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Summary / Sumario

Exercise is a scientifically-proven and valuable therapeutic and preventive tool, that everyone should take part in

El ejercicio físico, un recurso preventivo y terapéutico muy valioso y científicamente probado que deberíamos aprovechar mejor

Manuel Avelino Giráldez García

Médico especialista en Medicina de la Educación Física y el Deporte. Profesor titular del Departamento de Educación Física y Deportiva. Investigador del Performance and Health Group. Universidad de La Coruña.

Ever since Jeremiah Morris published his first studies on the association between the lack of physical activity and cardiovascular mortality in the mid-twentieth century, there has been increasing scientific evidence to support this. Today, physical inactivity and a sedentary lifestyle are considered to be an independent risk factor for the appearance of many chronic non-communicable diseases (CNCDs), and efforts are therefore being directed at promoting more active life styles. However, in addition to the fact that an active life style is beneficial to people's health, science has also demonstrated that physical exercise is a prime preventive and therapeutic resource for managing a growing number of diseases.

If there were an active ingredient for the treatment of CNCDs that offered so many benefits and so few side effects as physical exercise, then it would be possible to ease much of the heavy burden of disease supported by western societies and that continuously exceeds the capacity and resources of the healthcare systems. The truth is that such a drug does not exist, however physical exercise does, and it is something that is available, accessible and cheap. Despite this, physical exercise is rarely prescribed, resulting in an incomprehensible underutilization. We do not have the space here to analyse the multiple causes of such irrational behaviour, however we will endeavour to put forward some ideas that could be useful to change it. For example, we could...

Base the approach to CNCD management on healthy lifestyle habits and not so much on the primary use of medicines. In normal clinical practice, there is generally much emphasis on the prescription of medicines and on weight control, rather than advising patients to be physically more active and to exercise regularly. Leaving advice on the consumption of tobacco and alcohol aside, patients frequently leave the doctor's surgery with two very clear ideas: they must take the medication prescribed and they need to lose weight. For both parties alike, it is far simpler for the doctor to prescribe, and for the patient to take medication than to try and change lifestyles and habits. This course of action has a number of negative points. Firstly, it cannot be considered to be an etiological treatment, it does not "fight" the cause of the diseases but only its consequences. Secondly, there is the known lack of adherence to treatment, a fundamental reason for insisting on the use and improvement of the single-dose "polypill". The third, and far from insignificant point, is that the use of medication creates the false impression that the disease is now well under control, contributing to a greater "lack of concern" or "disregard" for the adoption of healthier habits which, in contrast, would constitute an etiological approach with important repercussions on primary, secondary and tertiary prevention. In the light of the evidence available, it would also be wrong to prioritise weight control over regular exercise. Today, we know that an overweight or moderately obese person in good physical condition faces fewer risks and maintains better functional capacity and quality of life than a slim person in poor physical condition. Likewise, many more beneficial effects are achieved by increasing the weekly energy expenditure and improving the physical condition rather than reducing excess weight with calorie restrictions.

Consider rest as one of the last resources for the treatment of diseases. There is a widely held misconception that rest is necessary in order to cure disease. The reality is that, although this may be true in some specific cases and at acute moments in time, rest is normally not necessary and, moreover, it is counterproductive. In 1965, Browse already affirmed that "The dangers of bed rest are so many, and in some cases so final,

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that we should always be striving to discard it from our therapeutic armamentarium..." and he emphasised " the absurdity of using a non-specific treatment for specific diseases without reason or proven value ". In fact, with regard to the more prevalent CNCDs, the lack of physical activity and a sedentary lifestyle play a decisive etiopathogenic role and, therefore, to recommend rest in these cases simply makes the problem worse.

Value exercise as a true preventive and therapeutic agent and not simply a leisure activity or one that is for athletes only. Exercise is generally considered to be a free-time activity, for pure enjoyment and leisure, and a lack of exercise is not seen as a risk. In some cases, exercise is also understood to be something for "athletes" and outside the possibilities of patients. This all results in exercise being perceived as something that is somewhat "superfluous" and it is not given its true value with regard to healthcare or recovery, relegating it to a lower priority. This way of understanding exercise, either consciously or unconsciously, is implicit in daily behaviour. Many people are unable to exercise regularly because there are always "other more important or urgent things" requiring attention, without realizing that "if health comes first" then exercise must be one of their top priorities. Something similar happens to many healthcare professionals who, probably unintentionally, act with this same preconception when prescribing treatments. It is customary to carefully inform a patient of the medicines that must be taken, with advice and help on giving up risky behaviour (smoking, alcohol, etc.) however here there is generally no mention of physical inactivity or a sedentary lifestyle. The patient is also advised to adopt specific dietary measures (eat at least 5 portions of fruit and vegetable a day, avoid saturated fats, drink two or more litres of water a day, etc.) and at the end, hopefully, it is casually mentioned that a little exercise would not be a bad thing. If healthcare professionals were really aware of the therapeutic value of exercise, then it would be prescribed as one of the principal medicines or even the most important one, because no other medicine will achieve so much improvement with so few side effects. Today, we know that exercise is the most successful, efficient and effective polypill for the prevention and treatment of CNCDs, and is something that is available to everyone. If, in addition, it is possible to associate exercise with leisure and make it enjoyable, then this is the icing on the cake: we will have a therapeutic option that is pioneering, fun, socialising and a source of physical and psychological wellbeing, increasing life expectancy and improving our functional capacity.

Consider exercise and its therapeutic use as a basic necessity. Aware of the preventive and therapeutic benefits of exercise, the tax treatment given by the Spanish State and by society in general to the price of sports and physical activity services is striking. At present, admission to a sports event is subject to a reduced VAT rate, while entrance to sports facilities to do some type of physical activity is subject to the general rate of 21%, the same as tobacco and alcohol. It would be desirable and extremely reasonable to reverse this situation and to consider the practice of sports and physical activity as a basic necessity, applying a super reduced VAT rate, comparable to that of other medicines. The possibility of tax allowances on the expenditure made by citizens on sports services and activities could also be considered. After all, this is an investment in health that would entail a considerable saving in healthcare, with very positive repercussions at a personal level and for society in general.

Understand that fatigue and disability should not be a barrier to physical exercise, but the fundamental reason for exercising. The physical impairment causing disability and the loss of quality of life related to CNCDs, is not directly attributable to the disease, but to disuse, too much rest, to the fact that the physical activity performed by individuals is insufficient to maintain a healthy physical condition. Insufficient aerobic capacity, decreased strength, loss of flexibility and joint mobility and change of body composition (higher percentage of fat and less muscle) cause people to increase their risk of falling ill and to feel weaker and more fatigued, with a greater feeling of "incapacity", making them even less active and increasing the deterioration of their physical condition. This closes a vicious circle that is not intrinsic to the disease, but to inactivity and a sedentary lifestyle. The reversal of this situation requires something more than medicine. However well prescribed the medication, there is still no "miraculous" medicine or active ingredient that improves the physical condition, this can only be achieved through physical activity in general and physical exercise in particular. Sufficient stimuli need to be provided in order to stress the physiological systems responsible for each component of the physical condition and to achieve its improvement or positive change, in other words it is necessary to exercise or to do training. It is impossible for the heart, the blood vessels, the remotest of muscles or any other organ or process to improve their structure or function if they are not suitably stimulated. As well as facilitating a better control of disease, increased physical fitness levels will give patients sufficient energy and vitality to perform normal daily tasks, to enjoy active leisure time, to face unforeseeable emergencies with no undue fatigue, to develop their intellectual capacity to the full and to fully experience the joy of living.

Accept that, to prescribe exercise to a person with one or more diseases is somewhat more complicated than making a generic recommendation with regard to the advisability of leading a physically active life. To advise a person to be physically more active is something as simple as telling that person to move more, either when going from one place to another, during the daily chores or in his/her leisure time. Nothing more is needed and this advice, which is increasingly more frequent during medical consultations, is of great value. However, whenever there is a pathology or specific need for improvement, to simply advise a patient that it would be a good idea to exercise, still remains a "prescription" that is extremely vague and imprecise, that is too generic. It would be equivalent to telling the patient to take medication, without specifying which medicine, or the quantity, frequency and duration. Indeed, we are talking of exercise prescription because the responses and adaptations are dose-dependent and, just like medicine, exercise can be extremely varied, it has its benefits and its risks or side effects and, therefore, its absolute or relative indications and contraindications. This therefore requires a thorough knowledge of the disease, of effort physiology, of how this can be modified by the disease itself or by the use of drugs, and knowledge of training principles and methods. It is necessary to evaluate the initial risks, indicate suitable types, "adjust the dose level" (training parameters, technical implementation, etc.), and monitor progress (appropriate responses and adaptations, appearance of injuries or other undesirable effects, etc.), and "readjust treatment". In short, this is extremely specialist knowledge that is not exhaustively addressed in the general training of healthcare professionals.

Recognise the need for more healthcare professionals trained to prescribe therapeutic exercise. As mentioned above, when prescribing exercise in the case of a pathology, it is advisable to count on specialist professionals who know how to do so by minimising the risks and optimising the benefits. Medicine in Physical Education and Sport is the only medical specialty to combine a knowledge of diseases, effort physiology and the parameters necessary for adapted training, which goes beyond attention to athletes, and whose objectives include the use of physical exercise to promote health and as a therapeutic resource. At the same time as scientific evidence, associations and administrations are calling for the need to prescribe exercise in the healthcare area, the NHS in our country is experiencing a contrary and absurd situation: it has hardly any specialists of this type on its staff and, if this were not enough, there is not even the possibility of continuing to train new specialists to address this matter, given the fact that this speciality has been eliminated from the MIR specialist training system. Reason indicates that the right way forward is to include this speciality in the portfolio of services, and the training of more specialists in order to ensure that patients receive quality healthcare. Will there be a politician capable of noticing this?

Have more spaces and professionals at the healthcare centres or at a different location, to carry out adapted training. While it is so necessary to prescribe exercise and to perform it in a clinical environment, so little consideration has been given to this that very few hospitals and healthcare centres have gyms and professionals to ensure that patients can do real adapted training. Likewise, there is practically a complete disconnection between healthcare centres and sports centres, which do have –or at least ought to have– competent professionals for the planning and supervision of adapted training for low-risk patients that do not require clinical monitoring during exercise. So that neither is it possible to send patients to these centres. Although we can assume that it is important to include and extend the use of physical training in the purely clinical environment, for those patients in an acute phase or with a high risk, it is still more important to ensure that, in all non-healthcare centres that offer leisure-sports services, there are competent professionals to deal with the general public with pathologies and to create protocols for the referral of the patients. This format is known as "referred exercise" in other countries.

In short, these are just some of the many possible considerations and initiatives that, recognising the valuable preventive and therapeutic role of physical exercise, could be useful to include in the healthcare area. The achievement of this is no longer just a desire, but an imperious need that should be implemented without delay, given that any such delay would lead to more disease, less functional capacity and a lower quality of life for a growing number of people. By contrast, the incorporation into the clinical routine of the prescription of physical exercise, provided that this is necessary, means offering many patients the best available medicine to treat their disease, helping them to prevent many other diseases while substantially improving their quality of life and wellbeing. In a healthcare system that is increasingly under strain, there is no excuse for not using, on a mass scale, a "drug that is so cheap" and so attainable, with so many proven benefits and so few side effects: today it is difficult to find a preventive and therapeutic alternative that is more profitable than physical exercise.

Recommended bibliography

- Booth FW, Roberts CK, Laye MJ. Lack of exercise is a major cause of chronic diseases. *Comprehensive Physiology*. 2012;2(2):1143-211. http://doi.org/10.1002/cphy.c110025. Lack
- Browse N. *The physiology and pathology of bed rest.* Springlield, IL: Charles C Thomas Publisher; 1965.
- Department of Health & Human Services - USA. 2018 Physical Activity Guidelines Advisory Committee Scientific Report; 2018.
- Fiuza-Luces C, Garatachea N, Berger NA, Lucia A. Exercise is the real polypill. *Physiology (Bethesda, Md.)* 2013;28(5):330-58. http://doi.org/10.1152/physiol.00019.2013
- Pedersen BK, Saltin B. Exercise as medicine - evidence for prescribing exercise as therapy in 26 different chronic diseases. *Scandinavian Journal of Medicine & Science in Sports.* 2015;25 Suppl 3:1-72. http://doi.org/10.1111/sms.12581
- Sallis R, Franklin B, Joy L, Ross R, Sabgir D, Stone J. Strategies for Promoting Physical Activity in Clinical Practice. 2014. http://doi.org/10.1016/j.pcad.2014.10.003

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Índice

Effect of rooster comb extract, rich in hyaluronic acid, on isokinetic parameters in adults with mild knee pain

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Summary

Background: Knee osteoarthritis manifests itself in a first phase as a mild gonalgia and produces a decrease in muscle strength, which can be objectively assessed with isokinetic testing. In the treatment of knee osteoarthritis, should be considered the hyaluronic acid orally.
Objective: Assess the evolution of isokinetic parameters of muscle strength in the knee joint with mild gonalgia before and after the consumption of RCE, rich in hyaluronic acid, orally.
Methodology: Nutritional intervention trial, double-blind, randomized, controlled with placebo and in parallel with two treatment groups: the active group with a low-fat yogurt with 80 mg of roster comb extract (RCE) and the control group with a low-fat yogurt without RCE. The main variables of the study were the peak torque, total work and mean power of the isokinetic valuation at the speed of 180 º/seg and 240 º/seg by the movements of flexion and extension of the knee joint.
Results: After 12 weeks of consumption of yogurt, men of the active group, compared with those in the control group, obtained statistically significant differences (p <0.05) and clinical improvement (>10%) at the speed of 180º/seg in the movement extension in the PT variable (p=0.048) (19.33%), TT (p=0.020) (37.97%) and PM (p=0.029) (47.25%), and in the flexion movement in the variable PT (p=0.007) (25.41%), TT (p=0.014) (42.98%) and PM (p=0.022) (48.90%).
Conclusions: The intake of a low-fat yogurt with RCE rich in hyaluronic acid improves the muscle strength of the knee in men with mild gonalgia.

Key words:
Knee. Pain. Isokinetic. Hyaluronic acid.

Efecto del extracto de cresta de gallo, rico en ácido hialurónico, sobre los parámetros isocinéticos en personas con gonalgia leve

Resumen

Introducción: La artrosis de rodilla se manifiesta en una primera fase como una gonalgia leve y produce una disminución de la fuerza muscular, que puede ser valorada objetivamente con la prueba isocinética. Dentro de su tratamiento se debe considerar el ácido hialurónico por vía oral.
Objetivo: Valorar la evolución de los parámetros isocinéticos de fuerza muscular en la articulación de la rodilla con gonalgia leve antes y después del consumo de un extracto de cresta de gallo (ECG), rico en ácido hialurónico, por vía oral.
Metodología: Ensayo de intervención nutricional, doble ciego, aleatorizado, controlado con placebo y en paralelo con dos grupos de tratamiento: grupo activo con ingesta de un yogur bajo en grasa con 80 mg de ECG rico en ácido hialurónico y grupo control con ingesta de un yogur bajo en grasa sin ECG. Se valoraron los parámetros isocinéticos de pico torque (PT), trabajo total (TT) y potencia media (PM) a las velocidades de 180º/seg y 240º/seg para los movimientos de flexión y extensión de la rodilla.
Resultados: Después de 12 semanas del consumo del yogur, los hombres del grupo activo, en comparación con los del grupo control, obtuvieron diferencias estadísticamente significativas (p<0,05) y mejora clínica (>10%) a la velocidad de 180º/seg en el movimiento de extensión en la variable PT (p=0,048) (19,33%), TT (p=0,020) (37,97%) y PM (p=0,029) (47,25%), y en el movimiento de flexión en la variable PT (p=0,007) (25,41%), TT (p=0,014) (42,98%) y PM (p=0,022) (48,90%).
Conclusión: La ingesta de un yogur bajo en graso con extracto de cresta de gallo rico en ácido hialurónico mejora la fuerza muscular de la rodilla en hombres con gonalgia leve.

Palabras clave:
Gonalgia leve. Isocinéticos. Ácido hialurónico.

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Introduction

Osteoarthritis (OA) of the knee is a major public health issue[3], as it causes chronic disability in older people[2]. There are no obvious injuries or associated anomalies in the initial phases, and it presents itself as mild gonalgia[3].

The stability of this joint depends largely on the ligaments and the power of the muscles that surround it, mainly the quadriceps and the hamstrings[4]. It is vital to understand the muscle function as objectively as possible, as alterations to the skeletal-muscle system are reflected in stability disorders[5]. Isokinetic devices enable us to assess muscle performance and provide quantitative, objective and documented data regarding muscle capacities[5-7]. With the isokinetic method, a movement is performed at a constant speed covering the entire range of movement (ROM) and with an adjustable resistance throughout the entire ROM of a joint[5,8,9]. The most cited measured parameter in literature – as the most reliable and easy to establish – is the peak torque (PT) [10], though there are others, such as total work (TW) and the average power (AP)[11,12].

PT corresponds to the maximum value of the Moment registered and is expressed in Newtons per metre (N m). TW is the total muscle strength to repeat with a greater work load and is expressed in Joules (J). AP represents the relationship between the work performed and the time needed to complete the duration of the test, and is expressed in Watts (W)[6].

Hyaluronic acid (HA) is a polysaccharide of high molecular weight formed of b-1.4- D-glucuronic acid and b-1.3-N-acetyl-D-glucosamine. It is the largest component of synovial liquid and of cartilage, responsible for their viscoelastic properties. Its unique viscoelasticity has led to its use in diverse biomedical applications, such as viscosupplementation in OA treatment[13]. Joint pain leads to restricted movement, and consequently a reduction of HA concentration, which worsens joint pain as it increases the friction on the surface of the cartilage. In the case of OA, it has been proven that HA concentration reduces drastically[14].

It has recently been shown that HA administered orally is absorbed and distributed to organs and joints[15]. This knowledge opens up the possibility of developing therapies with HA taken orally to treat joint pain. In a preliminary nutritional intervention study, low-fat yoghurts were administered, supplemented with Mobilee TM (natural rooster comb extract (RCE) rich in HA) for people with joint pain. The results showed improvements in muscle strength in the affected joint, as well as less pain[16].

The main aim of this study is to assess the evolution of the isokinetic parameters of muscle strength (PT, TW and AP) of the different muscle groups involved in a knee joint with mild gonalgia, before and after the oral consumption of RCE rich in HA compared to non-consumption. The secondary target is to study the influence of sex, age and body mass index on the isokinetic parameters assessed.

