimal handicap[9] – an athlete than is not eligible to participate in the adapted sport and may only compete in the inclusive modality, as his/her degree of disability and functioning are very similar to those for standard athletes in this specific sport.

Functional assessments and classifications of the disability

Classifying the degree of disability is a necessary assessment to ensure fair competition. Similar to wrestling, boxing and weight lifting, in which the athletes compete in accordance with established weight categories, athletes with disabilities are grouped into classes defined by the degree of functionality presented by the disability in a specific sport, which is often different despite the degree of disability being similar.

In 2003, the Paralympic Movement re-launched the study and analysis of the classification systems – initiated in 1990 by the Barcelona'92 Organising Committee of the 9th Paralympic Games (COOB'92)[10] –, recognising the need to coordinate some classifications under a theoretical and universal model. The outcome of this process is the International Paralympic Committee Classification Code, which is crucial for the future of Paralympic athletes as this classification ensures that the disability of an athlete is always relevant in his/her sporting performance (*IPC Classification Code*, 2011, Article 2.1.1)[9]. The code is complemented with international regulations establishing the technical and operative requisites for classification. There are three fundamental international control regulations for functionality:

- *Assessment of the athlete:* the procedures for athlete assessment and the adjudication of the sporting class and sporting class status.
- *Protests and appeals:* procedures for handling protests and appeals related to classifications when the disability of the athlete varies or if recommended.
- *Capacitation as classifier and certification*: management for uniform and universal training, and certification as specialised classifiers with authority to undertake classifying actions, whether nationally or internationally. The code is applied to all sports within the Paralympic Movement. The application of and compliance with the International Paralympic Committee Classification Code used by international sporting federations is supervised by the International Paralympic Committee (IPC).

The International Paralympic Committee Classification Code requires all assessment and subsequent classification systems applied to a specific sport to establish: a) the identification of the eligible impediments for this particular sport in athletes with disabilities; b) a detailed description of the assessment methods applied to the athletes so that the impact of the deficiency can be demonstrated.

These methods must be based on objective, standardised and certified objectives.

The IPC has adopted the research study *"International Paralympic Committee position stand—background and scientific principles of classification in Paralympic sport"*, by Tweedy and Vanlandewijck[11] as its benchmark, based on the evidence of an assessment and classification in a specific sport, specific classification systems that must coincide with the principles established in this section.

To guarantee that the competition is fair and equal, all Paralympic athletes have a categorisation system that ensures that winning is always based on the ability, aptitude, strength, resistance, tactical capacity and mental concentration of the athlete, and not by the level of his/her disability, taking into account the same factors that are considered for the successful sporting performance of an athlete without a disability. The aim is to minimise the impact of impairments in the sporting activity, discipline or sport. Therefore, having an impairment is not enough to be able to participate in the Paralympic games.

Currently, two classification models are applied in the International Paralympic Movement:

- *Sport-specific models*: in this classification system, athletes are evaluated and assessed taking into account the specific requirements needed in each sport and/or their basic sporting movements, for example, wheelchair sports/capacity to propel the wheelchair. This system is also known as functional classification.
- *General model*: in this classification system athletes are evaluated taking into account the type and degree of deficiency presented; for example, the degree of visual impairment and its repercussion on practicing the sport.

The impact of the sport must be proven; the sporting classes, in each Paralympic sport, establish grouping criteria of the athletes given their degree of limitation in the activity, resulting from their impairment. Classification is sport-specific, as impairment affects the capacity to perform different sports to different extents. As a result of this, an athlete may fulfil the criteria for one sport, but may not meet requirements for another sport, or may fulfil them with less functional significance.

Nutrition, hydration and ergogenic supports

The fundamental aspects of nutrition for athletes with disabilities will now be described. Two main aspects should be considered:

- On the one hand, the specific characteristics of the ramifications presented by the athlete with a disability, particularly persistent effects, whether physical, functional or mental, that may affect his/her capacity for nutrition. In the case of a tetraparesic or tetraplegic athlete, and even in cases of double-disarticulation of the shoulders, the fact that the athlete does not have easy access to drinks presents a complication when maintaining on-going hydration and even correct nutrition.
- On the other hand, it is also important to consider possible interaction with habitual and sporadic pharmacological treatments that many of these athletes receive to control their conditions, as well as the possible interaction between this base medication and the quantitative and qualitative effects they have on their nutrition, such as in the case of therapies that consider the use of diuretics, beta-blockers, muscle relaxers, anti-epileptic and/or anti-spasmodic drugs, among others.

It is important to know the practical aspects of correct hydration and nutrition in athletes with different disabilities: a) why it may be useful to drink or eat during exercise; b) the amount of liquid to drink; c) the best kind of drinks to consume; d) the amount and quality of nutrients to ingest and how to do it; e) the modifications that should be made in cold or hot environments; and f) the functional characteristics of athletes with disabilities.

Severe dehydration affects performance and increases the risk of illness through overheating, but drinking too much can also be harmful or uncomfortable, particularly for athletes with sphincter control difficulties.

Each athlete is different because each has different losses through sweat, different ramifications, treatments, etc., as well as different opportunities to drink liquids during training sessions and competitions. We must remember that humans do not adapt to dehydration, but we can learn to complain about it less.

Simple steps can help map out "good practices" for correct hydration (IOC: Nutrition for Paralympic athletes 2012)[12]:

- Start the session well hydrated.
- If the colour of the athlete's urine is darker than normal, more liquids may be required. This can be very objective for athletes that use diuresis bags for habitual incontinence for their disability[8].
- Drawing up a capacitation plan and drinking during competition is always necessary.
- If the athlete regularly has - in the terms of Casa *et al*. (2005) - a "salty shirt" [13], it is possible that he/she needs drinks with more salt, or to get more salt from foods, when sweat losses are considerable.

It is important to minimise the risk of gastro-intestinal problems, deriving from a condition that causes constipation, or from treatment with this side effect, occasionally also heightened on hot days, which favour constipation and dehydration. It may be best to avoid solid foods 2 to 3 hours before competing, as a combination of physical exercise and nervousness can lead to some gastric troubles.

Trainers of athletes with disabilities must have training resources available regarding specific nutrition and hydration, so they can guide their athletes towards good habits.

Thermoregulation mechanisms are generally less efficient in athletes with disabilities, and particular attention should be paid to the environment, activity patterns, clothing and hydration to avoid overheating and hypothermia.

Athletes with disabilities who consume a wide range of foods should not require dietary supplements, including the consumption of energy drinks containing large amounts of caffeine and that are not appropriate.

It is also very important for athletes with disabilities to always inform and update their trainers of any changes to medications that may have been prescribed, so that the FMS can assess new energy and hydration requirements, assessing whether or not specific ergogenic support mechanisms are needed. This information will always be regularly passed on to their trainers.

With regards to ergogenic supports, firstly it is necessary to have a correct knowledge of the energy system that is being used during the sport, as well as the characteristics of the ramifications and possible treatments used by the athletes with disabilities, as we have previously highlighted. This way, the right nutritional ergogenic support mechanisms can be used for each situation. These mechanisms are recommended for athletes with disabilities when the supplementation protocols proven to be effective are known, and upon assessing their possible interactions with the symptoms and treatments prescribed for these kinds of athletes. There is currently scarce regulation in the industry regarding specific nutritional supplementing for athletes with disabilities.