Material and method

Nutritional intervention double-blind randomised study, controlled with a placebo and parallel study comprising a control group and an active group.

The study demographic comprised participants (n=89) suffering from mild gonalgia, with a VAS score over 3 cm and below 5 cm, with a minimum evolution of 6 months. Some inclusion and exclusion criteria were established so the study participants could be selected (Figure 1). All the participant gave their written informed consent before starting the study, in accordance with the Helsinki Declaration (South Africa review from 2000) and the applicable Spanish regulation regarding nutritional intervention studies, biomedical research and personal data protection, and Good Clinical Practices (GCP) from the International Conference on Harmonisation (ICH).

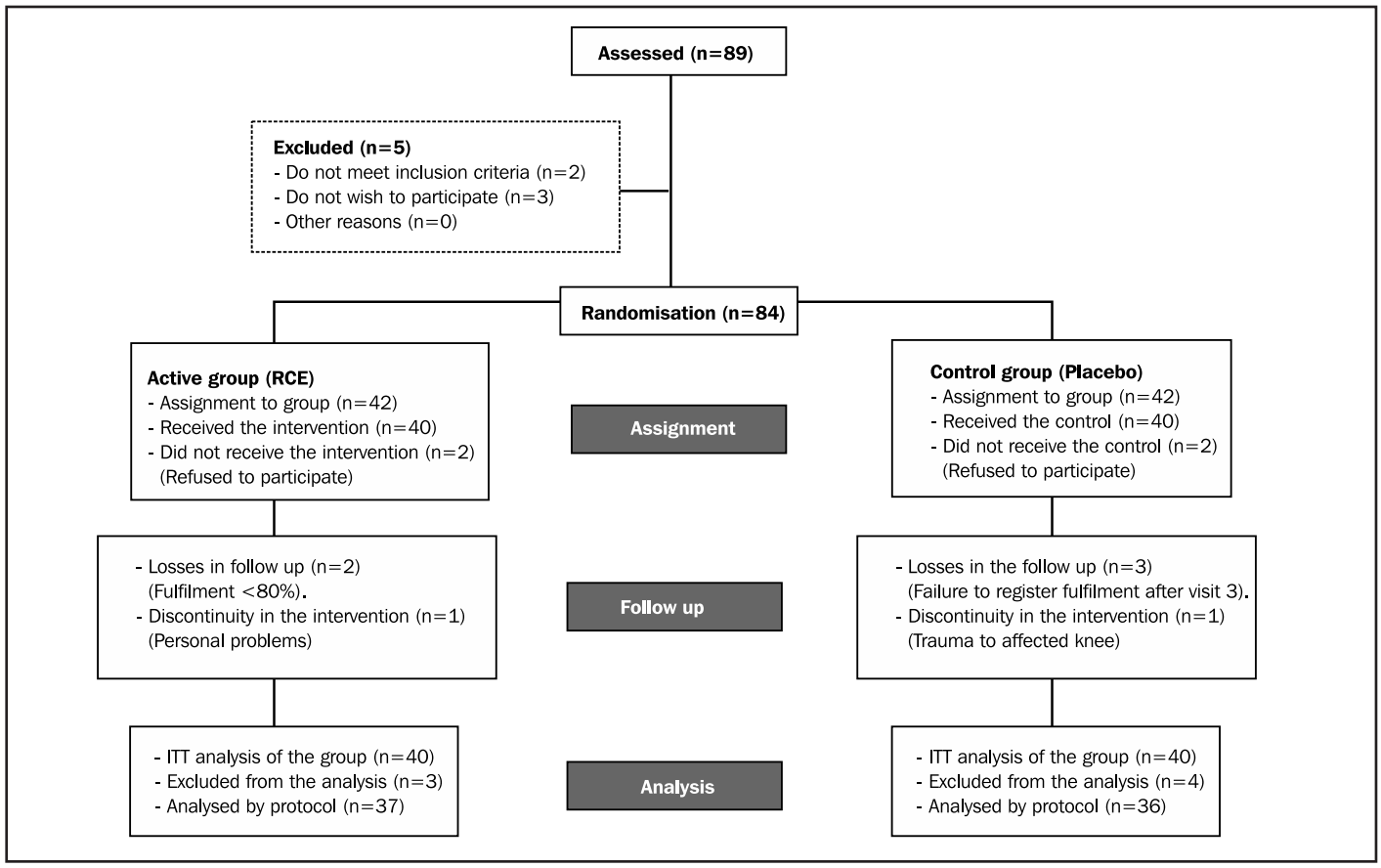
The study was conducted between September 2010 and March 2011 at the Sant Joan University Hospital (Reus, Spain).

The participants were randomly distributed into two treatment groups: one of the groups (RCE group) received a low-fat yoghurt (125 ml/day) with 80 mg of RCE added (Mobilee™; Bioibérica SA, Palafolls, Spain), whilst the other group (placebo group) received the same low-fat yoghurt without the added RCE. The treatment lasted for 12 weeks for both groups.

Figure 1. Study criteria.

Inclusion criteria
1. Adults aged between 20 and 70 years.
2. Subject that suffer from mild gonalgia (VAS value higher than 3 and lower than 5 for a minimum duration of 6 months).
3. Subjects that after understanding the protocol and the study process, provided their written informed consent to participate in the study.
4. Subjects considered to be in good general health according to their clinical history, physical examinations and available laboratory analyses.
Exclusion criteria
1. Subjects that require habitual treatment with paracetamol or other pharmaceutical drugs to control their joint pain.
2. Subjects that suffer from active rheumatoid arthritis and any inflammatory arthritic state that the researchers consider to be exclusionary.
3. Subjects undergoing oral corticosteroid treatment in the 4 weeks leading up to the selection.
4. Subjects undergoing intra-articular corticosteroid treatment in the study joint in the 3 months leading up to the selection.
5. Subjects with significant injury to the study joint in the 12 months leading up to the study (determined according to clinical history).
6. Subjects that are consuming medication or supplements for osteoarthritis at the time of selection.
7. Subjects that depend on medical prescription to control pain.
8. Subjects that are participating in any clinical trials or that have received a study product within the thirty days prior to the selection/inclusion in the study.
9. Subjects with allergies to dairy products.
10. Subjects following a hypocaloric diet for weight loss.
11. Pregnant or breastfeeding subject.
12. Subjects that take nutraceuticals containing HA or other muscle regeneration products.
13. Subjects that present axes alteration and inflammatory problems.

Figure 2. Flow chart.



Each 100 g low-fat yoghurt contained: 25.3% protein, 0.2% fat, 4.45% carbohydrates and 30 kcal of energy. The only difference between the products given to the RCE group and those given to the placebo group, was the RCE supplement (80 mg/ unit). The RCE group's yoghurt contained 65% HA.

A diet log was kept of 3 days before starting the study and at 12 weeks. Furthermore, participants were given a list of foods rich in mucopolysaccarides and/or in HA with instructions to avoid these elements, so as to anticipate any influence on measuring the research substance.

All the participants underwent an isokinetic assessment, which consisted in measuring their dynamic muscle strength with an isokinetic dynamometer (Biodex4Pro).

The muscle isokinetic test was implemented by physiotherapists at the Rehabilitation, Physiotherapy and Speech Therapy Service at the Sant Joan de Reus University Hospital. The first and final isokinetic test could be carried out up to 5 days before visit 2 (V2) of inclusion and visit 8 (V8) of finalisation, respectively. The main variables were those of the isokinetic test (PT, TW and AP), at two angular speeds, 180º and 240º/second, both in flexion (hamstring muscles) and in extension (quadriceps) of the knee. These variables were collected during V2 and V8. A standardised work protocol (SWP) was established, detailing the way that the isokinetic tests should be carried out. The isokinetic test consisted in performing one set of five repetitions at 180º/sec, and one set of five repetitions at 240º/sec, of the extension/flexion movement of the knee. A 2-minute break was given between sets.

As the main efficiency parameter, the evolution of the maximum strength was studied: the PT of the most affected joint in the extension movements at 240º/sec. As secondary efficiency parameters, the PT, TW and AP of both joints in extension and flexion at 180º/sec were studied, as well as the PT, the TW and the AP of both joints in flexion at 240º/sec, and the TW and AP of the two joints in extension at 240º/sec.

Prior to carrying out the study, the inter-evaluator and intra-evaluator reliability of the measurements performed with the isokinetic test were assessed. The results of this study reveal that the Biodex System 4 dynamometer has a reliability rating of good to very good in the assessment of the knee joint.

The flow chart (Figure 2) displays the selection and recruitment of the study demographic, the distribution of the participants in the control group with a placebo and the active group with RCE, and the reasons for excluding subjects.

All the data collected was introduced into a database created for the study. The descriptive results were expressed as average ± standard deviation (SD) or percentages, in accordance with the measurement value.

To compare the effects of the two products on the efficiency of the main variable, as well as on the main secondary efficiency variables, an analysis of covariance (ANCOVA) was performed, with the baseline value as the covariate. For the remaining efficiency variables, the hypothesis was tested using the exact Fisher test for the categorical variables, the Student *t* test for the continuous variables, and the Mann-Whitney U test for the ordinal variables. Based on the results of the previous trials, the efficiency of the main variables was tested in the sub-group of sex, participants > 50 years of age, and BMI. All the statistical tests were carried out using the SPSS package. A two-tailed significance trial of $p < 0.05$ was considered statistically significant.

Results

A descriptive analysis of the entire sample was performed, differentiating between the two treatment groups of the demographic by protocol (DP). The random distribution of the sample in the different treatments determined n=36 in the placebo treatment and n=37 in the RCE treatment. Table 1 displays the characteristics of each group in terms of the variables of age, weight, height, body mass index, sex and race. The two treatment groups were homogeneous in these characteristics, thus avoiding imbalances in the treatment groups.

The effectiveness of using RCE as a nutritional support was assessed according to the isokinetic variables in the two treatment groups. Table 2 displays the overall results of the isokinetic variables PT, TW and AP, in flexion and extension movement of the knee joint, at the speeds of 240º/sec and 180º/sec, in the two treatment groups, on the first visit with the baseline and the difference between the baseline and the final value, represented in the table in the "Changes at 12 weeks" after treatment column. No statistically significant differences were found at 12 weeks compared to baseline values in any of the two treatment groups, regardless of the movement and speed, nor in any of the isokinetic variables.

All the isokinetic variables for both treatment groups were assessed but the participants of each group were differentiated by sex.

Table 1. Demographic and baseline characteristics.

Variable	Placebo	RCE
Age; years	42.50±13.18	42.95±10.35
Weight; Kg	68.81±13.78	70.63±14.18
Height; cm	166.06±8.61	165.19±10.86
Body mass index; Kg/m^2	24.84±3.88	25.97±4.94
Sex; female, n (%)	21 (58.3%)	25 (67.6%)
male, n (%)	15 (41.7%)	12 (32.4%)
Race; Caucasian, n (%)	36 (100.0%)	37 (100.0%)

Table 2. Overall results of the isokinetic variables of each study product.

	Movement	Speed	Product	Baseline	Changes at 12 weeks	*p*
Peak torque (N m)	Extension	240º/sec	Placebo (n=36)	64.87 ± 32.85	7.60 [4.00 ; 12.16]$_a$	0.466
			RCE (n=37)	68.23 ± 32.14	5.40 [2.66 ; 11.41]$_a$	
		180º/sec	Placebo	72.86 ± 37.70	7.15 [4.45 ; 14.12]$_a$	0.631
			RCE	63.10 [60.94 ; 85.07]	6.60 [6.88 ; 19.91]$_a$	
	Flexion	240º/sec	Placebo	38.06 ± 19.48	4.55 [1.98 ; 8.79]$_a$	0.834
			RCE	33.40 [32.72 ; 48.67]	5.00 [0.11 ; 8.10]$_a$	
		180º/sec	Placebo	38.24 ± 20.44	5.30 [1.86 ; 8.74]	0.211
			RCE	38.34 ± 20.03	8.14 [5.13 ; 11.16]	
Total work (J)	**E**xtension	240º/sec	Placebo	283.85 [277.48 ; 416.18]	36.95 [7.76 ; 75.82]$_a$	0.408
			RCE	292.00 [271.87 ; 399.56]	47.20 [37.17 ; 116.41]$_a$	
		180º/sec	Placebo	370.75 ± 216.64	58.40 [31.81 ; 98.76]^a	0.289
			RCE	345.51 ± 187.22	66.60 [66.53 ; 161.73]$_a$	
	Flexión	240º/seg	Placebo	138,45 [118,50 ; 208,74]	33,73 [12,22 ; 55,24]	0,450
			ECG	171,84 ± 126,47	44,69 [24,84 ; 64,54]	
		180º/seg	Placebo	160,90 [126,01 ; 215,31]	46,15 [24,04 ; 68,94]$_a$	0,195
			In investigation	167,41 ± 122,88	51,10 [49,08 ; 100,34]$_a$	
Average power (W)	Extension	240º/sec	Placebo	127.08 ± 77.01	21.45 [10.77 ; 38.12]$_a$	0.667
			RCE	110.30 [99.76 ; 152.42]	19.50 [16.65 ; 51.4]$_a$	
		180º/sec	Placebo	109.73 ± 67.34	29.15 [20.12 ; 42.89]$_a$	0.938
			RCE	105.45 ± 64.99	22.30 [25.51 ; 59.27]$_a$	
	Flexion	240º/sec	Placebo	47.55 [41.46 ; 76.44]	16.78 [8.82 ; 24.73]	0.655
			RCE	61.54 ± 48.24	19.30 [11.08 ; 27.52]	
		180º/sec	Placebo	46.25 [37.10 ; 66.60]	17.65 [11.33 ; 26.17]$_a$	0.795
			RCE	51.85 ± 41.55	16.50 [15.64 ; 32.94]$_a$	

RCE: rooster comb extract. The sub-indexes "a" indicate not normal distribution.

Table 3. Results of the isokinetic variables of each study product by sex.

Sex	Movement	Speed	Product	Baseline	Changes at 12 weeks	*p*
Peak torque (N m)						
Male	Extension	240º/sec	Placebo (n=15)	86.05 ± 38.54	5.68 [-1.25 ; 12.61]	0.126
			RCE (n=12)	101.50 ± 30.36	14.63 [3.89 ; 25.37]	
		180º/sec	Placebo	94.69 ± 46.14	7.68 [0.23 ; 15.13]	0.095
			RCE	119.85 [86.17 ; 132.25]	21.87 [4.09 ; 39.64]	
	Flexion	240º/sec	Placebo	50.34 ± 21.36	4.60 [-1.32 ; 7.83]$_a$	0.300
			RCE	64.58 ± 23.17	7.65 [-8.57 ; 16.12]$_a$	
		180º/sec	Placebo	47.51 ± 25.26	6.66 [1.82 ; 11.50]	**0.039**
			RCE	58.70 ± 19.71	14.28 [8.34 ; 20.23]	
Female	Extension	240º/sec	Placebo (n=21)	49.74 ± 16.48	9.80 [4.46 ; 15.14]	**0.043**
			RCE (n=25)	52.26 ± 17.56	3.38 [-0.41 ; 7.18]	
		180º/sec	Placebo	57.27 ± 19.60	7.90 [3.56 ; 17.29]$_a$	0.683
			RCE	55.62 ± 19.79	5.90 [4.08 ; 14.57]$_a$	
	Flexion	240º/sec	Placebo	29.28 ± 12.27	6.91 [1.84 ; 11.97]	0.322
			RCE	29.23 ± 13.79	4.26 [1.56 ; 6.96]	
		180º/sec	Placebo	31.61 ± 13.19	4.33 [-0.76 ; 9.43]	0.756
			RCE	28.57 ± 10.82	5.20 [2.15 ; 8.25]	
Total work (J)						
Male	Extension	240º/sec	Placebo	463.93 ± 247.74	51.90 [-17.68 ; 108.64]$_a$	0.200
			RCE	523.43 ± 188.91	61.10 [44.65 ; 260.31]$_a$	
		180º/sec	Placebo	481.59 ± 271.43	80.10 [21.80 ; 138.40]	**0.053**
			RCE	579.100 [390.74 ; 645.49]	203.63 [73.73 ; 333.54]	
	Flexion	240º/sec	Placebo	242.63 ± 161.65	30.52 [-5.97 ; 67.01]	0.188
			RCE	300.63 ± 117.66	69.30 [16.45 ; 122.15]	
		180º/sec	Placebo	234.87 ± 166.13	64.63 [27.40 ; 101.86]	0.076
			RCE	277.14 ± 138.57	121.85 [62.34 ; 181.36]	
Female	Extension	240º/sec	Placebo	263.19 ± 113.69	39.16 [-3.00 ; 81.32]	0.955
			RCE	245.61 ± 112.10	40.46 [15.20 ; 65.71]	
		180º/sec	Placebo	291.58 ± 121.50	48.20 [11.31 ; 98.09]$_a$	0.421
			RCE	262.65 ± 110.03	55.80 [40.59 ; 101.75]$_a$	
	Flexion	240º/sec	Placebo	107.18 ± 69.31	36.02 [7.16 ; 64.89]	0.840
			RCE	110.02 ± 73.30	32.88 [15.86 ; 49.89]	
		180º/sec	Placebo	124.79 ± 76.51	33.54 [4.33 ; 62.74]	0.303
			RCE	114.74 ± 70.28	52.09 [28.75 ; 75.43]	
Average power (W)						
Male	Extension	240º/sec	Placebo	168.43 ± 93.52	26.07 [0.03 ; 52.11]	0.086
			RCE	106.75 [77.49 ; 136.79]	67.74 [20.85 ; 114.64]	
		180º/sec	Placebo	140.51 ± 86.16	38.14 [18.08 ; 58.20]	0.073
			RCE	161.33 ± 70.89	77.30 [32.51 ; 122.09]	
	Flexion	240º/sec	Placebo	87.56 ± 64.64	15.30 [0.56 ; 28.92]$_a$	0.200
			RCE	214.85 [151.18 ; 248.95]	27.60 [14.24 ; 53.99]$_a$	
		180º/sec	Placebo	71.43 ± 56.61	23.67 [10.95 ; 36.38]	0.108
			RCE	88,28 ± 47.01	41.45 [20.82 ; 62.08]	
Female	Extension	240º/sec	Placebo	97,54 ± 45.36	23.29 [6.84 ; 39.74]	0.564
			RCE	90,58 ± 50.90	17.86 [6.62 ; 29.09]	
		180º/sec	Placebo	87,74 ± 39.01	22.40 [12.33 ; 41.21]$_a$	0.501
			RCE	78,62 ± 41.48	21.60 [14.98 ; 36.27]$_a$	
	Flexion	240º/sec	Placebo	38,51 ± 26.42	18,23 [8.03 ; 28.43]	0.309
			RCE	39,66 ± 30.89	12.19 [5.04 ; 19.35]	
		180º/sec	Placebo	37,87 ± 24.29	13.20 [5.67 ; 24.81]$_a$	0.817
			RCE	34.37 ± 24.40	14.50 [8.80 ; 23.30]$_a$	

RCE: rooster comb extract. The sub-indexes "a" indicate not normal distribution.