Furthermore, studies relating these supplements to the characteristics of disabling conditions or their interactions with medication that may control them - therefore truly guaranteeing the specific effectiveness of these supports in adapted sport - are practically non-existent.

Anti-doping control

The desire to achieve the personal and economic prizes available in modern-day sport may cause some athletes to want to win at any cost. The Paralympic Movement has also been tarred with these unfair and unacceptable practices[14].

To guarantee clean and fair sport, the IPC and its international federations, and the multi-sport and single-sport organisations with inclusive modalities are signatories and active members of the World Anti-Doping Agency (WADA) and the World Anti-Doping Code (2015)[15]. As a stakeholder of the WADA, the IPC has developed and implemented its own International Paralympic Committee Anti-Doping Code *(IPC Anti-doping Code)*[16], which includes the anti-doping regulations applicable to the Paralympic Movement, as well as the annual Banned Substances List, which are the same as those applied to Olympic sports, established annually by the WADA. As such, national single-sport federations and their FMS must follow these guidelines, in the event that they are not specifically defined in the Organic Act 3/2013, 20th June, governing the protection of the health of athletes and the fight against doping in sporting activity (Official Spanish Gazette No. 148, 21st June 2013)[17], they should consult the Spanish Agency for Health Protection in Sports (AEPSAD) to apply them and to find out their usage regulations.

With regards to aspects that may be different in the doping control of athletes with disabilities, they are more technical aspects rather than regulatory ones, as the mentioned Act for protecting the health of athletes and the fights against doping in sporting activity (2013)[17] does not make significant distinctions, which is why we always highlight those applied in the IPC Anti-Doping Code[16].

In reality it is very difficult to determine and analyse the exact effects that a substance, a method or a combination of the two can have on athletes, and whether this is damaging to their health. In particular, if an athlete with a disability must use substances to treat or stabilise any of the effects of his/her condition, or as a result of the combination of his/her base therapies, false positives may be given.

For athletes with disabilities, the initial review of a treatment to establish whether or not a Therapeutic Use Exemption (TUE) can be applied for and accepted is very complex and on many occasions it is essential for fair play, yet at the same time it is paramount for the health of the athletes in question, which should not be compromised under any circumstances. Therefore, it is vitally important for the athlete to give all possible information to his/her federation doctors and to the panel of TUE experts regarding all treatments and palliative methods, in complete confidentiality and applying the ethic of professional secrecy. Within this relationship, the doctor will take on various roles, including: educator, doctor, detective, sporting judge and advisor.

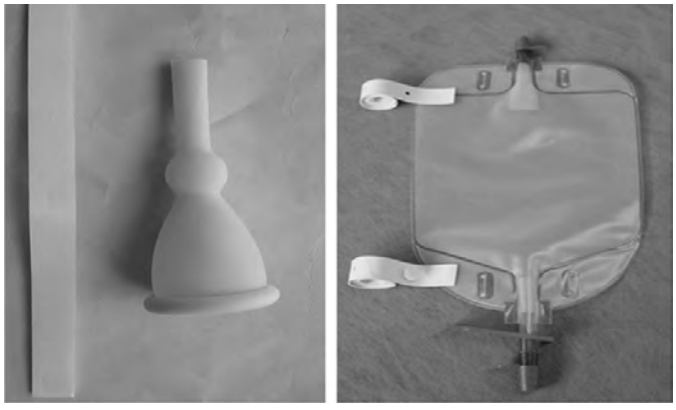
Some differentiating aspects of Anti-Doping Control in adapted sport.

- Therapeutic Use Exemptions (TUE): athletes with disabilities need to familiarise themselves with the TUE process. They should obtain an TUE, where applicable, from their national federations, and from the IPC if they are international athletes (Official Spanish Gazette No. 148, 21st June 2013; Article 17)[17]. Athletes must be aware that they may be likely to receive an adverse (positive) laboratory result, and the possible violation of anti-doping regulations until their TUE has been officially granted. Therefore, medical treatment should not start before the issuing date of the TUE authorisation certification, except for emergency medical conditions. The demands of the TUE will not be considered for back-dated approval, except for cases stipulated in the WADA World Code[15] such as: a) emergency; for example, urgent medical treatment or acute medical condition treatment; b) exceptional circumstance in which the athlete does not have enough time to request his/her TUE, or if there is insufficient time for the TUE Committee to consider it before a competition and before applying an anti-doping control plan.
- Adaptations of sample collecting techniques in adapted sport: the WADA World Code[15] provides the opportunity to modify sample-collecting processes for anti-doping controls. The Anti-Doping Official[17] enabled to perform anti-doping controls, following these recommendations, is authorised to modify standard procedures to take samples from athletes with disabilities, with the aim that these modifications do not violate the integrity, safety or identity of the sample, and with authorisation from the athlete and/or his/her representative.

  This may be the case when:

a) Athletes present limited mobility or coordination during the standard sample collection procedure; e.g. If the athlete is unable to handle the collection cup correctly, other, larger containers may be used that are adapted to his/her coordination and/or mobility deficit. The Anti-Doping Official can help carry out these tasks under the supervision and authorisation of the athlete and/or his/her representative.
b) In the case of visual impairment, the athlete's representative can sign the corresponding forms and records.
c) When the athlete cannot inspect the sample collection equipment, his/her representative will be authorised to carry out the inspection.
d) If he/she has neurological or neuromotor development conditions (e.g. Athletes with a neurological or development disability), the athlete's representative may accompany him/her at all times during the sample collection session.
e) When an athlete uses a catheter or a condom device for the production and diverting of urine (diuresis bags). Athletes that use urine-collecting bags can choose one of the following methods for the collection of their samples (Figure 2).
   - If the catheter or condom device can be separated from the diuresis bag and a new bag can be attached for subsequent sample collection.

Figure 2. To the left, a standard urine-collection device and adhesive strip for attachment to the penis (condom-type device), for leaking incontinence. To the right, a urine-collection bag with straps for attaching to the leg for wheelchair users (authors' private photographic archive).



- If the used catheter or condom must be replaced, the completely empty bag and a new sample of fresh urine must be collected. The sample can also be collected directly via the catheter in a collection cup.

In this latter case (section e), the IPC Statement on the Use of Catheters (2008) should be considered, with textual quotation: *"The IPC considers the use of a urinary catheter by an athlete with a need for self-catheterization as 'personal equipment'. There are potential hazards to using different catheters, such as infection and/or allergic reactions. Athletes use their own catheters, therefore, due to the variety of brands, models and sizes, it cannot be expected that Organising Committees or doping control authorities will supply catheters that meet the individual requirements of each athlete. Along these lines, and giving absolute priority to the health of the athlete, the catheter used is the athlete's responsibility. Though it is not compulsory, athletes are recommended to use sterile catheters for hygiene reasons and to prevent illnesses".*

f) When it is impossible to collect a blood sample though venepuncture on the arms (e.g. amputations of the upper limbs), the Spanish Anti-Doping Agency (AEPSAD) official will extract the blood sample from the vein on the foot or ankle, depending on the disability.

g) It should be noted that any of these specific adaptations in collecting samples from an athlete with a disability should be specified and listed in the Supplementation Form of the sample collection taken by the Anti-Doping Official.

Conclusions

In this first part of the review, the most significant aspects have been presented for FMS to consider in the inclusion process of athletes with disabilities in state single-sport federations. The different levels of standardisation that each athlete with a disability can attain in single-sport federations in general have been displayed, as well as inclusion/integration processes, which in any case will be related to the level and type of disability presented by the athlete, as well as his/her sporting modality.

The specific adaptations that single-sport federations must implement have also been presented. In this first part, focusing on the specific assessments that have to be carried out on athletes with disabilities, with a particular emphasis on the different characteristics and those that overlap with other athletes, both in physiological control and sporting performance, nutrition, the use of ergogenic supports, and as a result of them, the anti-doping control of these athletes.

In the second part of this review, to be prepared shortly, other actions and activities of FMS will be described, as well as a brief description of architectonic adaptations and the suppression of different types of barriers, with the overall objective of providing a service under equal conditions for athletes with disabilities.

The intention of this review as a whole is not to provide a standard list of adaptations and inclusive applications, rather to pool the main adaptations and inclusive adaptations that should be present in state single-sport federations, which, individually and specifically, should be assessed and redesigned, specifically considering the sporting modalities of the athlete, applicable to all athletes regardless of their conditions.

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The effect of therapeutic ultrasound on fibroblast cells *in vitro*: the systematic review

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Summary

Introduction: Therapeutic ultrasound is one of the most used physical resources in the area of physiotherapy for the treatment of injuries. However, the multiplicity of dosimetry used in clinical practice points to its indiscriminate use for pathologies that surround skeletal muscle and expresses the limitation of the available literature on the ideal dosimetric standardization to the tissue restoration, mechanism of action and its real effects on the treatment in question.
Objective: The objective of this study was to promote a systematic review about the different effects and the dosimetric parameters of therapeutic ultrasonic irradiation on the process of restoration of fibroblast cells *in vitro.*
Methods: To select the articles, three electronic data banks were consulted, with publication from January 2000 to September 2016. The studies were tracked by three freestanding reviewers, according to inclusion and exclusion criteria.
Results: 669 articles were selected and after the application of inclusion and exclusion criteria, 647 were excluded. Among the exclusions reasons there are: the utilization of another physical method, exclusive focus on another type of cell line, other experimental models or the use of another language, reaching at the end 22 studies directed to qualitative analysis.
Conclusion: The results of this study showed that the scientific basis is not enough to stablish real effects and dosimetric parameters of therapeutic ultrasonic on the process of restoration of fibroblast cells *in vitro,* due to the lack of generalization and conflict of found results.

Key words:
Cell culture techniques. Fibroblasts. Ultrasonic therapy.

Efecto del ultrasonido terapéutico en células fibroblásticas *in vitro*: revisión sistemática

Resumen

Introducción: El ultrasonido terapéutico es uno de los recursos físicos más utilizados en el área de fisioterapia para el tratamiento de lesiones. Sin embargo, la gran cantidad de dosimetrías utilizadas en la práctica clínica muestra su uso indiscriminado para patologías que circundan el músculo esquelético y además expresa la limitación de la literatura sobre la estandarización dosimétrica ideal para la restauración del tejido, mecanismo de acción y sus efectos reales sobre el tratamiento en cuestión.
Objetivos: El objetivo de este estudio fue realizar una revisión sistemática sobre los diferentes efectos y parámetros dosimétricos de la irradiación ultrasónica terapéutica en el proceso de reparación de células fibroblásticas *in vitro.*
Material y método: Para la selección de los artículos fueron consultadas tres bases de datos para buscar publicaciones entre enero de 2000 y septiembre de 2016. La búsqueda de trabajos se realizó por tres revisores independientes, conforme a los criterios de inclusión y exclusión.
Resultados: Se seleccionaron 669 artículos y tras la aplicación de los criterios de inclusión, se excluyeron 647 estudios. Entre los motivos de exclusión están la utilización de otro medio físico, enfoque exclusivo de otro tipo de línea celular, otros modelos experimentales o el uso de otro idioma, quedando 22 estudios para el análisis cualitativo.
Conclusión: Los hallazgos de este estudio mostraron que la base científica todavía es insuficiente para el establecimiento de los efectos reales y parámetros dosimétricos de la irradiación ultrasónica terapéutica en el proceso de reparación de células fibroblásticas *in vitro,* por la falta de generalización y conflicto de los resultados encontrados.

Palabras clave:
Técnicas de cultivo de célula. Fibroblastos. Terapia por ultrasonido.

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Introduction

The therapeutic ultrasound (TUS) is one of the most used physical resources in the physiotherapy area[1]. However, the multiplicity of dosimetries used in clinical practice points the indiscriminate use of it to pathologies which surround the musculoskeletal[2], and express the limitation of available literature on the ideal dosimetric standardization to tissue restoration, mechanism of action and its real effects on the concerned treatment[3].

This diversity of biological answers come from uncountable interactions of ultrasonic therapy with the cells and tissues, which have been studied for more than 50 years[4]. Among the biological answers, there is the stimulus to neuro-vascularization and leukocyte activity, to adenosine triphosphate production and collagen, to the speed of biochemical reactions, and yet, the significant influence TUS in the cell function in fibroblasts *in vitro* observed by Pires-Oliveira *et al*[5].

In this context, notably, the fibroblast cells play an important role in the production of extracellular matrix (in the connective tissue) and collagen (in the fibrous tissue), being directly involved in the mechanisms of tissue repair and in phase of remodeling tissues[6,7].

Thus, when the ultrasound treatment is correlated to the fibroblast cells culture, it is observed a relevant complementation of studies *in vivo*, especially when the TUS potential is evaluated, since it is admitted the minimization of thermal effects of TUS, as well as the realization of analysis[8-10]. In this regard, it is important to emphasize that, commonly the biophysical effects of TUS were proved in experimental studies *in vitro*, while the same could not be described or analyzed *in vivo*[11].

Besides, with this technique of laboratorial manipulation *in vitro*, it is possible to achieve a strict control of uncountable variables involved, answer the questions in a more systematic manner and, finally, reach a further clarification about the use of TUS[9,10].

Therefore, the objective of this study was to accomplish a systematic literature review about the different effects of therapeutic ultrasonic irradiation and its dosimetric parameters on the process of fibroblast cells restoration.

Material and method

To select the articles of this systematic review three electronic data bank were consulted (PubMed, Bireme, Ebsco Host (Sport Discus), Scopus and Web of Science), being the research done on September 14, 2016.

In the search strategy, the keywords were selected by the terms "MeSH" and its matchings: "Ultrasonic Therapy", "Ultrasonics", "Cell Culture Techniques", "In vitro Techniques", "Fibroblasts", "Connective Tissue" and "Connective Tissue Cells", which were associated to the Boolean terms AND, OR and NOT, shown in Table 1. Some necessary adaptations have been done to meet the specificities of the search engine of each electronic data bank.

To be included in this review, the article should have the following criteria: publication between January 2000 and September 2016, present the text structure in English, French, Italian, Portuguese, Spanish or German, use the therapeutic ultrasound treatment as physical method, fibroblast cells *in vitro* or the biomodulating effect of ultrasound in the fibroblast repair process.

Table 1. Keywords and keyword combinations used to screen the systematic review.