Table 3 displays the PT, TW and AP results obtained by sex, at the first visit and the change after 12 weeks of treatment, in both the placebo and RCE treatment groups. In the group of males, statistically significant differences were found at the speed of 180º/sec in the PT variable in flexion movement, and in the TW variable in extension movement. In terms of the females, statistically significant differences were found in the PT variable in extension movement at the speed of 240º/sec. If we display and compare the results of % of clinical improvement (Figure 3), which considers the result to be functionally important if it is ≥ 10%, we can observe that the males from the RCE group – in comparison to the placebo group – obtain more than 10% in all the variables and the movements studied at the speed of 180º/sec, with these results

Figure 3. Percentage of clinical improvement in males.

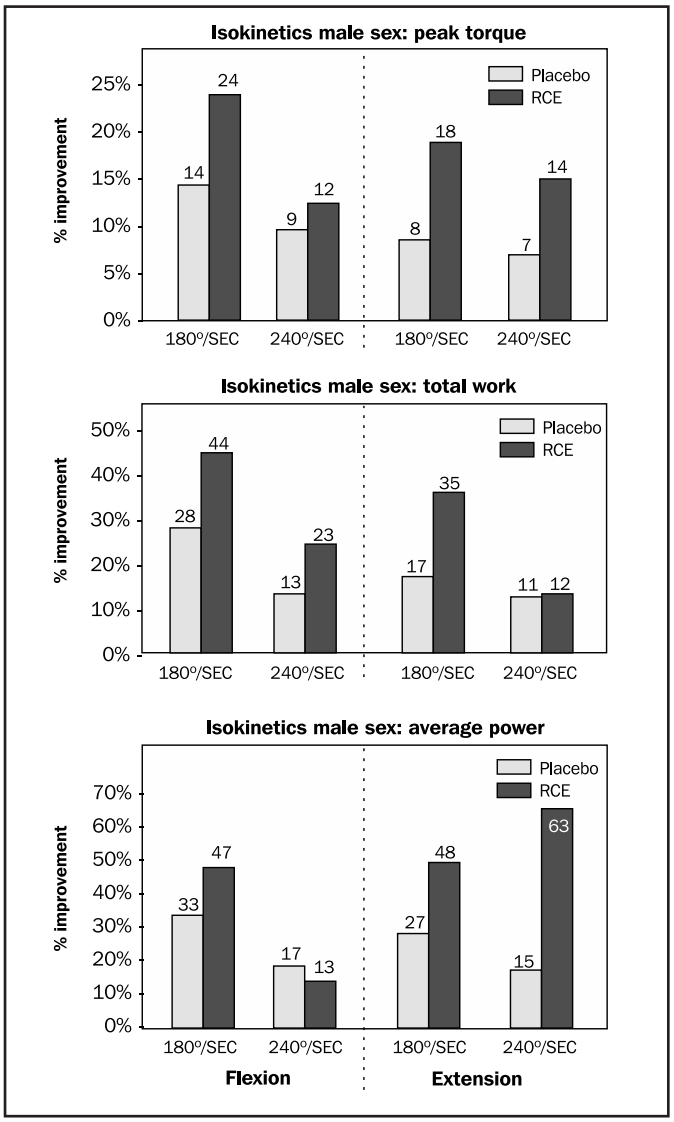
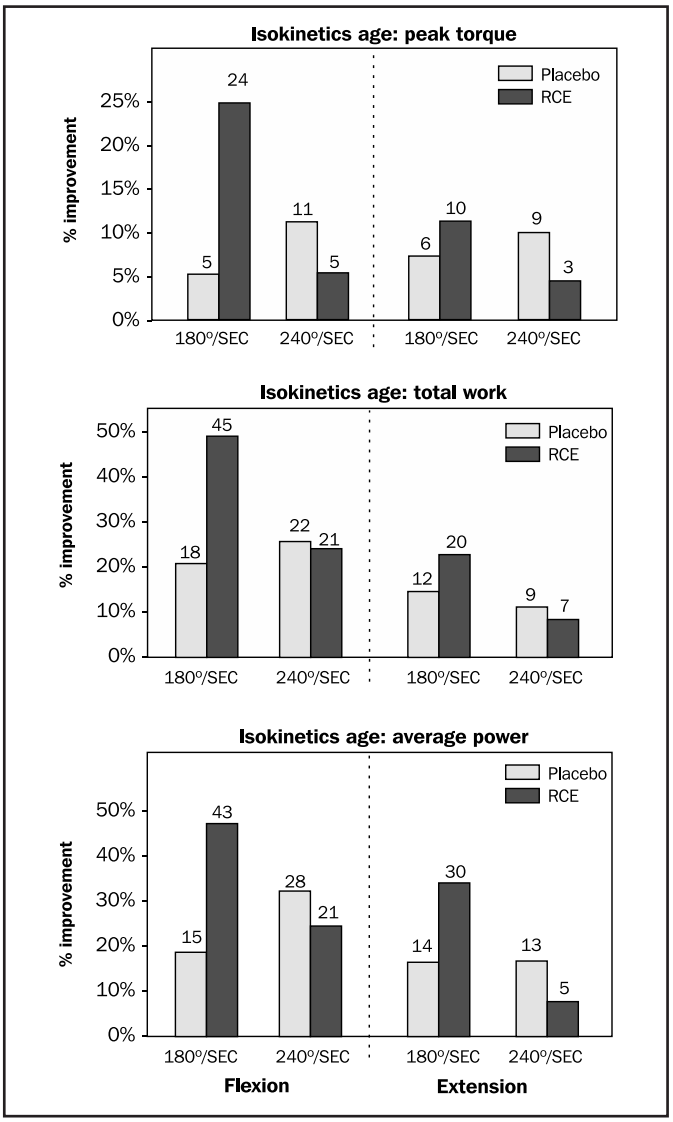


Figure 4. Percentage of clinical improvement in >50 years.



coinciding with statistical significance. At the speed of 240º/sec, there is also clinical improvement, but it is not ≥ 10% in all of them.

The same isokinetic variables were also assessed in the two treatment groups differentiated by age. Table 4 displays the results obtained from the PT, TW and AP variables differentiated by age (> 50 years and ≤ 50 years), at the first visit and the change after 12 weeks of treatment. Among the participants aged > 50 years we found statistically significant differences in the PT variable at the speed of 180º/sec and in the flexion movement. With regards to the participants aged ≤ 50 years, no statistically significant differences were found between groups in any of the variables, movements or speeds studied. When displaying the % of clinical improvement (Figure 4), we can see that those aged > 50 years in the RCE group, compared to the placebo group, obtained a 19% improvement, coinciding with the statistical significance of the difference variable ($p < 0.005$) in the PT in flexion movement at 180º/sec. We can also observe this clinical improvement of over 10% in the TW variable in flexion movement at 180º/sec, and in the AP variable at the same speed but in the two movements. However, for the participants aged ≤ 50 years, no clinical improvement was observed in any of the isokinetic variables.

After analysing the variables with the DP, we can see that the results revealing the most differences between the two treatment groups were those in which the demographics were separated by sex and at the speed of 180º/sec. For this reason we believe it would be advisable to carry out an analysis with the intention to treat (ITT) demographic, following the *Consolidated Standards of Reporting Trials* (CONSORT) regulations guide. Table 5 displays the results of the isokinetic variables in the ITT demographic, divided by sex and specifically at the speed of 180º/sec.

Table 4. Results of the isokinetic variables in each study product by age.

	Age	Movement	Speed	Product	Baseline	Changes at 12 weeks	*p*
Peak torque (N m)							
	> 50	Extension	240º/sec	Placebo (n=11)	56.54 ± 24.20	4.87 [-2.62 ; 12.36]	0.432
				RCE (n=12)	59.99 ± 26.05	1.89 [-2.05 ; 5.83]	
			180º/sec	Placebo	62.92 ± 26.49	3.56 [- 5.69 ; 12.81]	0.577
				RCE	63.83 ± 27.78	6.48 [-0.38 ; 13.33]	
		Flexion	240º/sec	Placebo	36.19 ± 18.50	3.80 [-2.40 ; 10.57]$_a$	0.786
				RCE	36.44 ± 16.98	1.70 [-1.93 ; 6.45]	
			180º/sec	Placebo	34.79 ± 15.27	1.85 [-2.54 ; 6.25]	**0.053**
				RCE	33.30 ± 15.29	7.88 [3.14 ; 12.63]	
	≤ 50	Extension	240º/sec	Placebo (n=25)	63.30 [53.74 ; 83.32]	9.50 [4.38 ; 14.61]	0.999
				RCE (n=25)	72.18 ± 34.48	9.50 [3.36 ; 15.64]	
			180º/sec	Placebo	77.24 ± 41.42	7.40 [6.01 ; 17.60]$_a$	0.587
				RCE	77.41 ± 39.35	7.00 [7.63 ; 25.80]$_a$	
		Flexion	240º/sec	Placebo	37.00 [30.53 ; 47.22]	5.70 [1.67 ; 10.24]	0.954
				RCE	33.40 [31.72 ; 53.76]	6.30 [-0.75 ; 10.72]$_a$	
			180º/sec	Placebo	40.40 [30.48 ; 49.02]	6.82 [2.20 ; 11.44]	0.629
				RCE	40.76 ± 21.81	8.27 [4.20 ; 12.33]	
Total work (J)							
	> 50	Extension	240º/sec	Placebo	305.14 ± 170.23	27.90 [-24.33 ; 83.11]$_a$	0.928
				RCE	301.23 ± 150.87	19.60 [0.29 ; 57.65]	
			180º/sec	Placebo	334.34 ± 159.77	40.50 [-32.43 ; 85.43]	0.347
				RCE	296.61 ± 134.31	58.65 [13.34 ; 117.73]$_a$	
		Flexion	240º/sec	Placebo	134.24 ± 115.46	29.91 [0.23 ; 59.59]	0.929
				RCE	149.69 ± 86.88	31.60 [2.75 ; 60.45]	
			180º/sec	Placebo	153.07 ± 104.24	27.50 [-24.17 ; 62.16]	0.134
				RCE	139.10 ± 93.64	62.45 [29.20 ; 111.16]$_a$	
	≤ 50	Extension	240º/sec	Placebo	285.90 [274.70 ; 455.65]	51.90 [2.06 ; 92.44]	0.290
				RCE	352.27 ± 209.01	54.70 [43.51 ; 155.98]$_a$	
			180º/sec	Placebo	386.77 ± 238.60	76.60 [40.92 ; 123.78]	0.399
				RCE	368.98 ± 206.25	74.90 [71.24 ; 203.68]$_a$	
		Flexion	240º/sec	Placebo	139.30 [118.45 ; 234.65]	35.41 [6.01 ; 64.81]	0.424
				RCE	182.47 ± 142.02	50.97 [24.07 ; 77.87]	
			180º/sec	Placebo	159.60 [119.06 ; 237.73]	49.90 [31.84 ; 85.34]	0.567
				RCE	181.00 ± 134.30	49.10 [42.50 ; 111.28]$_a$	
Average power (W)							
	> 50	Extension	240º/sec	Placebo	109.04 ± 63.50	14.70 [-6.85 ; 29.30]	0.928
				RCE	112.10 ± 65.18	5.40 [-4.46 ; 25.89]$_a$	
			180º/sec	Placebo	95.18 ± 45.76	13.08 [-5.24 ; 31.40]	0.279
				RCE	85.88 ± 51.19	25.81 [8.30 ; 43.32]	
		Flexion	240º/sec	Placebo	41.02 ± 42.73	11.57 [0.10 ; 23.05]	0.938
				RCE	52.07 ± 29.83	10.98 [-1.24 ; 23.19]	
			180º/sec	Placebo	44.67 ± 32.70	6.90 [-6.36 ; 22.88]	0.235
				RCE	41.63 ± 29.77	17.85 [7.72 ; 32.00]$_a$	
	≤ 50	Extension	240º/sec	Placebo	135.05 ± 82.18	26.10 [11.97 ; 48.56]	0.594
				RCE	132.80 ± 85.22	31.00 [21.11 ; 69.35]$_a$	
			180º/sec	Placebo	116.13 ± 74.84	38.80 [25.82 ; 53.41]	0.915
				RCE	114.84 ± 69.65	22.60 [26.66 ; 74.03]$_a$	
		Flexion	240º/sec	Placebo	48.20 [41.44 ; 86.96]	19.06 [8.41 ; 29.72]	0.568
				RCE	66.09 ± 54.93	23.30 [12.45 ; 34.15]	
			180º/sec	Placebo	51.20 [35.25 ; 74.77]	21.90 [14.79 ; 31.94]	0.734

RCE: rooster comb extract. The sub-indexes "a" indicate not normal distribution.

We have added a new column, which represents the change between the RCE group and the placebo group. There are statistically significant differences in all the isokinetic variables, both in the flexion and extension movement for males. No statistically significant differences were found for females. When displaying the % of clinical improvement in PT, TW and AP (Figure 5), it can be observed that the significant differences of the difference variable ($p < 0.005$) coincide with the clinical improvement of over 10% among the males, in the two movements at the

Table 5. Results of the isokinetic variables (PT, TW and AP) in each study product by sex and speed of 180º/second ITT demographic.

Sex	Movement	Speed	Product	Baseline	Changes at 12 weeks	Changes RCE *vs* placebo	p RCE *vs* placebo
Peak torque (N m)							
Male	Extension	180º/sec	Placebo	96.23±45.01	7.20 [0.20; 14.20]	16.14 [0.11; 32.17] (11.85%)	**0.048**
			RCE	112.86±37.28	21.82 [5.64; 38.01]		
	Flexion	180º/sec	Placebo	48.99±25.11	6.24 [1.66; 10.83]	10.21 [2.92; 17.50] (12.67%)	**0.007**
			RCE	60.89±19.58	15.47 [9.47; 21.47]		
Female	Extension	180º/sec	Placebo	55.10±19.21	10.43 [3.57; 17.30]	-1.37 [-8.84; 6.10] (-1.37%)	0.713
			RCE	55.17±19.54	9.69 [4.60; 14.77]		
	Flexion	180º/sec	Placebo	30.43±12.79	4.33 [-0.76; 9.43]	-0.065 [-5.29; 5.16] (4.27%)	0.980
			RCE	28.11±10.85	5.20 [2.28; 8.13]		
Total work (J)							
Male	Extension	180º/sec	Placebo	476.56±262.99	75.09 [19.86; 130.33]	139.1 [23.00; 255.1] (22.21%)	**0.020**
			RCE	539.76±195.15	204.94 [86.61; 323.26]		
	Flexion	180º/sec	Placebo	239.47±161.55	60.59 [24.92; 96.25]	74.53 [15.94; 133.1] (17.68%)	**0.014**
			RCE	294.33±135.03	126.49 [71.36; 181.62]		
Female	Extension	180º/sec	Placebo	278.51±119.02	54.70 [11.31; 98.09]	11.47 [-36.09; 59.03] (9.04%)	0.629
			RCE	260.01±108.65	74.56 [44.42; 104.69]		
	Flexion	180º/sec	Placebo	119.04±75.00	33.54 [4.33; 62.74]	15.03 [-19.26; 49.31] (17.51%)	0.381
			RCE	112.48±69.82	51.39 [28.96; 73.81]		
Average power (W)							
Male	Extension	180º/sec	Placebo	140.34±83.24	35.76 [16.43; 55.08]	46.32 [5.00; 87.64] (21.77%)	**0.029**
			RCE	167.76±67.95	79.26 [38.26; 120.27]		
	Flexion	180º/sec	Placebo	73.04±55.07	22.19 [9.96; 34.42]	25.56 [3.93; 47.19] (18.52%)	**0.022**
			RCE	92.18±44.52	45.08 [24.70; 65.46]		
Female	Extension	180º/sec	Placebo	83.35±38.27	26.77 [12.33; 41.21]	-2.67 [-18.87; 13.54] (2.02%)	0.741
			RCE	77.63±40.95	26.50 [16.14; 36.86]		
	Flexion	180º/sec	Placebo	35.83±23.76	15.24 [5.68; 24.81]	-0.17 [-11.30; 10.96] (4.60%)	0.976
			RCE	33.59±24.24	15.83 [8.86; 22.80]		

RCE: rooster comb extract. The sub-indexes "a" indicate not normal distribution.