("Ultrasonic Therapy"[Mesh] OR "Therapy, Ultrasonic" OR "Therapies, Ultrasonic" OR "Ultrasonic Therapies" OR "Ultrasonics"[Mesh] OR "Ultrasonic") AND ("Cell Culture Techniques"[Mesh] OR "Cell Culture Technique" OR "Culture Technique, Cell" OR "Culture Techniques, Cell" OR "Cell Culture" OR "Cell Cultures" OR "*In Vitro* Techniques"[Mesh] OR "In Vitro Technique" OR "Technique, *In Vitro*" OR "Techniques, *In Vitro*" OR "*In Vitro* as Topic" OR "*In Vitro*") AND ("Fibroblasts"[Mesh] OR "Fibroblast" OR "Connective Tissue"[Mesh] OR "Connective Tissues" OR "Tissue, Connective" OR "Tissues, Connective" OR "Connective Tissue Cells"[Mesh] OR "Cell, Connective Tissue" OR "Cells, Connective Tissue" OR "Connective Tissue Cell")

The papers which did not filled the inclusion criteria were excluded, and among them, there were the duplicated ones, with focus on another cell line, with another experimental model, with lack of essential information that affected the quality of the methods, the internal and external validity of the study and finally, the review of the articles. In addition to the exclusion criteria above mentioned, it was also included the summaries of events, editorials, consensus of physical means, validation of laboratory methods and manuals for clinical practice. At first, two freestanding reviewers (PDO and SKFZ) tracked the study searching for the title, abstract and key-words, and, in case of disagreement, a third reviewer was called (LDB). This way, after the phases of identification, screening and eligibility, all the studies potentially eligible (n=65) had their completed versions analyzed by these reviewers, according to the flowchart (Figure 1).

The critical evaluation of the studies was observed by the methodological quality in the results obtained through gold standard tests, by the integrity of the evaluations, and the mode adopted for laboratory manipulation in cell culture.

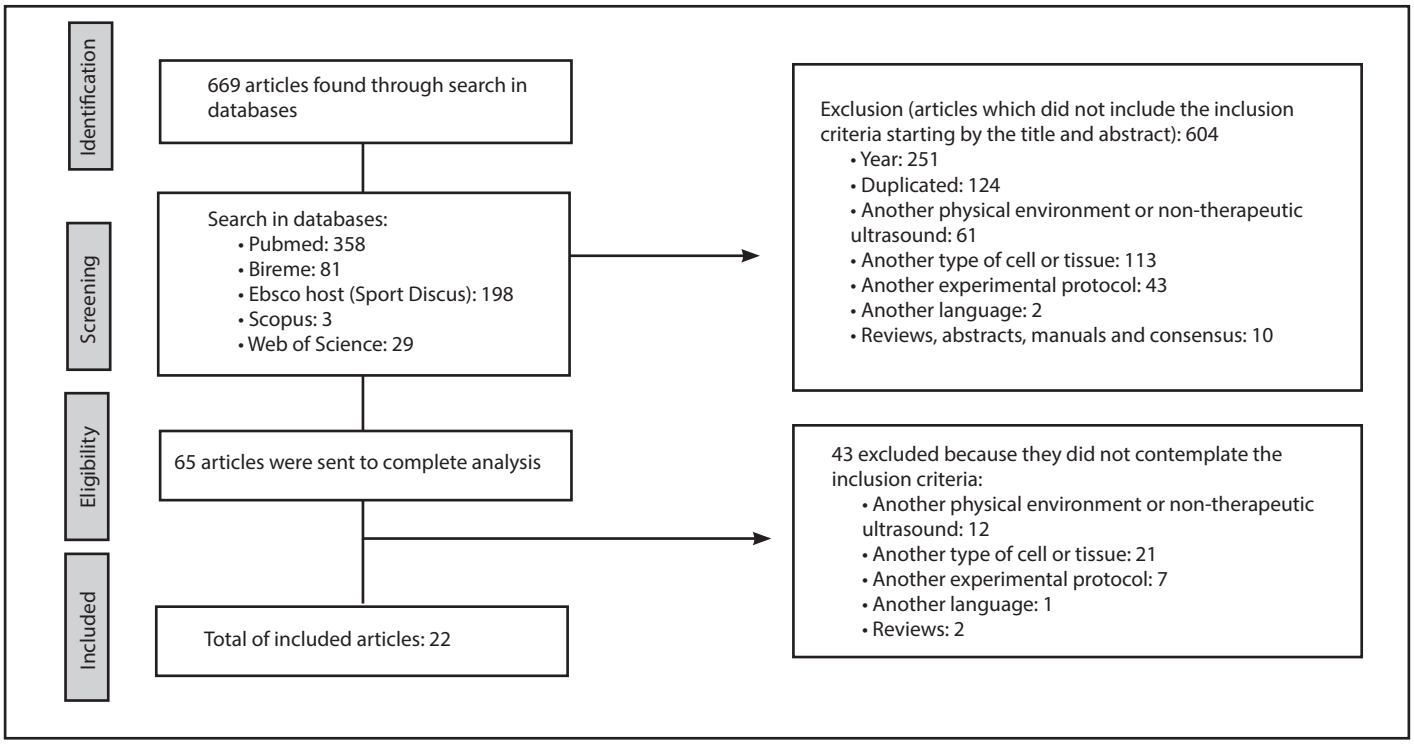
Thereafter, when analyzing the established criteria to determine the validity and reliability of the selected studies, the information were collected, in which were discarded the possibility of a meta-analysis due to the heterogeneity of data of the included studies, classifying this study as a qualitative systematic review.

The extraction and tabulation of the data of the documents obtained at the end of the scan was delimited in predefined fields (cell line, ultrasound parameters used, presence of biological effects after the ultrasonic treatment with statistically significant differences between the groups, or absence of biomechanical effects, or non-significant differences between the study control and the treated groups), and then, for the accuracy of the variables collection, the final database was again compared to the original sources by the evaluators and, lastly, interpreted.

Results

The results were presented in a PRISMA flow diagram[12] (Figure 1), describing the main phases of the systematic review, which are: identification, screening, eligibility and included.

Figure 1. Flow chart of triage of studies. This flowchart is according PRISMA Statement 2009[12].



The searches in the databases resulted in 669 articles and after the application of the criteria inclusion, 647 studies were excluded. Among the reasons of exclusion, there was the use of another physical method, such as laser, nano-particle emitters, scaller, softwares or use of non-therapeutic ultrasound for diagnosis. A total of 65 studies passed in the first three phases of filtering, and after reading the full texts, another 43 works were eliminated.

Regarding the exclusive presence of another cell line (such as chondrocytes, macrophages, mesenchymal cells, osteoblasts, cardio myocytes, mammary adipocytes, stromal cells, myofibroblasts, liposomes, odontoblasts, osteocytes, macrophages, phagocytes, fibronectin, osteoclasts), of tissue (vascular, tumor, muscle, cartilage, bacteria, tooth, venous ulcer, gum, vertebral disc, dentine, collagen, skin) and of experimental models (*in vivo*, with titanium association, biomaterials, nanoparticles, tissue engineering, measurement of attenuation, of temperature variation and wave propagation), in both stages of sorting, 156 and 28 works were excluded, respectively.

Furthermore, with regard to revisions, manuals, event summaries and consensus, 10 manuscripts were retained and finally, it has been also withdrawn three articles that appeared in another language (Chinese).

It is worth mentioning that the inclusion of the studies was conditioned by the absence incomplete outcomes due to missing data, any other loss involving the laboratory routine of the cell culture with its relevant weights or other easily detectable possible bias problems, to rule out the possibility of low methodological rigor and thus achieve more credible results.

Regarding the critical evaluation of the studies, since the methodology in question does not meet the criteria of available classifications (experimental studies in animals or clinical trials) it was not possible to calculate the final bias, since these are cell studies *in vitro*. In this sense, as the available information was not sufficient to classify the methodological aspect as having a high or low risk of bias, the domain receives the uncertain risk classification.

Then, after a wide search, a total of 22 articles were selected for this review, summarized and displayed in a chart (Table 2) to qualitative analysis. The selected studies observed the ultrasound action on rats and mice[15-18,19,21-27,29-31,33], hamsters[28], rabbits[32] and humans[13,14,19,20,28].

In relation to TUS parameters, it was observed the most diverse dosimetries, in such a way that the doses varied from 0.002 to 2 W/cm^2, and in frequencies of transducer there was the prevalence of 0.02 MHz (20 kHz)[29] over the 3 MHz[30,31], and another study did not mention this last parameter[32].

Concerning the emissions, the pulsed stood out, which appeared in 18 out of 22 analyzed papers, having the other ones approached together the continuous and pulsed emissions, or not reporting the type of emission used[14,18,26,31,32]. Regarding the treatment time, it was analyzed short-term duration applications from 10 seconds to 60 minutes.

The Table 2 also shows that the biological effects promoted were bigger DNA[13] and protein[5] synthesis, a significant increase of cell proliferation[18,22,27,29,32,33] and incidence of micronucleus[30], reorganization of actin cytoskeleton[13], endocytic cell activity[20], improvement in the efficiency of membrane permeability[27,31], increasing in gene transfer rate[15], of potential of osteogenic differentiation[19] and of the reticulum activity[5], as well as the amplification of vacuoles in cytoplasm[14], of Ca^{+2} available[21], of collagen contents and glycosaminoglycan[25], of the transfection of microbubbles rate[26], the size of the molecules of entry[31], and finally the induction of focal adhesion[24] and efficiency in absorption[31].

Table 2. Relation of scientific articles found with their respective cell lines, ultrasonic parameters and biological effects.

Study	Cell Line	Ultrasound Parameters	Biological effects
Zhou *et al*., 2004[13]	Human foreskin fibroblasts	F: 1.5 MHz; I: 30 mW/cm^2; DC: 20%; TE: 6 or 11 min	+/-
Lai and Pittelkow, 2007[14]	Fibroblasts neonatal foreskin	F: 40 kHz (mist) 1.0 cm from the cell culture; I: 0.002 W/cm^2; TE: 7, 15 and 30s	+/-
Chen *et al.*, 2007[15]	3T3-MDEI (Embryonic mouse fibroblast), C2C12 e CHO	F: 1 MHz; DC: 20%; I: from 0.5 to 2 W/cm^2; TE: 5 to 80 s.	+/-
Oliveira *et al.*, 2008[16]	Mouse fibroblast (L929)	F: 1 MHz; I: 0.2 e 0.6 W/cm^2; DC: 10 and 20%; TE: 2 min;	+
Oliveira *et al.*, 2008[17]	Mouse fibroblast (L929)	F: 1 MHz; I: 0.1, 0.2, 0.6, 0.8, 1.0 and 2.0 W/cm^2; DC: 10 and 20%; TE: 2 min	+/-
Tomankova *et al.,* 2009[18]	NIH3T3 (mouse fibroblast cells) and B16FO (mouse melanoma cells)	F: 1 MHz; I: 2 W/cm^2; TE: 10 min; control group; DC: did not report	+/-
Mostafa *et al*., 2009[19]	Human gingival fibroblasts (HGF)	F: 1.5 MHz; I: 30 mW/cm^2; DC: pulsed; TE: 5 or 10 min	+/-
Pires-Oliveira *et al.,* 2009[5]	Mouse fibroblast (L929)	F: 1 MHz; I: 0.2 e 0.6 W/cm^2; DC: 10 and 20%; TE: 2 min;	+
Hauser *et al.*, 2009[2]	Human foreskin fibroblasts	F: 1.5 MHz; I: 30 mW/cm^2; DC: 20%; TE: 6 min	+/-
Tsukamoto *et al*., 2011[21]	Mouse fibroblast (L929)	F: 1 MHz; pressure amplitude 0.4 MPa (peak to peak); DC: 20%; TE: 60s	+/-
Oliveira *et al.*, 2011[22]	Mouse fibroblast (L929)	F: 1 MHz; I: 0.2 e 0.6 W/cm^2; DC: 10 and 20%; TE: 2 min	+/-
Grimaldi *et al.*, 2011[23]	Murine fibroblasts (NIH-3T3)	F: 1 MHz; I: 307 and 46 mW/cm^2; DC: 75%; TE: 5, 15, 30, 45 and 60 min;	+/-
Roper *et al.,* 2012[24]	Mouse embryonic fibroblasts (MEFs)	F: 1.5 MHz; I: 30 mW/cm^2; DC: 20%; TE: 0, 10, 30 and 60 min	+
Bohari *et al*., 2012[25]	3T3 mouse fibroblasts	F: 1 MHz; I: 0.2 W/cm^2; DC: 20%; TE: 5 min;	+/-
Zhang *et al.*, 2012[26]	Mouse embryonic fibroblast cells (NIH3T3)	I: 0–11 W/cm^2, pulse repetition frequency (PRF, 50–50.000 Hz), duty ratio (10 to 50%), TE: 0–120s, and microbubble volume concentration (0 to 10%)	+/-
Domenici *et al*., 2013[27]	Murine fibroblasts (NIH-3T3)	F: 1 MHz; I: 11.8, 15.2 and 19.3 mW/cm^2; DC: 75%; TE: 5, 15, 30, 45 and 60 min;	+
Duvshani-Eshet *et al*., 2013[28]	Human foreskins fibroblasts and baby hamster kidney	F: 1 MHZ; I: 2 W/cm^2; DC: 30%; TE: 30 min;	+/-
Samuels *et al.*, 2013[29]	3T3 mouse fibroblasts	F: 20 kHz; I: 50 and 200 mW/cm^2; DC: 10% and 20%; TE: 15 min	+/-
Udroiu *et al.*, 2014[30]	Murine fibroblasts (NIH-3T3)	F: 1 and 3 MHz; I: 7.1, 11.8, 15.2 and 19.3 mW/cm^2 (for the 1 MHz exposure); 1.0, 4.9 and 7.0 mW/cm^2 (for the 3 MHz exposure); DC: 75%; TE: 5, 15, 30, 45 and 60 min;	+/-
Domenici *et al.,* 2014[31]	Murine fibroblasts (NIH-3T3)	F: 1 and 3 MHz; TE: 5, 15, 30, 45 and 60 min; DC: 75% for 1 MHz and 100% for 3 MHz; I: 0.11, 0.12 and 0.09 W/cm^2 (for 1 MHz); 0.01, 0.04 and 0.06 W/cm^2 (for 3 MHz)	+/-
Li *et al.*, 2015[32]	Fibroblasts of rabbit ears scar	F: did not report; I: 0.5 W/cm^2 TE: 10, 30, 60, 90s;	+/-
Oliveira *et al.*, 2015[33]	Mouse fibroblast (L929)	F: 1 MHz; I: 0.3 e 0.5 W/cm^2; TE: 2 min; DC: 10 and 20%	+/-

Exposure time (TE), Minutes (min), Seconds (s), Duty Cycle (DC), Intensity (I), Frequency (F), (+) present or statistically significant, (-) absent or not statistically significant.