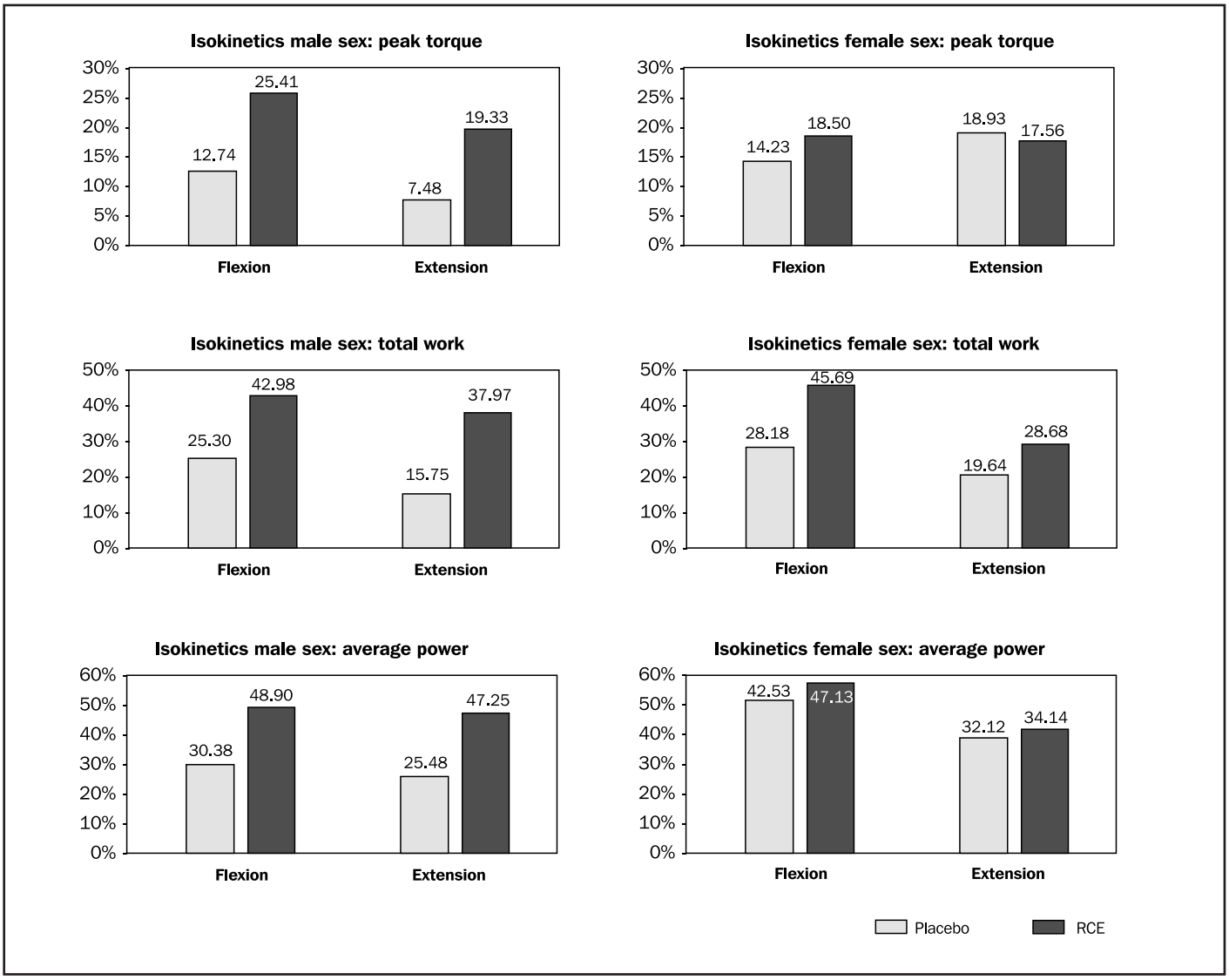
speed of 180º/sec. Regarding the females, no clinical improvement > 10% was found in any isokinetic variable, apart from in the TW variable in the flexion movement and at the speed of 180º/sec.

Discussion

These results suggest that consuming RCE may improve muscle strength deficiencies in knees affected by OA. The state of the muscles surrounding the joint, which give it stability, is very important in OA. The muscles involved are the quadriceps, responsible for the knee extension movement, and the hamstrings, responsible for the flexion movement of the knee[17]. Muscle strength varies by sex and age, and in a healthy population females have less muscle strength than males in all age groups. Male muscle strength diminishes progressively and in a linear fashion with age, whilst female muscle strength diminishes at around 41 years of age[18]. Kasai and co. observed differences in sex and age related to muscle composition and quality. Different studies have also suggested that the loss of ovarian function associated with the reduction of circulating concentrations of 17β-estradiol may be indirectly associated with the accelerated reduction of muscle strength following the menopause[19]. Changes in the sex hormones that affect muscular metabolism may explain why this response is better in males, however, more studies are required to explain the reasons behind these differences between sexes and also to provide more information about muscle functions[20].

The PT, TW and AP variables can be assessed at different angular speeds. In current literature, there is controversy regarding these speeds, yet the manufacturers of the devices suggest recommendations regarding the position and speed to be taken into account when performing the test[11]. In our study we have assessed an average speed (180º/sec) and a quick speed (240º/sec) based on the study by Martinez Puig[16]. The PT and TW allow us to see the strength of a muscle and how this strength can be maintained in a specific work time. That said, a muscle should not just have strength but also the ability to react quickly, which is what we can see with the AP variable. In the study, we can observe that after 12 weeks of consuming RCE-supplemented yoghurt, the isokinetic

Figure 5. Percentage of clinical improvement depending on sex and on the ITT population.



variables improve, and therefore the muscle capacities that will directly protect the joint so the knee can operate correctly.

From our knowledge, there is little information about the clinical importance of improvements to the isokinetic measurements of the knee. Knapik and Dauty suggest that when the comparison between two sets of isokinetic variable data is greater than 10%, it is generally considered to be functionally important[21,22]. In the ITT demographic divided by sex, this study confirms that low-fat yoghurt supplemented with RCE rich in HA (80 mg/d) and consumed for 12 weeks, can improve the muscle condition of knees affected with mild pain in men, in comparison to the baseline value of the same knee and at the speed of 180º/sec. Specifically, the clinical improvement is: 25.41% in the hamstring muscles and 19.33% in the quadriceps in the PT; 42.98% in the hamstrings and 37.97% in the quadriceps in the TW; and 48.90% in the hamstrings and 47.25% in the quadriceps in the AP. Overall it could be said that there is an improvement of at least 11% in males, compared to the control group at 180º/sec, with statistically significant differences obtained in all the isokinetic variables for males and at the speed of 180º/sec. Therefore, the improvement in muscle strength of the affected knee joint that was observed after the RCE treatment, could suggest its importance in clinical practice[23].

Regarding the methodology used, when the study analysis is performed we need to consider whether we are speaking of the ITT population or DP. As the CONSORT guide states in the description of an intervention study, the term "modified intention to treat" is very widely used to describe an analysis that excludes participants that do not adhere adequately to the protocol, in particular those that did not receive a minimum established amount of the treatment. However, the same guide suggests that an alternative terms is "by protocol", in favour of a clear description of exactly what was included in each analysis, those that adhered correctly

to the protocol, and in particular those that did not receive a minimum established amount of the treatmen[t24,25]. In view of this, the majority of our results and statistical analyses were performed on the DP population, despite also including a section that analyses a part of the ITT population.

In this study, the muscle assessments were performed using an isokinetic dynamometer, which is a precise method for assessing muscle activity[20]. Various literary articles highlight the importance of establishing the reliability and validity of these devices, as this way the precise assessment of muscle performance can be guaranteed[9]. Numerous studies have assessed the reliability and validity of isokinetic dynamometers in protocols of the different joints[26-29]. In our study, a regulatory work procedure (RWP) was created beforehand, in which each step of the test was specified, so that the physiotherapists that carried out the assessment could perform it in the same way. We performed a preliminary study to observe reliability and validity using the isokinetic test-retest on the knee joint. The results we obtained in this study revealed that the Biodex System $_4$ dynamometer is reliable for the intra-evaluator test, as well as for the inter-evaluator test on the isokinetic assessment of the knee joint.

Currently, muscle performance studies seem to be based on isokinetic assessment, though to interpret and describe the results more studies are required so a protocol assessment can be used as a reference[30]. In our study we contribute PT, TW and AP reference values of baseline isokinetic tests, for the pathology of mild gonalgia or early OA of the knee.

In terms of treatment with HA, Tashiro and co. performed a study on the effectiveness of the oral administration of HA. They observed 60 people with OA randomly divided into two groups. The first consumed HA (200 mg once a day) and the other was given a placebo for the duration of 12 months. The subjects from both groups performed quadriceps strengthening exercises each day. The HA group tended to improve and this improvement was clearer in subjects aged <70 years. The effect of oral HA on musculature was better in the second and fourth month after consumption in the relatively younger subjects[31].

Balogh and co. indicate that orally administered HA is absorbed and distributed ubiquitously in joints. Results from tests on rats and dogs indicate that orally-administered HA is absorbed and distributed in the skin, bones and synovial joints, including the knee joints, and remains there for prolonged periods of time[32].

Therapeutic effects of HA in patients with OA of the knee do not necessarily require HA absorption. A study by Asari *et al.,* states that a high molecular weight HA can attach to the Toll-like receptor $_4$ (TLR_4) in the intestinal epithelium and exercise biological activity without being absorbed; this union has been proven to increase the secretion of suppressor of cytokine signalling $_3$ ($SOCS_3$), which leads to the suppression of pro-inflammatory cytokines. This union also eliminates the expression of pleiotrophin, which contributes to the suppression of inflammation. The therapeutic effects of HA observed in this study could be the result of these mechanisms, with the HA that remains in the intestines without being absorbed[33].

Another possibility is that the therapeutic effect of HA is obtained via similar mechanisms to glucosamine (GlcN). GlcN is an agent that can modify the OA illness, though its therapeutic effectiveness and mechanism of action continue to be contested[34].

Souich observed the absorption, distribution and mechanism of action of symptomatic slow acting drugs for OA (SYSADOA). In his review he supports data on the oral absorption and corporal distribution of SYSADOA, and discusses its mechanism of action. SYSADOA are absorbed in the small intestine with a bio-availability that ranges from 5 to 45%, and they accumulate in the joint tissues. They comprise three natural components: HA, chondroitin sulphate (CS) and GlcN[35]. The mechanism of action of the HA and CS differ in various aspects from the GlcN. As they are large molecules, HA and CS do not penetrate chondrocytes, synoviocytes, osteoblasts, osteocytes or osteoclasts, and therefore cause an anti-inflammatory effect with the participation of membrane receptors (CD44, TLR4 and ICAM1), with a resulting double-effect: preventing these receptors from participating in the fragments of the extracellular matrix – the cause of inflammatory reaction – and blocking the signal transduction pathways by the fragments, therefore reducing the nuclear translocation of pro-inflammatory transcription factors. GlcN penetrates cells via glucose transporters. Its primary effect is linked to its O-GlcNAcylate protein capacity, and consequentially, modulates its activity, for example reducing the nuclear translocation of the NF-kB. GlcN can also affect the transcription of pro-inflammatory cytokines via epigenetic mechanisms. The characteristics of the mechanism of action support the use of CS combined with GlcN and suggest that HA and CS will be more effective in the initial phases of OA[36].

To conclude, it is possible to establish that the consumption of a nutritional support containing hyaluronic acid (RCE) can help muscle strength and knee functionality in a general population suffering from mild gonalgia, more specifically males, and it can prevent knee arthritis. This line of study should be continued so as to establish assessment protocols, action mechanisms and treatment options for this pathology. The confirmation of these findings in other groups of patients suffering from muscle-originating mild gonalgia could be of socio-economic value.

The European Commission has approved RCE as a new food ingredient (*European Food Safety Authority Journal* 2013).

Conflict of interests

The authors declare to have no conflicts of interest whatsoever.

Bibliography

1. Woolf AD, Pfleger B. Burden of major musculoskeletal conditions. *Bull World Health Organ*. 2003;81(9):646-56.
2. Guccione AA, Felson DT, Anderson JJ, Anthony JM, Zhang Y, Wilson PW, *et al*. The effects of specific medical conditions on the functional limitations of elders in the Framingham Study. *Am J Public Health.* 1994;84(3):351-8.
3. Kon E, Filardo G, Drobnic M, Madry H, Jelic M, van Dijk N, *et al*. Non-surgical management of early knee osteoarthritis. *Knee Surg Sports Traumatol Arthrosc.* 2012;20(3):436-49.
4. Llorente F. Potenciación de la rodilla. En: *Potenciación muscular.* Jornadas Nacionales de Fisioterapia MAPFRE. Madrid: Ed. MAPFRE, S.A; 1988. p. 155-71.
5. Slocker A, Segovia JC. Valoración de la fuerza isocinética. En: Segovia JC, López FJ, Legido JC. *Manual de Valoración Funcional. Aspectos clínicos y fisiológicos*. 2ed. Madrid: Ed. Elseiver; 2008. p. 221-33.
6. Huesa F, Garcia J, Vargas J. Dinamometría Isocinética. En: Sánchez I, Ferrero A, Aguilar JJ, Climent JM, Conejero JA, Flórez MT, Peña A, Zambudio R. *Manual SERMEF de Rehabilitación y Medicina Fisica.* 2º ed. Madrid: Ed. Médica Panamericana; 2008. p. 83-8.
7. Jimenez J. Potenciación muscular con aparatós cinesiterápicos-isocinéticos. En: Fundación Mapfre. *Potenciación Muscular.* Madrid: Ed. Mapfre; 1989. p. 63-74.

8. Oman J. La Isocinética en la Rehabilitación. En: Prentice W. *Técnicas de Rehabilitación en la Medicina Deportiva.* 3ª ed. Barcelona: Ed. Paidotribo; 2001. p. 94-106.
9. Orri JU, Darden Gl. Technical Report: Reliability and validity of the isam 9000 isokinetic dynamometer. *JSCR*. 2008; 22(1):310-7.
10. Amorim M, Leme LE. Isokinetic dynamometry in elderly women undergoing total knee arthroplasty: a comparative study. *Clinics (Sao Paulo).* 2006;61(3):215-22.
11. Alqualo RE, Magalhaes LE, Hiroko SA, Jones AN, Natour JA. Isokinetic assessment of the hip muscles in patients with osteoarthritis of the knee. *Clinics.* 2010;65(12):1253-9.
12. Zawadzki J, Bober T, Siemieński A. Validity analysis of the Biodex System 3 dynamometer under static and isokinetic conditions. *Acta Bioeng Biomech*. 2010;12(4):25-32.
13. Fakhari A, Berkland C. Applications and emerging trends of hyaluronic acid in tissue engineering, as a dermal filler and in osteoarthritis treatment. *Acta Biomater.* 2013; 9(7):7081-92.
14. Brandt KD, Block JA, Michalski JP, Moreland LW, Caldwell JR, Lavin PT. Efficacy and safety of intraarticular sodium hyaluronate in knee osteoarthritis. ORTHOVISC Study Group. *Clin Orthop Relat Res.* 2001;(385):130-43.
15. Balogh L, Polyak A, Mathe D, Kiraly R, Thuroczy J, Terez M, *et al.* Absorption, uptake and tissue affinity of high-molecular-weight hyaluronan after oral administration in rats and dogs. *J Agric Food Chem*. 2008;56(22):10582-93.
16. Martinez-Puig D, Moller I, Fernandez C, Chetrit C. Efficacy of oral administration of yoghurt supplemented with a preparation containing hyaluronic acid (MobileeTM) in adults with mild joint discomfort: a randomized, double-blind, placebo-controlled intervention study. *Med J Nutrition Metab.* 2013;6:63-8.
17. Hafez AR, Al-Johani AH, Zakaria AR, Al-Ahaideb A, Buragadda S, Melam GR, *et al.* Treatment of knee osteoarthritis in relation to hamstring and quadriceps strength. *J Phys Ther Sci.* 2013;25:1401–5.
18. Danneskiold-Samsøe B, Bartels EM, Bülow PM, Lund H, Stockmarr A, Holm CC, *et al.* Isokinetic and isometric muscle strength in a healthy population with special reference to age and gender. *Acta Physiol (Oxf).* 2009;197 Suppl:1-68.
19. Sirola J, Rikkonen T. Muscle performance after the menopause. *J Br Menopause Soc.* 2005;11(2):45-50.
20. Molczyk L, Thigpen LK, Eickhoff J, Goldgar D, Gallagher JC. Reliability of Testing the Knee Extensors and Flexors in Healthy Adult Women Using a Cybex II Isokinetic Dynamometer. *J Orthop Sports Phys Ther.* 1991;14:37-41.
21. Knapik JJ, Bauman CL, Jones BH, Harris JM, Vaughan L. Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. *Am J Sports Med*. 1991;19:76-81.
22. Dauty M, Dupré M, Potiron-Josse M, Dubois Ch. Identification of mechanical consequences of jumper's knee by isokinetic concentric torque measurement in elite basketball players. *Isokinet Exerc Sci.* 2007;15:37-41.
23. Leung WC. Balancing statistical and clinical significance in evaluating treatment effects. *Postgrad Med J.* 2001;77:201-4.
24. Altman DG, Schulz KF, Moher D, Egger M, Davidoff F, Elbourne D, *et al.* The revised CONSORT statement for reporting randomized trials: explanation and elaboration. *Ann Intern Med.* 2001;134(8):663-94.
25. Moher D, Hopewell S, Schulz KF, Montori V, Gøtzsche PC, Devereaux PJ, *et al.* CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. *Int J Surg.* 2012;10(1):28-55.
26. Tunstall H, Mullineaux DR, Vernon T. Criterion validity of an isokinetic dynamometer to assess shoulder function in tennis players. *Sports Biomech.* 2005;4(1):101-11.
27. Aydoğ E, Aydoğ ST, Cakci A, Doral MN. Reliability of isokinetic ankle inversion- and eversion-strength measurement in neutral foot position, using the Biodex dynamometer. *Knee Surg Sports Traumatol Arthrosc*. 2004;12(5):478-81.
28. Meeteren JV, Roebroeck ME, Stam HJ. Test-retest reliability in isokinetic muscle strength measurements of the shoulder. *J Rehabil Med.* 2002;34(2):91-5.
29. Lund H, Søndergaard K, Zachariassen T, Christensen R, Bülow P, Henriksen M, *et al.* Learning effect of isokinetic measurements in healthy subjects, and reliability and comparability of Biodex and Lido dynamometers. *Clin Physiol Funct Imaging.* 2005;25(2):75-82.
30. Nerin MA, Montaño JA, Carrasco L, Martínez Romero JL. Evaluación isocinética de la musculatura flexoextensora de la rodilla en universitarios: estudio preliminar. *Rev S And Traum y Ort.* 2007;24-25:24-31.
31. Tashiro T, Seino S, Sato T, Matsuoka R, Masuda Y, Fukui N. Oral administration of polymer hyaluronic acid alleviates symptoms of knee osteoarthritis: a double-blind, placebo-controlled study over a 12-month period. *ScientificWorldJournal.* 2012;2012:167928.
32. Balogh L, Polyak A, Mathe D, Kiraly R, Thuroczy J, Terez M, *et al.* Absorption, uptake and tissue affinity of high-molecular-weight hyaluronan after oral administration in rats and dogs. *J Agric Food Chem.* 2008;56(22):10582-93.
33. Asari A, Kanemitsu T, Kurihara H. Oral administration of high molecular weight hyaluronan (900 kDa) controls immune system via Toll-like receptor 4 in the intestinal epithelium. *J Biol Chem*. 2010;285:24751–8.
34. Torrent A, Ruhí R, Theodosakis J, Blanco F. Comparison of the efficacy of two products sold as orally-adminsitered hylauronic acid supplements, ib0004 and id386 on the endogenous in vitro synthesis of hyaluronic acid by human synoviocytes. *Osteoarthr Cartil.* 2009;17:S277–8.
35. Zhang W, Nuki G, Moskowitz RW, Abramson S, Altman RD, Arden NK, *et al.* OARSI recommendations for the management of hip and knee osteoarthritis: part III: Changes in evidence following systematic cumulative update of research published through January 2009. *Osteoarthritis Cartilage.* 2010;18(4):476-99.
36. du Souich P. Absorption, distribution and mechanism of action of SYSADOAS. *Pharmacol Ther.* 2014;142(3):362-74.