On the other hand, in these papers, the inhibitory effects or the effects which did not have significant statically results comprehended the non-significant increase of cellular viability[29,33] or a significant decrease on the number of cells[15,17,25,26,30-32], absence of significant alterations on the Collagen-I expression[19], on the observed morphology[14] or on the actin fibers[28], and even, the rupture of cell membrane[21]. Specifically, on high intensities, there was fast collapse of cell membranes[26], besides the loss of adhesion, plasmatic membrane retractions and verification of cellular fragmentation[17].

Due to the heterogeneity of the obtained database, with different cell types, treatment doses and several methods of analysis, it was not possible to carry out the statistical analysis for a meta-analysis.

Discussion

The main results of this systematic review show that still exists a gap in standardization of dosimetries of ultrasonic therapy and its respective correlations with biological effects on fibroblast cells *in vitro*,

due to the scarce available literature found with scientific evidences referring to the subject.

Such divergences about the biological responses appear on the studies frequently, due to the lack of agreement in relation to the intensities, time of application and type of pulse[5,13-33]. As can be seen on Zhou *et al*.[13] experiments, made on human fibroblasts, in which the low intensities of TUS, spite of inducing the DNA synthesis, did not activate EGFR (epidermal growth factor receptor), with periods of 6 or 11 minutes and 30 mW/cm^2 intensity or in the study of Hauser *et al.*[20], which triggered a peak in metabolism by means of endocytotic vesicles.

In contrast, Lai and Pittelkow[14] with similar line cell and dose of 0.002 W/cm^2, reported the absence of difference in morphology and mitosis activities between the treated cells and controls, except on the activation of keratinocyte growth factor (KGF), of c-Jun N-terminal Kinase (JNK) and of extracellular regulated Kinase (ERK), however, with expositions of 7, 15 and 30 seconds. Yet, with higher intensities (2 W/cm^2) and longer irradiation time (30 minutes), other authors did not observe relevant impacts on actin fibers in human fibroblasts[28].

On the other hand, in fibroblast culture of rabbit ears, the control group, only with ultrasound (I: 0.5 W/cm^2; TE: 10s), presented a high survival rate, but, in 30, 60 or 90 seconds there was a decrease of survival levels, pointing a "dose-effect" relation between the treatment durability stablished and apoptosis[32].

At the same time, several authors studied the TUS influence using fibroblasts from rats, and, not differently from others, presented many results[15,18,23-31,33]. Like Grimaldi *et al.*[23], who showed a sensibility of these treated cells (1MHz; 307 and 46 mW/cm^2; 75%; 5, 15, 30, and 60 minutes) and the lack of association with nuclear division rate in these experimental conditions.

As well as Domenici *et al*.[27], differing the last one only in intensity (11.8, 15.2 and 19.3 mW/cm^2), concluded that the lipid membrane alterations, with consequent high efficiency on molecular absorption by cellular permeability, are related to the sub cavitation manners applied. Still, in tests with 3 MHz frequency, other researchers pointed that the fibroblasts did not present improvements on absorption efficiency (0.01, 0.04 and 0.06 W/cm^2)[31] or positive cellular viability, with analog time to the former ones (1.0, 4.9 and 7.0 mW/cm^2)[30].

Considering these facts, it is important to highlight the remarkable presence of the bioeffects with the use of equipment with a frequency of 1 MHz[18,21,22,25,28,33] or even with 20 kHz and, even when compared to 3 MHz[29], some authors verified more expressive results with 1 MHz and, they argue, that it is due to the fact that the energy that reaches the cell monolayer is smaller with 3 MHz, as well as they indicate that the loss of energy imposed by the attenuation, absorption, reflection and refraction[30,31], since these transferred behaviors to the tissues are intrinsic to both kind of TUS, mechanic and thermic[25].

When the applied doses were higher (2 W/cm^2), having as examples researches done by Tomankova *et al*. [18], specifically the negative control group of NIH-3T3 demonstrated a bigger percent of viable cells than its control, confronting data from Chen *et al*.[15], in which this number decreased drastically.

In the meantime, on mice fibroblasts studies, the main results showed low and medium intensities (F:1 MHz; I: 0.2, 0.3, 0.5 and 0.6 W/cm^2; DC: 10 and 20%, TE: 2 min), with reflection on the cell proliferation extension[16,17,33], of the endoplasmic reticulum performance and protein synthesis, being these dosimetries considered beneficial for this biological tissue activity[5,16,17,33], but with no exact definition of which is the most indicated dose[5, 16,17,33]. However, with 0.08, 1.0 and 2.0 W/cm^2, there was a cell growth limitation, appearance of morphologic deformation (membrane retraction) or even, the complete loss of adhesion and cell destruction[17].

Lastly, the findings of this study express that the biophysical properties of ultrasound may unleash biological effects on different biological tissues in different ways. But, due to the heterogeneity of results, there is the necessity of a broader investigation so that these mechanisms can be clearly elucidated.

Conclusion

The analysis of the selected articles for this systematic review shows that the scientific basis is not enough to stablish the real effects and dosimetric parameters of therapeutic ultrasonic irradiation on the process of restoration of fibroblast cells *in vitro*, due to the lack of generalization and conflict of found results. Hence, new studies should be done aiming at the protocol standardization and its interaction with the biological tissue concerned.

Limitations

The authors assume the risk of language bias due to the exclusion of articles published in Chinese.

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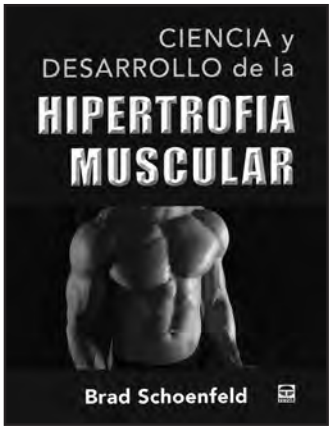
Con este libro se aprende practicando. Las secuencias de instrucciones y las fotografías detalladas guiarán al lector para aplicar las técnicas y tácticas del juego: tiro interior y tiro exterior, pases, dribbling, defensa, rebotes, etc. Además de los elementos básicos, este manual ofrece el material didáctico para aumentar el repertorio de destrezas y usar esas tácticas para mejorar los resultados en los partidos.

Incluye más de 100 de los mejores ejercicios para perfeccionar el juego y mejorar el rendimiento. Contiene todo lo necesario para aumentar el conocimiento del juego, de las estrategias ofensivas y defensivas, y de las jugadas de eficacia probada. Esta obra es la mejor forma de aprender los aspectos básicos en menos tiempo. Una guía única que enseña las destrezas y a amar el juego.



CIENCIA Y DESARROLLO DE LA HIPERTROFIA MUSCULAR

Por: Brad Schoenfeld
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 2017, 224 páginas, P.V.P: 39,95 euros

Esta obra es una recopilación exhaustiva de principios, basados en la ciencia, para ayudar a los profesionales en el desarrollo de la hipertrofia muscular de sus atletas y clientes. Con más de 825 referencias y directrices prácticas a lo largo de su texto, no existe otro libro que ofrezca una cantidad comparable de contenido sobre este tema. Los lectores encontrarán en él una información actualizada con la que podrán comprender la ciencia de la hipertrofia muscular y sus aplicaciones para diseñar programas de entrenamiento.

Escrito por Brad Schoenfeld, autoridad eminente en hipertrofia muscular, este texto proporciona a los profesionales de la fuerza y del acondicionamiento, a los entrenadores personales, a los científicos del deporte, a los investigadores y a los instructores de la ciencia del ejercicio la fuente definitiva de información relativa a la hipertrofia muscular: los mecanismos de su desarrollo, cómo cambia estructural y hormonalmente el organismo cuando se le expone al estrés, las vías más efectivas para diseñar programas en entrenamiento y las normas habituales de alimentación para provocar los cambios hipertróficos.

FLUIR (FLOW) EN LOS CORREDORES

Por: Mihaly Csikszentmihalyi, Philip Latter, Christine Weinkauff Duranso
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 2017, 208 páginas, P.V.P: 19,95 euros

Si se le pregunta a cualquier corredor comprometido, este dirá que para el éxito en el deporte es fundamental tener una buena salud emocional y mental. La capacidad de suscitar un estado mental de flujo es algo a lo que el doctor Mihaly Csikszentmihalyi ha dedicado toda su vida académica. Esta obra de referencia es el primer libro dedicado a que los corredores alcancen el estado de flujo en los entrenamientos y las competiciones.

El lector hallará un estudio exhaustivo del fenómeno, ejercicios prácticos que no encontrará en ningún otro libro y que ayudarán a favorecer dicho estado, y relatos de primera mano de corredores de élite sobre sus experiencias con el estado de flujo. Las barreras psicológicas asociadas con el entrenamiento y la competición pueden ser tan exigentes como las físicas. Este libro está destinado a ser un clásico en la bibliografía del *running* y a abrir la mente del lector, no solo para que mejore su rendimiento y sus actuaciones, sino también para que disfrute de mejores experiencias, más sanas y agradables.

2018		
The Nutrition in Athlete Development Summit 2018	1-2 Marzo Madrid	web: http://vonlanthengroup.com/en/events/nutrition-in-athlete-development-summit.htm
2nd Annual International Musculoskeletal Medicine Congress	2 Marzo Dubai (Emiratos Árabes Unidos)	web: http://www.cvent.com/events/dubai-international-musculoskeletal-medicine-congress
I Congreso internacional sobre prescripción y programación de deporte y de ejercicio en la enfermedad crónica	8-9 Marzo Murcia	web: https://eventos.ucam.edu/event_detail/14741/programme/i-congreso-internacional-sobre-prescripcion-y-programacion-de-deporte-y-de-ejercicio-en-la-enfermed.html. / http://www.femede.es/page.php?/interno/OtrasActividades
36 Congress International Society for Snowsports Medicine	13-15 Marzo Arosa (Suiza)	web: http://www.sitemsh.org/
II Jornadas Nacionales SETRADE	15-16 Marzo Vitoria	http://www.setrade.org/congresos/jornadasvitoria2018/
Conference on Mental Health in Sport	21 Marzo Milton Keynes (Reino Unido)	web: http://www.open.ac.uk/blogs/OU-Sport/?p=1641
15th International Scientific Conference and 14th annual Congress of the Montenegrin Sports Academy	12-15 Abril Bubva (Montenegro)	web: http://csakademija.me/conference/
World Congress on Osteoporosis, Osteoarthritis and Musculoskeletal Diseases	19-22 Abril Cracovia (Polonia)	web: www.wco-iof-esceo.org/
14º Congreso Internacional de Ciencias del Deporte y la Salud	3-5 Mayo Pontevedra	web: www.sportis.es/congresos
18th ESSKA Congress	9-12 Mayo Glasgow (Reino Unido)	web: http://esska-congress.org/
III Congreso Internacional y IV Nacional de Hidratación	13 Mayo Bilbao	web: http://hydration2018.cieah.ulpgc.es/programa.asp
56 Congreso SERMEF	16-19 Mayo Gijón-Asturias	web: www.sermef.es
7thWorld Conference on Women and Sport	17-20 Mayo Gaborone (Bostwana)	web: www.icsspe.org/sites/default/files/e8_7TH%20IWG%20Conference%20docx.pdf
ICAS 2018: 20th Int. Conference on Adoleslescent Sports	24-25 Mayo Montreal (Canadá)	web: https://www.waset.org/conference/2018/05/montreal/ICAS
XXII Curso Asoc. Española Med. del Futbol	25-26 Mayo Málaga	web: http://www.aemef.org/es/
19th EFORT Congress	30 Mayo-1 Junio Barcelona	web: https://www.efort.org/barcelona2018/
XXVII Isokinetic Medical Group conference:"Football medicine outcomes. Are we winning?"	2-4 Junio Barcelona	E-mail: conference@isokinetik.com web: www.footballmedicinestrategies.com

5th International Congress of Exercise and Sport Sciences	5-10 Junio Netanya (Israel)	web: https://events.eventact.com/EventsList/5sportsceince2017/General-Information
20th Int. Conference on Women nd Sport	6-7 Junio San Francisco (EEUU)	web: www.waset.org/conference/2018/06/san-francisco/ICWS
Curso nacional de rehabilitación en deformidades del raquis	14-15 Junio Barcelona	web: www.aulavhebron.net/aula/index.php?go=info_cursos&curso=110&idioma=es
XXIX Jornadas AEMB	28-30 Junio Barcelona	web: https://aemeb.es/barcelona2018/
European Congress of Adapted Physical Activity (EUCAPA)	3-5 Julio Worcester (Reino Unido)	Andrea Faull. E-mail: a.faull@worc.ac.uk Ken Black. E-mail: k.black@worc.ac.uk
23rd Annual Congress of the European College of Sport Science	4-7 Julio Dublín (Irlanda)	web: www.ecss-congress.eu/2018/
World Congress of Biomechanics	8-12 Julio Dublín (Irlanda)	web: http://wcb2018.com/
12th World Congress of the International Society of Physical and Rehabilitation Medicine (ISPRM)	8-12 Julio París (Francia)	web: http://isprm2018.com/
The Annual World Congress of Orthopaedics	25-27 Julio Milán (Italia)	web: http://www.bitcongress.com/wcort2018 / http://www.bitcongress.com/wcort2018/programlayout.asp
World Congress of the Association Internationale des Ecoles Supérieures d'Education Physique (AIESEP)	25-28 Julio Edimburgo (Reino Unido)	web: http://aiesep.org/
XXXV Congreso Mundial de Medicina del Deporte	12-15 Septiembre Rio de Janeiro (Brasil)	web: www.fims.org
28º Congress European Society for surgery of the shoulder and the elbow (SECEC-ESSSE)	19-22 Septiembre Ginebra (Suiza)	web: www.secec.org
55 Congreso SECOT	26-28 Septiembre Valladolid	web: www.secot.es
5th International Scientific Tendinopathy Symposium (ISTS)	27-29 Septiembre Groningen (Países Bajos)	web: http://ists2018.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	6-8 Octubre Madrid	web: http://www.congresoand.com/2018/
VII Congreso Asociación Hispanoamericana de Médicos del Fútbol	6-8 Octubre Lima (Perú)	web: http://hispamef.com/
7º Congreso Mundial del Deporte Escolar, Educación Física y Psicomotricidad	8-10 Noviembre A Coruña	web: www.sportis.es/congresos