Analysis of the use of nutritional supplements in gyms in Coquimbo, Chile

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Summary

Nutritional science is a crucial component for improving health and sports performance. The use of nutritional supplements (NS) has increased considerably in recent years. Studies show high consumption of nutritional supplements that lack scientific evidence and could be putting the health of the population at risk. The objective was to analyze the use of NS in clients of a gymnasium franchise in the Coquimbo Region of Chile during 2016. Was applied to 359 clients (191 men and 168 women) a previously validated survey in four locations of a gymnasium franchise in the Coquimbo Region. The median age of the sample population was 28±10.1 years and 43.2% of the population had used NS. The main goal of the NS users was to increase muscle mass (32%); the most commonly used NSs were whey protein (72.9%), branched-chain amino acids (21.9%), and glutamine (9.7%). Of the 26 types of NS consumed, 50% are classified as type C, that is, there exists little evidence regarding their benefits. Two variables showed statistical significance for the use of NS: hours of training, and the person who had recommended the NS to the user. This information supports the importance of specialized nutritional assessment for the population to avoid ineffective and harmful products.

Key words:
Sports medicine. Sports nutrition sciences. Whey protein. Athletic performance. Doping in sports.

Análisis del uso de suplementos nutricionales en gimnasios de la Región de Coquimbo, Chile

Resumen

La ciencia de la nutrición actualmente es considerada un componente crucial para la mejora de la salud y del rendimiento deportivo. El uso de suplementos nutricionales (SN) ha aumentado considerablemente en los últimos años. Estudios evidencian que en gimnasios, existe un alto consumo de productos que carecen de evidencia científica y que pueden poner en riesgo la salud de la población. El objetivo del estudio fue analizar el uso de SN en usuarios de una cadena de gimnasios de la Región de Coquimbo, Chile durante el año 2016, para este fin se aplicó una encuesta previamente validada a 359 usuarios (191 hombres y 168 mujeres) en cuatro sedes de una cadena de gimnasios de la Región de Coquimbo. La edad media de la muestra fue de 28±10,1 años, el consumo de SN fue del 43,2%. El principal objetivo de uso de SN fue aumentar masa muscular (32%), los SN más consumidos fueron proteína de suero de leche (72,9%), aminoácidos de cadena ramificada (21,9%) y glutamina (9,7%). De los 26 diferentes tipos de SN consumidos, el 50% se clasificó como tipo C (existe poca evidencia acerca de sus efectos beneficiosos). Las variables; horas de entrenamiento y quien recomienda el uso de SN mostraron significancia estadística para el uso de SN. Esta información respalda la importancia de asesoría nutricional especializada en esta población, con el fin de evitar el uso de productos inefectivos y/o que puedan perjudicar su salud.

Palabras clave:
Medicina deportiva. Nutrición deportiva. Proteína de suero de leche. Rendimiento deportivo. Dopaje en el deporte.

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Introduction

Physical activity increases the need for energy and nutrients[1]. For this reason, nutrition science is considered to be a crucial component in the improvement of sports performance, playing an important role in training adaptations, energy reserves, fatigue delay and recovery, among other factors[2].

It is with this perspective that Martínez-Sanz *et al*. in 2013 explained that those persons performing physical exercise must cover their requirements for energy, macronutrients, vitamins, minerals and water, based on a balanced diet through food intake and, only if necessary, the use of nutritional supplements (SN)[3]. However, over the last few years, various studies have shown that a low level of knowledge in the area of sports nutrition among gym-goers is associated with low sports performance[4,5], revealing the importance of getting proper advice on diet and supplements applied to sport.

Supplements and meals for athletes not only need to provide nutrients that meet the nutritional requirements to optimize daily training or competition performance, but must also contain a sufficient amount of nutrients to cover specific deficiencies, while also containing adequate quantities of nutrients or other components to increase sporting performance, maintain and/or restore health and the immune function. Furthermore, such nutritional supplements must be based on scientific evidence[6,7]. This latter point is fundamental, given the fact that a large amount of nutritional supplements currently used for different goals, actually have no ergogenic effect[8]. Among these goals, we could mention, for example: muscle mass gain, strength improvement, disease prevention and sporting performance improvement[9]. It is worth mentioning that, as a result of the widespread use of these products, the NS industry has become an industry that is globally valued at billions of dollars[10]. Another issue regarding this problem is that a large number of NS are recommended by sources that are not suitably qualified to do so[11,12]. This increases the risk of giving a positive result in a doping test, given that the products may be contaminated with prohibited substances, such as steroids or other toxic substances such as heavy metals[13,14]. Added to this, scientific evidence indicates that the abuse of any type of substance to improve sporting performance has extended to regular gym-goers, for example for aesthetic purposes, without considering the potential harmful effects that the abuse of substances of this type may entail[15].

With regard to the evidence available on the use of nutritional supplements in gyms, the results are variable, with prevalences at an international level of between 36.3% to 84.7%[8,16–20]. In Chile, there is limited information on this subject. In a study conducted in 2011, Rodríguez *et al.* assessed the intake of supplements in gyms in the city of Viña del Mar, finding that, of the 314 respondents, 54.5% used NS[21], while in 2106, in gyms in the city of Santiago de Chile, Jorquera et al found, a prevalence of use of 28.6%. Furthermore, this study detected that, the greater the gym attendance time, the greater the use of NS. This same situation occurs when the weekly training frequency is greater[22].

Given the limited information available in Chile on the use of NS, the goal of this study was to analyse the use of NS in users of a gym chain in the Region of Coquimbo throughout the year of 2016. This would allow us to establish the general and training characteristics of gym users, to describe the NS used and to identify the nutritional assessment mechanisms that determine their use, in order to obtain relevant information for the tasks of the sports and healthcare professionals in Chile.

Material and method

This study has a non-experimental, cross-sectional design with a quantitative approach and analytical scope.

The participants in the study were active users of all the branches (four) of a chain of gyms in the Region of Coquimbo, Chile. Those going to the gym at least once a week during the month prior to the data collection were considered to be active members.

A randomized cluster sampling was taken with non-proportional allocation, giving a sample of 359 persons, including men and women aged between 18 and 65 years in the study. It should be mentioned that the study sampling size was defined from the total universe of registered members on the data collection start date (3950).

The instrument used was a structured questionnaire with 18 closed alternative questions and 2 open questions, adapted and validated by experts and by a pilot study based on the NS consumption instrument of Jorquera *et al* in 2016[22]. The questions were directed at obtaining information on the subjects' characteristics, such as age, years of training, occupation, level of education, and other specific questions related to the use of NS, consumption goals, frequency, prescription of the use of NS and the perception of the results obtained in relation to use, among other variables. All the questions were oriented so that the respondents gave answers related to the last month.

The instrument was applied by professional nutritionists and previously trained students of nutrition and dietetics, at the peak gym attendance hours, in a place on the premises that was suitable for this task, subject to the signing of the informed consent by each anonymous participant.

The NS used by the participants were grouped together based on their principal ingredient, in the case of NS with more than one principal ingredient, their generic name was used. The NS were subsequently classified according to the ABCD system of the Australian Institute of Sport[23], in order to assess the scientific evidence on the efficacy and safety of the consumption of NS.

The data analysis firstly comprised an exploratory data study, to correct missing, incorrectly tabulated or out-of-range data. A descriptive analysis of the data was subsequently made and, finally, a bivariate analysis of the data was made, considering the consumption of NS as a result variable, through Fisher's test and a multivariable logistic regression to determine potentially confounding variables. The SPSS software (21st edition) was used for the analyses.

It should be mentioned that this investigation was approved by the scientific ethics committee of the Faculty of Medicine of the Universidad Católica del Norte, based in Coquimbo, Chile.

Results

Of the 359 participants, 191 were men (53.2%) and 168 women (46.8%). The mean age of the sample was 28 ± 10.1 years. When analysing the sample according to age range, it is noteworthy that the age of the majority of the sample was between 18 to 29 years, with 54.9%. With regard to the level of education, 64.3% corresponded to university level, while the main occupation of participants was that of a worker with 59.3% (Table 1). It should be mentioned that, in the bivariate analysis, no significant differences were found for any of these variables based on the use of NS (sex p=0.455; occupation p=0.739; level of education p=0.768).

In relation to the time spent at the gym (p=0.455), 41.5% of the total number of respondents had been going to the gym regularly for less than a year.With regard to training frequency, most went to the gym four or more times a week (68%) (Table 2); for this variable, significant differences were found in the bivariate analysis for the use of NS (p=0.001). On the other hand, with regard to the duration of each training session, the behaviour of men and women is similar. Of the total sample, a duration of less than 2 hours predominated with 67.4% (p=0.004).

Questions on the training goal revealed that the three key goals of the men were, in descending order: gain muscle mass, lower body fat and improve health with 21.6%, 19.5% and 18.3% respectively. According to the women respondents, training is primarily to lower body fat, improve health and improve physical condition with 24.9%, 24.1% and 18.4% respectively (Table 2).

With regard to the consumption of NS, 43.2% of respondents declared that they had taken NS in the last month, while 56.8% said that they had not done so. Men show a greater intake of NS than women, represented by 50.3% of men versus 35.1% of women (Figure 1).

When detailing this information, we detected the intake of 26 different types of NS used by respondents, where the most-consumed NS

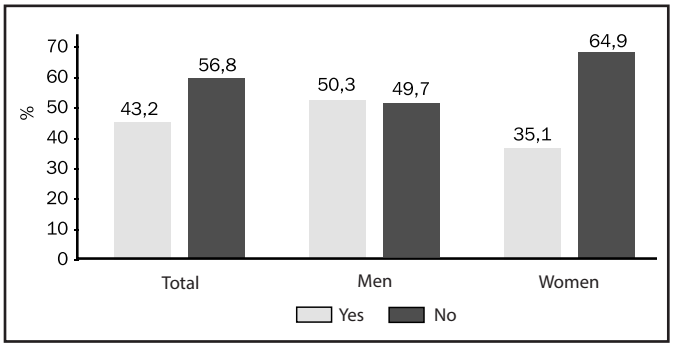
Table 1 General characterisation of the sample according to age, level of education and occupation. Each variable is also shown in relation to the total for each sex.

Characteristics	Total n (%) 359 (100)	Men n (%) 191 (53.2)	Women n (%) 168 (46.8)
Age groups (years)			
18 to 29	197 (54.9)	116 (60.7)	81 (48.2)
30 to 39	86 (24)	40 (20.9)	46 (27.4)
40 to 49	56 (15.6)	27 (14.1)	29 (17.3)
50 to 59	17 (4.7)	7 (3.7)	10 (6)
60 to 69	3 (0.8)	1 (0.5)	2 (1.2)
Level of education			
School	71 (19.8)	38 (19.9)	33 (19.6)
Vocational training	57 (15.9)	27 (14.1)	30 (17.9)
University	231 (64.3)	126 (66)	105 (62.5)
Occupation			
Student	105 (29.2)	59 (30.9)	46 (27.4)
Worker	213 (59.3)	122 (63.9)	91 (54.2)
Unemployed	39 (10.8)	8 (4.1)	31 (18.5)
Professional athlete	2 (0.6)	2 (1)	0 (0)

Table 2. Characterisation of the sample based on gym attendance time, frequency, duration and training goals. Each variable is also shown in relation to the total for each sex.

Characteristics	Total n (%)	Men n (%)	Women n (%)
Gym attendance time			
Less than 1 year	149 (41.5)	72 (37.7)	77 (45.8)
1 to 3 years	105 (29.2)	55 (28.8)	50 (29.8)
3 to 5 years	39 (10.9)	23 (12)	16 (9.5)
More than 5 years	66 (18.4)	41 (21.5)	25 (14.9)
Training frequency			
≤3 times a week	115 (32)	50 (26.2)	65 (38.7)
≤4 times a week	244 (68)	141 (73.8)	103 (61.3)
Training duration			
< 2 hours	242 (67.4)	133 (69.6)	109 (64.9)
≥2 hours	117 (32.6)	58 (30.4)	59 (35.1)
Training goals			
Lower body fat percentage	170 (22.1)	78 (19.5)	92 (24.9)
Improve health	162 (21.1)	73 (18.3)	89 (24.1)
Gain muscle mass	135 (17.6)	86 (21.6)	49 (13.3)
Improve physical condition	132 (17.2)	64 (16)	68 (18.4)
Improve athletic performance	72 (9.4)	48 (12)	24 (6.5)
Maintain physical condition	68 (8.9)	38 (9.5)	30 (8.1)
Other	29 (3.8)	12 (3)	17 (4.6)
Total	**768 (100)**	**399 (100)**	**369 (100)**

Figure 1. Percentage distribution of the use of nutritional supplements according to sex.



for the total sample were: milk whey protein (72.9%), branched amino acids (21.9%), glutamine (9.7%), lipolytic agents (9%) and multivitamins (7.1%). When analysing the data by sex, the men preferred, in descending order, milk whey protein (80.2%), branched amino acids (27.1%) and glutamine (11.5%), while the intake of women was preferentially milk whey protein (61%), branched chain amino acids (13.6%) and lipolytic agents (13.6%) (Table 3).

The main reasons for the intake of NS in the total of the sample was to gain muscle mass (31.6%), improve recovery (21.1%) and lower body fat (14.3%), finding similar results in men and women (Table 4).

In relation to the sources of information used by the respondents when deciding on which NS to use, the most important sources were: trainer (34.1%), friend (17.7%) and other (15.9%). If analysed according to sex, it is important to note that, in the case of men 35% used NS recommended by their trainer, followed by 20.4% recommended by a friend and 14.6% who obtained the information through the Internet.

Table 3. Consumption of nutritional supplements by sex and classification grouping according to the ABCD system of the Australian Institute of Sport.

Nutritional supplements	Total n (%)	Men n (%)	Women n (%)	Classification ABCD
Milk whey proteins	113 (72.9)	77 (80.2)	36 (61)	A
Branched-chain amino acids	34 (21.9)	26 (27.1)	8 (13.6)	C
Glutamine	15 (9.7)	11 (11.5)	4 (6.8)	B
Lipolytic agents	14 (9)	6 (6.3)	8 (13.6)	C
Vitamin complex	11 (7.1)	5 (5.2)	6 (10.2)	A
Liquid meals	9 (5.8)	2 (2.1)	7 (11.9)	A
Pre-training	7 (4.5)	7 (7.3)	0 (0)	C
Caffeine	5 (3.2)	3 (3.1)	2 (3.4)	A
Creatine	5 (3.2)	5 (5.2)	0 (0)	A
Spirulina	5 (3.2)	2 (2.1)	3 (5.1)	C
Green tea	4 (2.6)	1 (1)	3 (5.1)	C
Weight gainer	3 (1.9)	3 (3.1)	0 (0)	C
Proteins (meat)	3 (1.9)	2 (2.1)	1 (1.7)	C
Omega 3	3 (1.9)	2 (2.1)	1 (1.7)	B
Vitamin C	3 (1.9)	2 (2.1)	1 (1.7)	B
Proteins (Casein)	3 (1.9)	2 (2.1)	1 (1.7)	C
Collagen	3 (1.9)	1 (1)	2 (3.4)	C
Proteins (vegetable)	2 (1.3)	1 (1)	1 (1.7)	C
Energy drink	2 (1.3)	2 (2.1)	0 (0)	C
Guarana	2 (1.3)	0 (0)	2 (3.4)	C
Vitamin B complex	2 (1.3)	1 (1)	1 (1.7)	B
Arginine	2 (1.3)	2 (2.1)	0 (0)	C
Testosterone production booster	1 (0,6)	1 (1)	0 (0)	D
Magnesium	1 (0.6)	0 (0)	1 (1.7)	A
Calcium	1 (0.6)	0 (0)	1 (1.7)	A
L-carnitine	1 (0.6)	0 (0)	1 (1.7)	B
Total	254	164	90	

Table 4. Characterisation of the goals of NS intake, source of information or recommendation for NS intake and perception of the efficacy of use in relation to the goals.

Characteristics	Total n (%)	Men n (%)	Women n (%)
Goal of NS intake			
Gain muscle mass	84 (31.6)	52 (33.1)	32 (29.4)
Improve recovery	56 (21.1)	38 (24.2)	18 (16.5)
Reduce body fat	38 (14.3)	20 (12.7)	18 (16.5)
Obtain energy	33 (12.4)	17 (10.8)	16 (14.7)
Improve athletic performance	26 (9.8)	18 (11.5)	8 (7.3)
Improve health	20 (7.5)	6 (3.8)	14 (12.8)
Other	9 (3.4)	6 (3.8)	3 (2.8)
Total	266 (100)	157 (100)	109 (100)
NS intake recommended by:			
Trainer	56 (34.1)	36 (35)	20 (32.8)
Friend	29 (17.7)	21 (20.4)	8 (13.1)
Other	26 (15.9)	14 (13.6)	12 (19.7)
Healthcare professional	25 (15.2)	12 (11.7)	13 (21.3)
Internet	19 (11.6)	15 (14.6)	4 (6.6)
NS salesperson	9 (5.5)	5 (4.9)	4 (6.6)
Total	164 (100)	103 (100)	61 (100)
Perception of the efficacy of use of NS			
Yes	141 (90.9)	93 (96.9)	48 (81.4)
No	14 (9)	3 (3.1)	11 (18.6)

For their part, in descending order, the women's intake of NS as recommended by the trainer, healthcare professional and "other" was 32.8%, 21.3% and 19.7% respectively. It should be mentioned that only 15.2% of the total number of respondents referred to the intake of NS as a result of recommendations given by a healthcare professional (Table 4).

When classifying the 26 different types of NS used by the respondents, based on the Sports Supplement Program of the Australian Institute of Sport, it was found that 30.8% were type A (supported for use in specific situations in sport), 15.4% as type B (further investigation required), 50% as type C (little meaningful proof of beneficial effects) and 3.8% as type D (Banned or with a high risk of contamination that could lead to a positive test for illegal substances) (Table 3).

It should be mentioned that participants indicated an average investment of 72±65 USD a month in the purchase of NS, with no significant differences between the amount invested by sex.

With regard to the perception of the efficacy of the NS intake in relation to the goals, Table 4 shows that 96.9% of men and 81.4% of women report that the intake of NS enabled them to achieve their goals.

With regard to nutrition, 59.9% of respondents stated that they followed a healthy meal plan based on their training goals (p=0.001), with the principal sources of information being, healthcare professional, "other" and internet with 32.7%, 25.7% and 17.7% respectively (p=0.018) (Table 5).

The multivariate logistic regression analysis included all the variables in the study, making it possible to identify those variables that showed no significant differences. Finally, the variables "hours of training" and "who indicated or recommended the use of NS" were considered to be confounding, highlighting the fact that, the greater the number of weekly training hours the greater the probability of taking NS (p=0.005), controlling the variable of who recommends the use of NS. With regard to the variable for who indicates or recommends the use of NS, associated with a greater use of NS, this was the seller, followed by a friend and healthcare professional, as shown in Table 6.

Discussion

This investigation made it possible to analyse the use of NS for gym-goers at all the branches of a chain of gyms in the region of Coquimbo, Chile, where it was found that the variables for hours of training and who indicates or recommends the use of NS are confounding and are directly related to the use of NS (statistically significant).

With regard to the variables for gym attendance, training duration and the following of a nutrition plan, these are statistically associated with the intake of NS. In contrast, the variables for age, sex, level of education, occupation, gym attendance time, number of training targets and who recommended the nutrition plan, showed no significant differences using the Fisher test for the use of NS.

With regard to the prevalence of intake of NS, this was 43.2%. Although the results obtained are similar to those presented in other investigations, the figure mentioned is greater than those reported in prior studies conducted in Beirut, Lebanon (36.3%), Belo Horizonte, Brazil (36.8%), Tanta, Egypt (38.2%), and Athens, Greece (41%) and lower than those found in Riyadh, Saudi Arabia (47.9%), Sevilla, Spain (56.1%) and New York, USA (84.7%)[8,16–19,24]. Likewise, when compared to similar studies conducted in Chile, the result is greater than the prevalence found in the city of Santiago with 28.6% and is lower than that found in the city of Viña del Mar, with 54.5%[21,22].

With regard to the NS intake characteristics. Of the total of 26 substances used by the gym goers, the five most used were: milk whey protein, branched chain amino acids, glutamine, lipolytic agents and multivitamins. Similar results were reported in studies conducted on active gym goers in Chile and Saudi Arabia[17,21,22], which found a high use of proteins, amino acids and multivitamins.

Although the prevalence of use of NS in the gyms evaluated in the Region of Coquimbo could be considered to be high, studies of elite athletes show that the prevalence in this population is even greater, as reported by Jongkyu et al, who studied Korean Olympic athletes from different disciplines, finding an 80% intake of NS. However, when analysing the most-used NS, certain similarities can be found with other investigations. In the case of the Korean elite athletes, the three most-used NS were vitamins (63%), oriental supplements (mainly infusions) (58%) and amino acids (25%)[25], a similar situation was reported by Omeragić *et al*, in a study conducted on elite athletes from Bosnia and Herzegovina, where use of amino acid supplements and single vitamins or multivitamins were the most prevalent[26]. Another study, made on Dutch elite and sub-elite athletes revealed that 84.7% of respondents had used NS in the last 4 weeks, highlighting multivitamins and minerals (42.9%), isotonic drinks (44.1%) and caffeine (13%)[27]. This is in line with what Maughan et al reported, who mentioned that the more years of experience, the greater the belief that diet is insufficient to cover the requirements associated with exercise[28]. This indicates the relationship that could exist between the years of training and the use of NS, a similar situation to that shown by gym-goers in this present study.

Table 5. Following of a nutrition plan based on training goals and source of information.

Characteristics	Total n (%)	Men n (%)	Women n (%)
Following of a nutrition plan			
Yes	215 (59.9)	125 (65.1)	90 (53.9)
No	144 (40.1)	67 (34.9)	77 (46.1)
Total	359 (100)	192 (100)	167 (100)
Suggestion or recommendation of a nutrition plan			
Healthcare professional	74 (32.7)	37 (28.9)	37 (37.8)
Other	58 (25.7)	35 (27.3)	23 (23.5)
Internet	40 (17.7)	27 (21.1)	13 (13.3)
Trainer	36 (15.9)	20 (15.6)	16 (16.3)
Friend	18 (8)	9 (7)	9 (9.2)
Total	226 (100)	128 (100)	98 (100)

Table 6. Multivariate logistic regression analysis of the intake of nutritional supplements.

Variables	Coefficient	Standard Dev	Confidence interval		P Value
Hours of training	0.64	0.22	0.19	1.09	0.005
Prescription of seller in comparison with:					
Healthcare professional	-1.36	0.47	-2.29	-0.43	0.004
Trainer	-1.81	0.66	-3.12	-0.49	0.007
Friend	-1.04	0.52	-2.07	-0.01	0.047
Internet	-1.28	0.49	-2.25	-0.32	0.009

When analysing the reason why the respondents consume NS, these were principally to gain muscle mass (32%), improve recovery (21%) and reduce body fat (14%). These results show that, in most cases, participants are seeking to meet goals that are more associated with fitness and aesthetics rather than sport performance. These results are in line with those found in other, similar investigations[17,22].

The fact that almost 50% of respondents use NS raises the question whether, in actual fact, so many individuals actually have an unbalanced diet, making it necessary to ingest NS in order to cover the nutrient deficiency, as there is sufficient evidence to indicate that the physically active population does not require additional nutrients to those provided by a balanced diet[29] or whether, in actual fact, marketing and a lack of knowledge, leads them to ingest products that they probably do not need. This aspect is relevant, considering the fact that the respondents state that they invest an average of 72 USD a month in the purchase of NS, of which only 30.8% correspond to NS with solid scientific evidence of their efficacy and safety. Added to the above, only 15% of respondents state that the use of NS was recommended by a professional in the area of healthcare or nutrition. This scenario could contribute to a greater use of NS with little scientific evidence or, even worse, the use of NS could represent a health risk. This question takes on even more importance if it is considered that 50% of the NS consumed by respondents are classified as type C (little meaningful proof of beneficial effects), according to the sports supplement programme of the Australian Institute of Sport, a result that is lower than the 57.9% reported by Jorquera et al in a study conducted in Santiago de Chile[22].

In relation to the above, a study conducted by Shaw on Australian elite swimmers is worth mentioning. This study evaluated the influence that the sports supplement programme of the Australian Institute of Sport had on the NS practices of these athletes. This showed that swimmers taking part in this programme reported that their principal advisers were dietitians and sports physicians, and this was related to a greater use of NS with evidence of its ergogenic effect, compared to those that were not part of the sports supplement programme, who tended to consume NS primarily recommended by other athletes and the NS consumed by these athletes tended to have little scientific evidence with regard to efficacy[30]. These results are in line with those found in this present investigation. This is relevant, if it is considered that it has been observed that the use of NS is greater in athletes, regardless of the potential risk to health involved[31].

On the other hand, of the 60% of respondents reporting that they followed a nutrition plan to achieve their goals, it should be highlighted that 59.3% reported that they did not consult a dietician or healthcare professional to define what changes needed to be made to their eating habits. This would probably cause them to have inadequate habits, largely due to the fact that the sources of information selected are neither suitable nor the right ones to give scientifically supported nutritional recommendations, which could negatively affect the achievement of goals, physical performance or even their health.

The results of this present investigation show that 43% of the users of a chain of gyms in the region of Coquimbo report use of nutritional supplements. Within the variables directly influencing the use of NS are the hours of training and who recommends the use of NS. In relation to the other variables studied, no significant differences were found based on the use of NS.

With regard to the most-used NS type, it should be emphasised that only 30.8% are classified as type A, revealing a high use of NS with little scientific evidence to support its efficacy and safety. This is relevant information for science of nutrition applied to sport and performance, considering that the maintenance of the energy and nutritional balance is fundamental in order to improve sport performance and permit the changes caused by training[32]. In view of the foregoing, this study is of great significance for applied sports and performance nutrition, as it supports the importance of specialist advice for gym goers in order to avoid the use of ineffective products and/or that could be harmful to health, thereby promoting the use of nutrients in suitable doses, times and frequencies in order to achieve the goals of each user[28].

Finally, this study establishes a baseline for future investigations related to the use and intake of nutritional supplements. For this, we would suggest an evaluation of the use of NS in the sports area, considering variables such as: different sports disciplines, both in formative and competitive stages, training periods, seasonality, among others.

Conflict of interests

There was no conflict of interests in this investigation.

Bibliography

1. Nogueira JAD, Da Costa THM. Nutrient Intake and Eating Habits of Triathletes on a Brazilian Diet. *Int J Sport Nutr Exerc Metab.* 2004;14:684–97.
2. Baar K. Nutrition and the adaptation to endurance training. *Sports Med Auckl NZ.* 2014;44 Suppl 1:S5–12.
3. Martínez-Sanz, J. M., Urdampilleta, A., Mielgo-Ayuso, J. Necesidades energéticas, hídricas y nutricionales en el deporte. *Eur J Hum Mov*. 2013;30:37–52.
4. Folasire OF, Akomolafe AA, Sanusi RA. Does Nutrition Knowledge and Practice of Athletes Translate to Enhanced Athletic Performance? Cross-Sectional Study Amongst Nigerian Undergraduate Athletes. *Glob J Health Sci*. 2015;7:215–25.
5. Ozdoğan Y, Ozcelik AO. Evaluation of the nutrition knowledge of sports department students of universities. *J Int Soc Sports Nutr.* 2011;8:11.
6. Burke L. *Nutrición en el deporte, un enfoque práctico.* Madrid. Editorial médica panamericana; 2010. p. 18-19.
7. Thomas DT, Erdman KA, Burke LM. Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. *J Acad Nutr Diet.* 2016;116(3):501–28.
8. Sanchez Oliver A, Miranda León MT, Guerra Hernández E. Estudio estadístico del consumo de suplementos nutricionales y dietéticos en gimnasios. *Arch Latinoam Nutr.* 2008;58:221–7.
9. Sundell J, Hulmi J, Rossi J. Whey protein and creatine as nutritional supplements. *Duodecim*. 2011;127:700–5.
10. Van Thuyne W, Van Eenoo P, Delbeke FT. Nutritional supplements: prevalence of use and contamination with doping agents. *Nutr Res Rev*. 2006;19:147–58.
11. Bianco A, Mammina C, Thomas E, Ciulla F, Pupella U, Gagliardo F, *et al.* Protein supplements consumption: a comparative study between the city centre and the suburbs of Palermo, Italy. *BMC Sports Sci Med Rehabil.* 2014;6:29.
12. De Rose EH, Feder MG, Pedroso PR, Guimarães AZ. Uso referido de medicamentos e suplementos alimentares nos atletas selecionados para controle de doping nos Jogos Sul-Americanos. *Rev Bras Med Esporte.* 2006;12:239–42.
13. Geyer H, Parr MK, Koehler K, Mareck U, Schanzer W, Thevis M. Nutritional supplements cross-contaminated and faked with doping substances. *J Mass Spectrom JMS.* 2008;43:892–902.

14. Kohler M, Thomas A, Geyer H, Petrou M, Schanzer W, Thevis M. Confiscated black market products and nutritional supplements with non-approved ingredients analyzed in the Cologne Doping Control Laboratory 2009. *Drug Test Anal.* 2010;2:533–7.
15. Leifman H, Rehnman C, Sjoblom E, Holgersson S. Anabolic androgenic steroids - use and correlates among gym users - An assessment Study using questionnaires and observations at gyms in the Stockholm Region. *Int. J. Environ. Res. Public Health*. 2011;8:2656-74.
16. Abo Ali EA, Elgamal HH. Use of dietary supplements among gym trainees in Tanta city, Egypt. *J Egypt Public Health Assoc*. 2016;91:185–91.
17. Alshammari SA, AlShowair MA, AlRuhaim A. Use of hormones and nutritional supplements among gyms' attendees in Riyadh. *J Fam Community Med.* 2017;24:6–12.
18. El Khoury D, Antoine-Jonville S. Intake of Nutritional Supplements among People Exercising in Gyms in Beirut City. *J Nutr Metab*. 2012;1–12.
19. Morrison LJ, Gizis F, Shorter B. Prevalent use of dietary supplements among people who exercise at a commercial gym. *Int J Sport Nutr Exerc Metab.* 2004;14:481–92.
20. Tsitsimpikou C, Chrisostomou N, Papalexis P, Tsarouhas K, Tsatsakis A, Jamurtas A. The use of nutritional supplements among recreational athletes in Athens, Greece. *Int J Sport Nutr Exerc Metab.* 2011;21:377–84.
21. Rodríguez F, Crovetto M, González A, Morant N, Santibañez F. Nutritional supplement intake in gymnasium, consumer profile and characteristics of their use. *Rev Chil Nutr*. 2011;38:157–66.
22. Jorquera Aguilera C, Rodríguez-Rodríguez F, Torrealba Vieira MI, Campos Serrano J, Gracia Leiva N. Consumo, características y perfil del consumidor de suplementos nutricionales en gimnasios de Santiago de Chile. *Rev Andal Med Deporte.* 2016;9:99–104.
23. Australian Sports Commission. Classification. (Material electrónico) (consultado 0812/2016). Disponible en: http://www.ausport.gov.au/ais/nutrition/supplements/classification
24. Goston JL, Correia MITD. Intake of nutritional supplements among people exercising in gyms and influencing factors. *Nutr Burbank Los Angel Cty Calif.* 2010;26:604–11.
25. Kim J, Kang SK, Jung HS, Chun YS, Trilk J, Jung SH. Dietary Supplementation Patterns of Korean Olympic Athletes Participating in the Beijing 2008 Summer Olympic Games. *Int J Sport Nutr Exerc Metab.* 2011;21:166–74.
26. Omeragić E, Đeđibegović J, Sober M, Marjanović A, Dedić M, Niksić H, *et al.* Use of dietary supplements among elite athletes. *SportLogia*. 2015;11:49–56.
27. Wardenaar FC, Ceelen IJ, Van Dijk J-W, Hangelbroek RW, Van Roy L, Van der Pouw B, *et al.* Nutritional Supplement Use by Dutch Elite and Sub-Elite Athletes: Does Receiving Dietary Counselling Make a Difference? *Int J Sport Nutr Exerc Metab.* 2016;1–25.
28. Maughan RJ, Depiesse F, Geyer H. The use of dietary supplements by athletes. *J Sports Sci.* 2007;25 Suppl 1:S103–13.
29. Smith-Rockwell M, Nickols-Richardson SM, Thye FW. Nutrition knowledge, opinions, and practices of coaches and athletic trainers at a division 1 university. *Int J Sport Nutr Exerc Metab.* 2001;11:174–85.
30. Shaw G, Slater G, Burke LM. Supplement Use of Elite Australian Swimmers. *Int J Sport Nutr Exerc Metab*. 2016;26:249–58.
31. Salgado JVV, Lollo PCB, Amaya-Farfan J, Chacon-Mikahil MP. Dietary supplement usage and motivation in Brazilian road runners. *J Int Soc Sports Nutr.* 2014;11:41.
32. Kreider RB, Wilborn CD, Taylor L, Campbell B, Almada AL, Collins R, *et al*. ISSN exercise & sport nutrition review: research & recommendations. *J Int Soc Sports Nutr.* 2010;7:7.

Distance Covered and Activity Analysis of Football Players during World Cup 2014

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Summary

Introduction: In the sport at top level of competition physical activities profile may be influenced by several factors as well as environmental or biological factors. Some factors in football strongly effect on team success. Distance covered and maximum speed of players during a full match will show important data to the coaches.
Objectives: Analyzing distance covered and maximum speed of football players during FIFA World Cup, 2014 was the main purpose of this investigation. This data was analyzed by player positions and team ranking.
Methods: Activity profile of 474 football players including 104 forwards, 163 midfielders, 169 defenders and 38 goalkeepers, which played minimum 90 minutes at this tournament were analyzed by the researcher at this study. Distance covered in per minutes and maximum speed analyzed by routine methods according to player positions and team ranking.
Results: Analyzing data by one way ANOVA has shown that the distance covered by player was significantly different by player position $P<0.05$. The data of research has shown that maximum speed of players was significantly different between players according to their position $P<0.05$. The comparison of distance covered during game at condition in possession has shown that there are significant differences at the distance covered with this condition between groups $P<0.05$.
Conclusion: In conclusion players need to improve their endurance performance according to their match position. Endurance performance ability is not only used to determine distance covered by the players. By the way there are several factors that may influenced at the profile activities such as tactical manners by the coaches.

Key words:
Soccer. Football. Distance covered. Endurance. Player activity.

Distancia recorrida y análisis de actividad en jugadores de fútbol en el mundial de 2014

Resumen

Introducción: En el deporte de élite, la condición física puede estar influenciada por factores biológicos o externos. Algunos de estos factores pueden afectar en gran medida al éxito del equipo. La distancia recorrida y velocidad máxima de cada jugador durante el partido puede dar datos importantes a los entrenadores.
Objetivos: Analizar la distancia recorrida y la velocidad máxima en jugadores de fútbol durante el mundial FIFA de 2014 fue el principal objetivo de esta investigación. Estos datos se analizaron en función de las posiciones de cada jugador y el ranking del equipo.
Resultados: Analizando los datos de una Anova de un factor, observamos que la distancia recorrida por cada jugador fue significativamente diferente en función de la posición de juego ($p<0,05$). Los datos de la investigación han mostrado que la velocidad máxima es significativamente diferente entre jugadores en función de su posición ($p<0,05$). La comparación de la distancia recorrida durante el partido muestra que existen diferencias estadísticamente significativas entre grupos ($p<0,05$).
Conclusión: Los jugadores necesitan mejorar su resistencia en función de su posición de juego. El rendimiento en resistencia no es solo variable para determinar la distancia recorrida por los jugadores. Hay muchos factores que pueden influir en la actividad como las tácticas del entrenador.

Palabras clave:
Fútbol. Distancia cubierta. Resistencia. Actividad del jugador.

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Introduction

Football is one of the most popular sports during recent century. At this sport several aspect of human body are involved. Both of physical and mental preparations required for success at this sport. The Football is a high demanding energy sport, thus players need to improve their fitness in several aspects as well as aerobic and anaerobic capacities[1]. In football players, performance may be influenced by a number of physiological and environmental factors. Researchers have found that football is multi-demanding energy system sport. We need to improve all aspect of energy system for a football team. By the way it has been shown that there are differences between energy system specificity at the player's position at the field. For example goalkeepers need to improve their Alactic energy system more than the others[2]. It has been shown that aerobic and anaerobic energy system are also important components of football players at the forward and mid and defend positions[3]. Improving aerobic energy system may help players to run effectively during a full time game. Any decrease of aerobic energy system directly effect on aerobic capacity and distance covered by players during a football game[4]. Coaches and sport scientists need to monitor running ability of football players during training and completions. Distance Covered (DC) is the most important factor to determinate player's ability in competitions[5]. It has been shown that distance covered during football games strongly influenced on team success. Of course some other factors are involved in football games which may effect on football results. By the way DC has key role of completion success during official tournament[6-8].

Previously the only data for influence of the aerobic energy system and distance covered has only shown at the sport science books or practical reports, but nowadays researchers may track the DC real time during games and analyze it after games. The technology helped researchers at this area[9,10]. Now it is time to show coaches important aspects of players and team successfully with these type of technology.