XVIII Congreso latinoamericano de Nutrición (SLAN) 2018	11-15 Noviembre Guadalajara (México)	web: www.slaninternacional.org
XVII Congreso Nacional de la SEMED-FEMEDE	29 Noviembre-1 Diciembre Toledo	web: www.femede.es
2019		
2019 AMSSM Annual Meeting	12-17 Abril Houston (EEUU)	web: https://www.amssm.org/
12th Biennial ISAKOS	12-16 Mayo Cancún (México)	web: www.isakos.com
24th Annual Congress of the European College of Sport Science	3-6 Julio Praga (Rep. Checa)	E-mail: office@sport-science.org
13th Congreso Mundial de la International Society of Physical and Rehabilitation Medicine	9-13 Julio Kobe (Japón)	web: http://www.isprm.org
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/
XV Congreso Nacional de Psicología de la Act. Física y del Deporte	Zaragoza	web: www.psicologiadeporte.org
2020		
25th Annual Congress of the European College of Sport Science	1-4 Julio Sevilla	E-mail: office@sport-science.org
XXXVI Congreso Mundial de Medicina del Deporte	24-27 Septiembre Atenas (Grecia)	web: www.globalevents.gr
2021		
26th Annual Congress of the European College of Sport Science	7-10 Julio Glasgow (Reino Unido)	E-mail: office@sport-science.org
22nd International Congress of Nutrition (ICN)	14-19 Septiembre Tokyo (Japón)	web: http://icn2021.org/

Cursos *on-line* SEMED-FEMEDE

Curso "ENTRENAMIENTO, RENDIMIENTO, PREVENCIÓN Y PATOLOGÍA DEL CICLISMO"

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

Curso "ELECTROCARDIOGRAFÍA PARA MEDICINA DEL DEPORTE"

ACREDITADO POR LA COMISIÓN DE FORMACIÓN CONTINUADA (ON-LINE 15/10/2015 A 15/10/2016) CON 4,81 CRÉDITOS

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

Curso "FISIOLOGÍA Y VALORACIÓN FUNCIONAL EN EL CICLISMO"

Curso dirigido a los titulados de las diferentes profesiones sanitarias y a los titulados en ciencias de la actividad física y el deporte, destinado al conocimiento profundo de los aspectos fisiológicos y de valoración funcional del ciclismo.

Curso "AYUDAS ERGOGÉNICAS"

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

Curso "CARDIOLOGÍA DEL DEPORTE"

ACREDITADO POR LA COMISIÓN DE FORMACIÓN CONTINUADA (VÁLIDA DEL 15/10/2016 AL 15/10/2017) CON 8,78 CRÉDITOS

Fecha límite de inscripción: 15/06/2017

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

Curso "ALIMENTACIÓN, NUTRICIÓN E HIDRATACIÓN EN EL DEPORTE"

Curso dirigido a médicos destinado a facilitar al médico relacionado con la actividad física y el deporte la formación precisa para conocer los elementos necesarios para la obtención de los elementos energéticos necesarios para el esfuerzo físico y para prescribir una adecuada alimentación del deportista.

Curso "ALIMENTACIÓN Y NUTRICIÓN EN EL DEPORTE"

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

Curso "ALIMENTACIÓN Y NUTRICIÓN EN EL DEPORTE" Para Diplomados y Graduados en Enfermería

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

Curso dirigido a facilitar a los Diplomados y Graduados en Enfermería la formación precisa para conocer los elementos necesarios para la obtención de los elementos energéticos necesarios para el esfuerzo físico y para conocer la adecuada alimentación del deportista.

Curso "CINEANTROPOMETRÍA PARA SANITARIOS"

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

Curso "CINEANTROPOMETRÍA"

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

Más información:
www.femede.es

Guidelines of publication Archives of Sports Medicine

The ARCHIVES OF SPORTS MEDICINE Journal (Arch Med Deporte) with ISSN 0212-8799 it is the official publication of the Spanish Federation of Sports Medicine. It publishes original works on all of the aspects related to Medicine and Sports Sciences from 1984. It has been working uninterruptedly with a frequency of three months until 1995 and two months after then. It's a Journal that uses fundamentally the system of external review by two experts (peerreview). It includes regularly articles about clinical or basic investigation, reviews, articles or publishing commentaries, brief communications and letters to the publisher. The works may be published in SPANISH or in ENGLISH. The submission of papers in English will be particularly valued.

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

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   A letter in which the first author on behalf of all signatories to the study, the assignment of the rights of total or partial reproduction of the article, if accepted for publication shall be attached.

   Furthermore, attachment, the consignor will propose up to four reviewers to the editor may be used if necessary. In the proposed, one at least shall be responsible for the different nationality work. Reviewers signatory institutions work will not be accepted.
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   a. Original report: maximum 5.000 words, 6 figures and 6 tables.
   b. Reviews articles: maximum 5.000 words, 5 figures and 4 tables. In case of needing a wider extension it is recommended contact the journal Editor.
   c. Editorials: they will be written by order of the Editorial Board.
   d. Letters to the Editor: maximum 1.000 words.
5. Structure of the text: it will change according to the section to which it is destined:
   a. **ORIGINALS REPORTS**: It will contain an introduction, which will be brief and will contain the intention of the work, written in such a way that the reader can understand the following text.

      Material and method: the material used in the work, human or of experimentation, will be exposed, as well as its characteristics, criteria of selection and used techniques, facilitating the necessary data, bibliographical or direct, in order to allow the reader to repeat the experience shown. The statistical methods will be described in detail.

      Results: They report, not interpret, the observations made with the material and method used. This information can be published in detail in the text or by tables and figures. Information given in the tables or figures must not be repeated in the text.

      Discussion: The authors will expose their opinions about the results, their possible interpretation, relating the observations to the results obtained by other authors in similar publications, suggestions for future works on the topic, etc. Connect the conclusions with the aims of the study, avoiding free affirmations and conclusions not supported by the information of the work. The acknowledgments will appear at the end of the text.

b. **REVIEWS ARTICLES:** The text will be divided in as much paragraphs as the author considers necessary for a perfect comprehension of the treated topic.
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There will not be included in the bibliographical appointments personal communications, manuscripts or any not published information.
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   - **World Wide Web**, online journal. Example: Morse SS. Factors in the emergence of infectious diseases. Emerg Infect Dis (revista electrónica) 1995 JanMar (consultado 0501/2004). Available in: http://www.cdc.gov/ncidod/EID/ eid.htm
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La **Sociedad Española de Medicina del Deporte**, en su incesante labor de expansión y consolidación de la Medicina del Deporte y, consciente de su vocación médica de preservar la salud de todas las personas, viene realizando diversas actuaciones en este ámbito desde los últimos años.

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

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