Sport analysis and tracing system by the new technology in software and hardware help coaches to find the results and reports to improve player's ability[11]. In order to gain the enough knowledge and information during soccer games, researchers need to applied several technologies. Analysis of game activities also provides information regarding to the positions physiological requirements[12].

Activity profiles of player during world cup 2010 has been investigated by Filipe and his colleagues. They have shown that midfielders have recorded more distance covered by almost 120 meters per minute and goalkeepers recorded nearly of 45m/min[13]. Several investigations have shown differences of activities profile of players during football game and they mentioned that these activities may affected by player fitness and tactical and positional differences[14]. Identifying of physical activities profile by player at top level of competition will help coaches to find weaknesses of their players and design training plan according to influenced factors at successful. At the top level of football competition researchers need to know differences conditioning status in compare between teams. Some researchers they believe that there is not conditioning and fitness differences between players at this level and the only experiences or tactical factors are important.

The major objective of this study is to investigate player activities and distance cover during football world cup 2014. In this study position related distance covered, world cup final ranking and players distance covered analyzed.

Material and method

Data and information of 474 soccer players who had minimum 90 minutes in world cup 2014, Brazil, were applied in this study. Total of 607 players with height 181.19±6.69 and age 27.42±3.79 were played in this event. For improve accuracy of this research, only used data from players who had minimum 90 minutes obtained. Players which played less than 90 minutes during this tournament were removed from list of data Information was obtained from official website of FIFA World Cup 2014. Number of match played, total playing time (minutes), total distance covered, distance covered in possession and distance covered in not-possession (per minutes), age, height, average of speed, and position of each players were recorded in excel software of proceeding data analysis.

Position of players were used as the independent variable in 4 area; goal keeper, defender, midfielder and forwards. Total distance covers were obtained for per players. Distance covers in per minute and per 10 minutes were calculated. Maximum speed were obtained from physical activity player of FIFA official website and applied by meter per second at this study.

Distances covered in differences position were compared. Distance covered was compared between 4 first position teams (Germany, Argentina, Netherlands and Brazil) *versus* others teams.

Statistic method

Result of analyzing data by Kolmogorov Smirnov test has been shown non-homogeneity of sample. Due the importance aspect of parametric test at this research, the Central Limit Theorem (CLT) was applied, that allowed us to adopt the assumption of normality[15]. One-way ANOVA was applied to determination of difference between groups and the Tukey test was used as *post hoc* test. This analysis was applied by using IBM SPSS Statistics software for a significance level of 5%.

Results

At the first step, distance covered (per min) was compared by player positions. The result of statistical analysis has been show significant difference between groups at distance cover $F(3, 470) = 611.945$; $P<0.05$. The post hoc test has been shown that largest distance cover at the midfielders. Players at the defend position were at the second rank after midfielders. Midfielders player were significantly different at DC with defenders ($p<0.05$), forwards ($p<0.05|$) and with goalkeepers ($p<0.05$).

At the second step, speed by the posts (Maximum Speed) was compared by player positions. The result of statistical analysis has been show significant difference between groups at maximum speed $F(3, 470) = 131.690$; $P<0.05$. The post hoc test has been shown that higher speed at the midfielders. Players at the defend position were at the second rank after forward players. Forwards player were significantly different at maximum speed with goalkeepers ($p<0.05$), midfield players ($p<0.05|$) but not to defenders ($p<0.497$) (Figure 1).

Figure 1. Comparison at distance covered by player according to players positions.

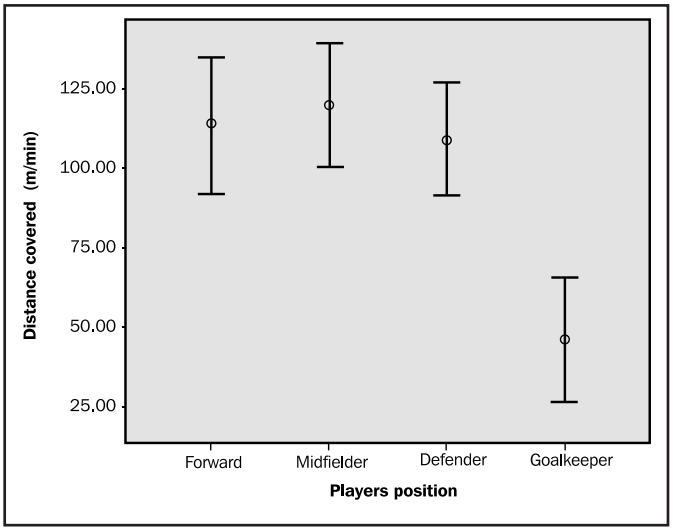
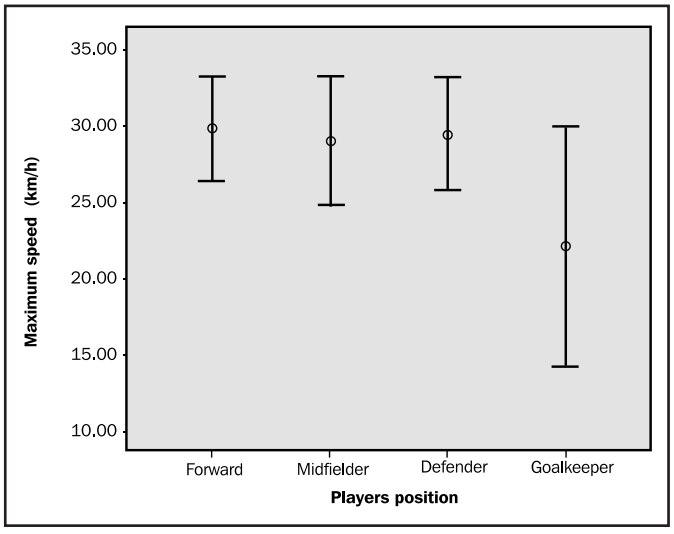


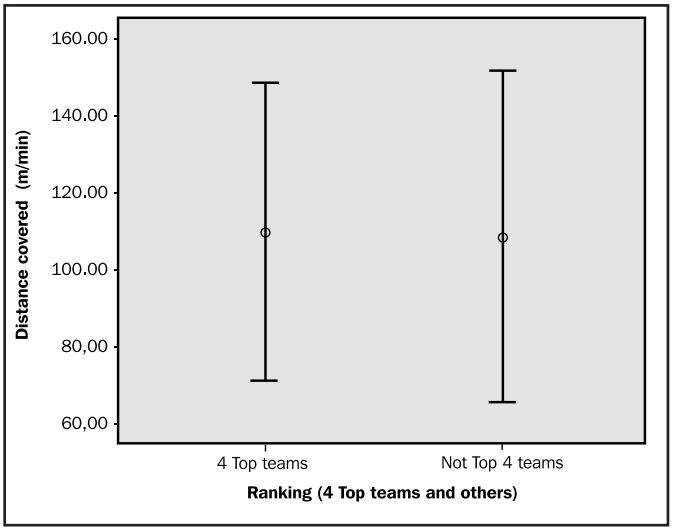
Figure 2. Comparison of Maximum Speed according to player positions.



Result of one way analysis of variance at the distance covered (per 90 minutes) while in possession at the player positions has been shown significant differences F(3,470)=190.725; P<0.05. Statistical analysis and also has been confirmed significant differences at the distance cover (per 90 minutes) at the player position while not in possession F (3, 470) =230.273; P<0.05. These results have been shown largest distance cover per 90 minutes at both conditions among the midfielder players. At the condition of in possession, forward position was at the second rank at distance cover after midfielders. Defenders were at the second position in condition of not in possession (Figure 2).

At the next step, researcher compared distance cover (per minute) according to teams ranking. Four team by the best position (one to four); players of Germany, Argentina, Poland and Brazil, were compared with others. Statistical result has been shown there is not nay significant differences at DC between groups F (1, 472) =0.190; P=0.663. It has been shown there is not any significant difference at the distance cover during not in possession has been shown there is not there is not nay significant differences at DC during not in possession between groups F (1, 472) =1.826; P=0.177.

Figure 3. Comparison of Distance Covered by teams according their ranking- Top 4 teams in compare to others.



The comparison of distance cover during game at condition in possession has been shown that there is significant differences at the distance cover with this condition between groups F (1, 472) =10.753; P=0.01. This result has been shown top four team were with higher at distance cover in this condition. Maximum speed also has been reported with higher speed at top 4 team than others F (1, 472) =12.862; P=0.000 (Figure 3).

Discussion and Conclusion

Player's performance at the several variables as well as distance cover and maximum speed were analyzed at the several studies[5,10,16]. It has been shown that there is strong relationship between player's positions and distance covered during the game and maximum speed too[17,18].

The main purpose of the current study was to analyze player performance during game according to player positions and team ranks at the world cup 2014 Brazil. This study examined distance covered by players and maximum speed at four positions. Researcher also compared DC and Maximum speed at teams according to their ranking at this event. Result of this study has been shown highest distance covered by players at midfielder players. The forward players was at the second position regarding to distance covered at per game. In support of this results Mohr *et al.* reported the largest distance covered by midfielder players. They also reported forward players were at the second rank at distance covered after midfielders[18].

This research confirmed that midfield players covered highest distance covered during the game, because they are linking between defends and forward players during the matches[13]. This study also

has been reported highest amount of distance cover by midfielders by both possession and not-in-possession condition. They covered a small amount more during not-in-possession condition. Bangsbo *et al.* have been reported same distance covered by defenders and forward players during the game[19].

The distance covered strongly related to the tactical manners of the coaches. The differences method at tactics has been shown between the teams. This research for the first time has compared player's distance covered between 4 top team at world cup 2014 and other teams that were participated at this tournament.

The result of this study has been shown, there is not significant differences at the distance covered by player between 4 top teams and other teams, but comparison of distance covered by teams according to in possession and not in possession has been shown significant higher at distance cover during in possession by 4 top teams than the others. Interesting find outs in this study mean of 374 m higher at distance covered at per 90 min of match at 4 top teams player than the other teams.

Improving aerobic performance and endurance abilities at the football player is very important at games successfully[20]. Endurance performance strongly effect of distance covered. Players normally spend with mean of 70% of maximum oxygen uptake during 90 min football game[21]. By the way some time tactical methods by the coaches may make the players at limited conditions and they are not allow to run despite their abilities.

Maximum speed of players has been monitored during match by several researchers[18,22]. Nowadays technology help researcher to tack at real time player at the field. This study confirmed that forward players were with highest amount of maximal speed. Defenders and midfielder were at the next step respectively. Forward players need special ability to reach the goal. At this time teams with defender at highest level of speed will be more successful in front of these forward players. By the way has been well documented that speed of player need another variable to be complete. This variable is acceleration[23].

Researcher at this study notice that the distance covered will not be alone cause of competition successfully. The tactical and technical readiness and experience of players at related strategy are important. Consequently at the high level of competitions players need to prepare in multi aspect to show their highest performance level at the match. This study were limited by finding some data as well as weight of players. At conclusion researcher suggest players and coach to improve their ability according fitness demand related to their position. At this study has been shown strong effect of distance covered during in possession time at four top teams. This data confirmed that not only ability to distance covered also speed, acceleration influenced at team successfully. By the way for several limitation researcher has not access to full activity profile of players during the tournament. Researcher recommend to compare physical activities of player with women's world cup. Also physical activity profile according to result of competitions are strongly recommended for feature research.

The data of current study may apply by coaches and player to find the best way for improving players according to factors influenced at team successfully. Distance cover as the important factor for team successfully at the world cup strongly related by endurance performance. Several factors as well as lactate lactate threshold, economy of activity, fraction utilization and strength and endurance of muscle effect on endurance performance.

Conflict of interest

The authors do not declare a conflict of interest.

Bibliography

1. Aslan A, AcikadaGüvenç C, Güvenç A, Gören H, Hazir T, Özkara A. Metabolic demands of match performance in young soccer players. *J Sports Sci Med*. 2012;11(1):170-9.
2. Verheijen R. *The complete handbook of conditioning for soccer*. Spring City. Reedswain Inc;1998. p 76-90.
3. Tumilty D. Physiological characteristics of elite soccer players. *Sports Med.* 1993;16(2):80-96.
4. Reilly T, Drust B, Clarke N. Muscle fatigue during football match-play. *Sports Med*. 2008;38(5):357-67.
5. Reilly T, Gilbourne D. Science and football: a review of applied research in the football codes. *J Sports Sci*. 2003;21(9):693-705.
6. Carling C. Influence of opposition team formation on physical and skill-related performance in a professional soccer team. *Eur J. Sport Sci.* 2011;11(3):155-64.
7. Miyagi O, Ohashi J, Kitagawa K. Motion characteristics of an elite soccer player during a game. *J Sports Sci.* 1999;17(10):26-35.
8. Andrzejewski M, Chmura J, Pluta B, Kasprzak A. Analysis of motor activities of professional soccer players. *J Strength Cond Res.* 2012;26(6):1481-8.
9. Edgecomb SJ, Norton KI. Comparison of global positioning and computer-based tracking systems for measuring player movement distance during Australian football. *J Sci Med Sport*. 2006;9(1):25-32.
10. Xu M, Orwell J, Jones G. Tracking football players with multiple cameras. Velastin SA, Remagnino P. in Intelligent Distributed Video Surveillance Systems. London: Institution of Electrical Engineers; 2004. p 2909-12.
11. Castellano J, Alvarez-Pastor D, Bradley PS. Evaluation of research using computerised tracking systems (Amisco and Prozone) to analyse physical performance in elite soccer: a systematic review. *Sports Med*. 2014;44(5):701-12.
12. Lago-Peñas C, Rey E, Lago-Ballesteros J, Casais L, Domínguez E. Analysis of work-rate in soccer according to playing positions. *Int J Perform Anal Sport.* 2009;9(2):218-27.
13. Clemente FM, Couceiro MS, Martins L, Manuel F, Ivanova MO, Mendes R. Activity profiles of soccer players during the 2010 world cup. *J Hum Kinet.* 2013;38:201-11.
14. Lago C, Casais L, Dominguez E, Sampaio J. The effects of situational variables on distance covered at various speeds in elite soccer. *Eur J Sport Sci.* 2010;10(2):103-9.
15. Akritas MG, Papadatos N. Heteroscedastic one-way ANOVA and lack-of-fit tests. *J Am Stat Assoc.* 2004;99(466):368-82.
16. Krustrup P, Mohr M, Ellingsgaard H, Bangsbo J. Physical demands during an elite female soccer game: importance of training status. *Med Sci Sports Exerc.* 2005;37(7):1242-8.
17. Di Salvo V, Benito P, Calderon F, Di Salvo M, Pigozzi F. Activity profile of elite goalkeepers during football match-play. *J Sports Med Phys Fitness.* 2008;48(4):443-6.
18. Mohr M, Krustrup P, Bangsbo J. Match performance of high-standard soccer players with special reference to development of fatigue. *J Sports Sci.* 2003;21(7):519-28.
19. Bangsbo J, Nørregaard L, Thorsoe F. Activity profile of competition soccer. *Can J Sport Sci.* 1991;16(2):110-16.
20. Behi A, Amani A, Fahey TD, Afsharnezhad T. Effect of High Intensity Interval Training with Blood Restriction on Anaerobic Performance. *Int J Appl Exerc Physiol.* 2017;6(2):45-52.
21. Bangsbo J, Michalsik L. Assessment of the physiological capacity of elite soccer players. Spinks W, Reilly T, Murphy A. in *Science and football IV*. London: Routledge; 2002. p 53-62.
22. Little T, Williams A. Specificity of acceleration, maximum speed and agility in professional soccer players. *J Strength Cond Res.* 2003;19(1):76-8.
23. Bompa T, Buzzichelli C. Periodization Training for Sports, 3E. London. *Human kinetics;* 2015. p 107-27.

Injury occurrence and related performance factors in ACB players

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Summary

The aim of this study is to analyse whether there are significant relationships between the occurrence of injuries and official ACB statistical variables related to performance, anthropometry and play position. Statistical variables of 554 professional basketball players (age: 26.97±4.86 years, height: 199.23±8.80 cm, minutes per season: 441.18 ± 301.41) in ACB competition were analysed for two seasons (2012-13 and 2013-14). In addition, injury reports were registered and injuries were categorized taking into account OSICS-10 classification. Anthropometric variables (weight, height, BMI) and age were also analysed. Ankle (77 players; 23.7% of total injured players) and knee (52 players; 16.0% of total injured players) were the most reported injuries. There were no relationships between weight or BMI and the occurrence of injuries ($P>0.05$). Shooting-guards, power-forwards and centers suffered more injuries in average than point-guards and small-forwards ($P<0.05$). Players who reported any anatomical injury played more minutes during the regular season (527±260 *vs.* 380±315 min; $P=0.000$). Significant differences ($P<0.05$) were also found in statistics per minute of points (0.382±0,114 *vs*. 0.352±0,284), performance rating (0.391±0,172 *vs*. 0.290±0,469), rebounds (0.167±0,092 *vs.* 0.151±0,110), assists (0.066±0.045 *vs*. 0.062±0.065), goals made (0.138±0.047 *vs.* 0.125±0.083), blocks made (0.015±0.019 *vs*. 0.013±0.019), dunks (0.013±0.022 *vs*. 0.009±0,017), steals (0.034±0.015 vs. 0,032±0.024), received fouls (0.105±0.040 *vs*. 0.096±0.093), free throws attempted (0.093±0.044 *vs*. 0.091±0.166) and +/- statistic (-0.013±0.241 *vs.* -0.124±0.640). Players who were injured during the season did more actions per minute in average for every variable, excepting the blocks against. Statistical performance variables influence the occurrence of injuries, especially those variables that measure positive actions imply a higher risk of injury. Higher performance in basketball involves a higher risk of injury.

Key words:
Basketball. Injuries. Performance. Anthropometry. Game position.

Ocurrencia de lesiones y factores de rendimiento asociados en jugadores ACB

Resumen

El objetivo de este estudio es analizar la relación entre la ocurrencia de lesiones y los valores de rendimiento recogidos en las estadísticas oficiales de la liga ACB, variables antropométricas y de posición de juego. Se ha analizado la información estadística de 554 jugadores de baloncesto profesional (edad: 26,97±4,86 años, estatura: 199,23±8,80 cm, minutos por temporada: 441,18±301,41) en la liga regular ACB durante dos temporadas (2012-13 y 2013-14). Además, se han recogido los partes médicos de cada jornada y categorizado las lesiones según el sistema OSICS 10. También se han incluido variables de tipo antropométrico (peso, estatura e IMC) y la edad. Las lesiones con mayor incidencia fueron las de tobillo (77 jugadores; 23,7% del total de lesionados) y rodilla (52 jugadores; 16,0% del total de lesionados). No se encontraron relaciones entre el peso o el IMC y la ocurrencia de lesiones ($P>0,05$). Los escoltas, ala-pívots y pívots padecieron más lesiones de media que los bases y los aleros ($P<0,05$). Los jugadores que padecieron alguna lesión disputaron más minutos durante la temporada regular (527±260 *vs*. 380±315 min; $P=0,000$). Además, se observaron diferencias significativas ($P<0,05$) en las estadísticas por minuto de la liga ACB en puntos (0,382±0,114 *vs.* 0,352±0,284), valoración (0,391±0,172 *vs*. 0,290±0,469), rebotes (0,167±0,092 *vs.* 0,151±0,110), asistencias (0,066±0,045 *vs*. 0,062±0,065), tiros convertidos (0,138±0,047 *vs*. 0,125±0,083), tapones a favor (0,015±0,019 *vs.* 0,013±0,019), mates (0,013±0,022 *vs*. 0,009±0,017), recuperaciones (0,034±0,015 vs. 0,032±0,024), faltas recibidas (0,105±0,040 vs. 0,096±0,093), tiros libres intentados (0,093±0,044 vs. 0,091±0,166), estadística +/- (-0,013±0,241 *vs*. -0,124±0,640). Los jugadores que presentaron alguna lesión anatómica realizaron más acciones de media por minuto en todos los aspectos, excepto en los tapones en contra. Las variables de rendimiento estadístico de la liga ACB influyen en la ocurrencia de lesiones y las variables que indican acciones positivas implican un mayor riesgo de padecer lesiones.

Palabras clave:
Baloncesto. Lesiones. Rendimiento. Antropometría. Posición de juego.

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Introduction

Sports activities increase the risk of injury which, in some cases, could cause permanent disability[1] or joint degeneration in the long term[2]. Different types of sports are associated with certain injury patterns and types, while age, gender and type of activity (for example: recreational or competitive) are influential factors in the risk of sustaining injury[3-5]. This risk has increased in the case of practising basketball: the sport has progressed towards an increasingly more physical game in which contact is accepted and expected6. Present-day basketball emphasises the speed and power of its players, as well as the strength and rapidity required to control the opponent's position, get a rebound or shoot a basket. A greater incidence has been observed (number of injuries per player, each year) the higher the level of competition[7], with particular mention of professional levels[8,9].

Longitudinal studies on professional, university and lower category basketball players have served to describe the characteristics of the injuries occurring in this sport[10]. In general, injuries are significantly more common during a match than during training[11,12] and are more frequent when there is contact between players[13]. Although improvements have been made in the safety of playing basketball, injuries are still influential on insurance costs, lost working days and the use of medical resources[14].

In scientific literature, the epidemiology of injuries in basketball has been described, based on a number of factors. The most prominent include the total incidence of injuries on the number of injuries per hours of exposure at matches and/or training sessions[8,12,15,16], the difference in the incidence of injuries at different competition levels[15,17,18], the incidence of injuries with regard to the body site or type of injury (bruise, muscle injury, ligament strain, etc.)[6,8,12], the incidence of the injuries based on the cause of the injury (with contact, without contact, jumping, sprinting etc.) and the incidence of injuries based on anthropometric variables (age, weight BMI, height, sex, etc.)[6,15,18-20].

However, few investigations have studied the relationship existing between the occurrence of injury and the performance of players during the matches. The studies existing have mainly been conducted in the United States (NBA), studying differences in performance after sustaining long term injuries or injuries requiring surgery[21,22]. A study of the relationships between performance and incident occurrence could offer information of interest to trainers and fitness coaches and promote specific preventive type work[5,23] with the profiles of players that are most likely to sustain injury. Moreover, this information could be of assistance in decision making with regard to any changes in the rules of this sport, directed at reducing injuries.

With this aim in mind, this study is directed at analysing the occurrence of injuries and the relationship with sporting performance for basketball players in the ACB professional league, as well as the effect of the match position and anthropometric variables.

Material and method

Design

In order to analyse basketball player injuries in the ACB league, a cross-sectional, descriptive, retrospective methodology was used to study the injuries and performance of players based on the information provided by the official website of the ACB league[24] for each of the injury reports prior to each regular league match for the seasons 2012-13 and 2013-14.

Participants

The study population comprised all the players (554) forming part of the ACB league for seasons 2012-13 and 2013-14. The following requirements were established for inclusion in the study: i) to have played at least one match in the ACB league and ii) not to have played in another team in the same competition during the season. A sample of 554 ACB league players during seasons 2012-13 and 2013-14 met both requirements and, therefore, were included in this study.

Procedure

We examined the information on "Novedades y Parte Médico" (news and medical report) on the official ACB basketball league website[24], corresponding to the Regular League for seasons 2012-13 and 2013-14, with a total of 68 matches recorded. All the injury reports were obtained for all the matches played. Based on this information, we identified which league players had been injured, the type of injury sustained, recording the body site of the same. The OSICS classification was used to classify the injuries[25].

Subsequently, the total individual statistics were obtained for each player for each of the two seasons[24]. The statistics showed the performance of the players for each variable, in absolute values (total for the season) and for each match played. As the risk of sustaining injuries increased with the match exposure time in minutes[26], the original data were used to calculate the individual statistics per minute for each player. In this way, the time effect was eliminated in the correlation between actions and playing time (the greater the playing time, the more actions made). Data not related to performance were also collected, such as: height, weight, date of birth and playing position[24]. Age was calculated by deducting the player's date of birth from the year corresponding to the last regular league match played in the season studied.

Statistical analysis

Absolute frequencies and percentages were used to analyse the qualitative variables. Contingency tables with Pearson's $\chi 2$ statistic were used to analyse the relationship between qualitative variables.

For the quantitative variables, the Kolmogorov-Smirnov test was used to check the normality of the variables for a sample. The data are presented as mean ± standard deviation. To determine whether or not there are any significant differences between players sustaining a type of injury during the season, the different match performance variables were taken and a means comparison was made, using the t-test for variables with a normal distribution and the Mann-Whitney U statistic for those nonparametric variables. The significance level was set at $P<0.05$ for all cases.

The PASW Statistics 18 software program was used for the statistical analysis.

Results

Table 1 shows the results for the incidence of injuries. From this, it can be seen that the most common body injuries are to the knee (25.85%), ankle (19.17%), leg (between the ankle and knee) (12.18%) and foot (9.43%). The lower extremities account for approximately 80% of the total number of injury reports. Injuries to the ankle (23.69%), knee (16.00%), leg (between ankle and knee) (10.46%), wrist and hand (8.92%) are the most common injuries sustained by players during a season. Injuries to the knee (4.69±6.27), foot (4.68±4.93) and hip and groin (4,07±5,48) account for the greatest number of convalescence days during the season. The most common injury sustained by players (ankle) accounted for an average of 2.5±2.56 convalescence days per player. In general, each injured player lost an average of 4.21±4.54 days, slightly less (4.04±4.59) in the case of body injuries.

With regard to the percentage of players presenting a certain type of injury during the season, the most common injuries were to the ankle (13.90%), knee (9.39%) and medical illnesses or infections (9.21%).

Table 2 shows the statistical performance variables with regard to the occurrence of body injuries. During the regular season, players with some body injury played more minutes on average (527±260 *vs.* 380±315 min; P=0.000). Moreover, significant differences were observed (P<0.05) in all game statistics, both for throw statistics (attempted and made), rebounds (total, offensive and defensive), blocks (for and against), dunks, fouls received, as well as the +/- statistic (partial marker in the game while a certain player is on court), and the rating (all the variables calculated per minute played). Those players sustaining some type of body injury, performed an average of more actions per minute in all aspects commented except in the case of blocks against, where they received less actions of this type.

With regard to anthropometric variables, no significant differences were found between players with an body injury, based on height, weight and BMI (P>0.05). However, statistically significant differences were observed when taking the age of the players into account (P=0.000). Players with some body injury during the regular season were older than the group of players with no injuries (28.06 *vs.* 26.19 years; P=0.000). Finally, the analysis of injuries based on the game positions of the players gave statistically significant differences (P<0.05) in the case of the shooting guards (1.87±2.88 injuries), power forwards (1.81±3.76 injuries) and centres (2.07±4.54 injuries), who sustained more injuries on average than the point guards (1.23±3.18 injuries) and the small forwards (1.49±3.06 injuries).

Table 1. Incidence of injuries by reports, players and convalescence days.

OSICS	LA	Reports(n)	% PLA	JL (n)	% JLA	% J	JDC (weeks)
A	Ankle	181	19.17	77	23.69	13.90	2.35±2.56
B	Pelvis and buttocks	4	0.42	3	0.92	0.54	1.33±0.57
C	Thorax	2	0.21	2	0.62	0.36	1.00±0.00
D	Thoracic spine	20	2.12	12	3.70	2.17	1.67±0.47
E	Elbow	8	0.84	5	1.54	0.90	1.60±0.55
F	Foot	89	9.43	19	5.85	3.43	4.68±4.93
G	Hip and groin	57	6.04	14	4.31	2.53	4.07±5.48
H	Head	17	1.80	11	3.38	1.99	1.55±1.21
K	Knee	244	25.85	52	16.00	9.39	4.69±6.27
L	Lumbar spine	35	3.70	19	5.85	3.43	1.84±2.12
M	Infection	63	N/A	51	N/A	9.21	1.24±0.68
N	Neck	14	1.48	11	3.38	1.99	1.27±0.93
O	Abdomen	15	1.59	3	0.92	0.54	2.00±1.73
Q	Leg	115	12.18	34	10.46	6.14	3.38±3.67
R	Forearm	7	0.74	2	0.62	0.36	3.50±3.54
S	Shoulder	26	2.75	9	2.77	1.62	2.89±2.20
T	Thigh	43	4.56	23	7.08	4.15	1.87±1.18
U	Arm	0	0.00	0	0.00	0.00	0.00±0.00
W	Wrist and hand	67	7.10	29	8.92	5.23	2.31±1.98
X	Not specified	247	-	108	-	19.49	2.29±2.23
Total		1254	100.00	484	100.00	100.00	4.21±4.54

OSICS: injury code. LA: Body Site. %PLA: percentage of Reports in relation to total number of Body Injuries. JL: Injured Players. %JAC:percentage of Players in relation to the total number of Body Injuries. %JAC:percentage of Players in relation to the total number of Body Injuries. JDC: Convalescence Days.

Table 2. Relevant performance variables with regard to the occurrence of body injuries.

Study variable (per minute of play)	Not injured	Injured	*P*
Total Minutes	380±315	527±260	0.000*
Points	0.352±0.284	0.382±0.114	0.000*
3-point field goals made	0.034±0.040	0.036±0.027	0.011*
2-point field goals made	0.091±0.082	0.102±0.054	0.003*
Field goals made	0.125±0.083	0.138±0.047	0.000*
Free throws made	0.068±0.161	0.071±0.034	0.000*
Free throws attempted	0.091±0.166	0.093±0.044	0.000*
Offensive rebounds	0.045±0.042	0.049±0.035	0.025*
Defensive rebounds	0.106±0.094	0.118±0.075	0.002*
Total rebounds	0.151±0.110	0.167±0.092	0.016*
Assists	0.062±0.065	0.066±0.045	0.001*
Steals	0.032±0.024	0.034±0.015	0.016*
Blocks for	0.013±0.019	0.015±0.019	0.000*
Blocks against	0.016±0.038	0.013±0.008	0.003*
Dunks	0.009±0.017	0.013±0.022	0.001*
Fouls received	0.096±0.093	0.105±0.040	0.000*
+/- Statistic	-0.124±0.640	-0.013±0.241	0.006*
Rating	0.290±0.469	0.391±0.172	0.000*

Discussion

The aim of this investigation was to study the occurrence of injuries and the relationship with performance factors for professional ACB basketball players. The results obtained show how ankle and knee injuries prevail over other injuries, both for the number of days in which the player is convalescing and in the total number of players injured. These results are consistent with those of other studies, which indicate that the most common injuries in basketball are those to the lower extremities[10,12], of which ankle injuries are the most frequent[8,27,28]. Taking into account the combined frequency of ankle and foot injuries (33.89% of injury days), this gives a similar percentage to that obtained by Borowski *et al*.[11] for North American high school leagues. With regard to the total number of injured players, knee injuries were in second place, concurring with a number of studies conducted in Europe at a professional level[15,29] and in the United States at university and high school levels.[6,16].

Furthermore, there are coincidences with the results of other studies that point to the relative predominance of knee and back injuries, with hip and groin injuries being less common[8], and hand and wrist injuries as the most frequent in the upper extremities[11,27]. Leg injuries (between the ankle and knee) were the third in importance, being significantly higher than those of other, similar studies conducted on the NBA *(National Basketball Association)*, in which this type of injury was the fifth in number of occurrences[6,8,20]. It should also be mentioned that it is possible to appreciate a slight increase in the occurrence of this type of injury, from the older to the more recent studies: 4.8%[8], 7.6%[6,20] and 9.2% in our data.

Wrist or hand injuries were the fourth in the number of injured players and the fifth in the total number of injury reports. Specifically, wrist injuries accounted for 7.1% of the total of known body injuries. This percentage is exactly the same as that analysed in the NBA years before[8], although slightly lower than a number of studies conducted in North America[6] and Europe[15] which placed the number of injuries of this type at around 9% of the total. In general, the data for the incidence of hand and wrist injuries concur with other works conducted for basketball, pointing to this body site as the most susceptible to injury with regard to the upper extremities[6,8,10,14,15,20].

A foot injury incident was recorded (5.9%) in the range defined by other studies conducted at the NBA: 7.9%[20], 7.6%[6] and 4.2%[8] in relation to the total number of injuries. This situation is repeated for hip injuries: 4.3% in relation to a 7.5%[20], a 6.2%[6], and a 2.4%[8]; and in head or skull injuries (3.4%) in relation to the 1.9%[8], 5.3%[20] and 5.7%[6] recorded in other studies of the NBA. The low incidence of injuries to the thoracic column, neck, shoulder, elbow, thorax, pelvis, abdomen and forearm concur with studies of the NBA[6,8,20]. This similarity between studies and competitions is probably due to the similar energy and muscle demands of basketball at a professional level[30].

With regard to performance factors, it is extremely interesting that those players sustaining some type of injury obtained better averages in all positive aspects of the match statistics. Moreover, the difference in averages for negative factors is not significant, except for the blocks against, in which lower averages were obtained (implying better action). It appears that the best players are more exposed to injuries, given the fact that those players sustaining some type of injury, obtained a better statistical performance per minute than those players that were not injured. As indicated by some studies, the evolution of basketball towards a sport where contact is permitted[6,12], may have something to do with this fact. Numerous studies indicate that the most common cause of injury is landing from a jump[10,15,31]. With actions of this type, there is more risk of injury than changes of pace dribble[15], so that it is not surprising that injured players have obtained better averages in rebounds and dunks. Likewise, all the actions implicitly involve a jump during normal performance (except for free throws). The 2 and 3-point throws, blocks and rebounds are generally performed with a jump, where the risk of injury is increased.

Offensive actions have traditionally been identified as significantly more likely to produce injuries[15]. The importance of points, field goals made and rating, give grounds to expect that those players with great offensive skills are more likely to be injured. This may be due to their capacity to score points, which would increase the level of contact with the defence. The fact that injured players have averaged more steals may be due to the predominance of contact in this type of action, although it should be borne in mind that this does not always happen in this way.

The players with the greatest rating in the ACB final statistics are more likely to sustain injuries. The rating is a statistical value that depends

on offensive and defensive actions alike, but can be considered as a mixed variable in which offensive actions have a greater contribution. The case of the fouls received deserves particular attention. Contact between players has been considered to be a variable that is particularly likely to cause injuries, and injured players suffer more fouls per minute played. The study conducted by Hootman *et al.*[12] on university competition in the USA - National Collegiate Athletic Association (NCAA) identified that 58% of competition injuries were due to physical contact.

Attempted and made free throws were indicated as decisive factors in the occurrence of injuries: injured players attempted and made more free throws per minute of play. This fact may appear surprising, given the fact that a free throw is an action in which no jumping or contact is involved. However, it should be borne in mind that a free throw is the result of a foul (implying contact) and, on many occasions, the throw simultaneously involves taking a shot at the basket (implying a jump). Although studies have been made that indicate a greater predisposition to injury with regard to contact or a jump[6,13], it is necessary to explore the relationship existing between free throws and injuries in order to clarify this possible explanation.

Assists have been identified as a determining factor in the occurrence of injuries, although passing and receiving the ball is not considered to be so decisive as jumping, in order to produce an injury of this type[15]. However, account should be taken of the fact that many assists are made with a jump in order to dish the ball when getting a defensive assist. This aspect should be studied more deeply, as the passing and jumping actions take place simultaneously on many occasions.

On the other hand, it was to be expected that injured players should have had significantly more minutes of game exposure time, given the fact that other studies indicate the logical importance of the relationship between a greater exposure time and a higher risk of injury[9,12]. Finally, it is interesting to emphasise that neither weight, height nor BMI were significant variables with regard to injury occurrence. This fact suggests that these variables are not as determinant in injury exposure as the technical level and level of involvement in the game, in addition to other variables that are outside the scope of this study, such as physical preparation and prior history of injuries sustained by these athletes[1,9,12].

As limitations to this study, we would highlight, on the one hand, the fact that there is no indication of the reasons for the injuries (contact, non-contact, jumping, sprinting, etc.) or the types of injuries (muscle, bone, tendon, ligament, etc.), which would enable a deeper analysis of the injuries sustained in the ACB league. On the other hand, it should be pointed out that we did not have access to the minutes of training exposure for each player. Therefore, we have only taken account of the exposure to injuries during matches. Due to the design of this investigation, it was not possible to resolve these two constraints. However, we consider that the information provided may be of interest in order to progress in the understanding of professional basketball injuries in Spain, by compiling the injuries occurring in all top professional teams during two complete seasons, providing a new way of studying injuries and relating them to statistical performance. It would be advisable to conduct prospective studies, although it would be complicated to do so with reliable data from all the teams involved.

Conclusion

There are differences between the match statistics for injured and uninjured players during the professional basketball season in Spain. The weight and height of players are not determining variables in the occurrence of injuries. The most common injuries are to the ankle and knee, and there are differences in injury occurrence between the different game positions.

Conflict of interests

The authors have no conflict of interest whatsoever.

Bibliography

1. Bahr R, Holme I. Risk factors for sports injuries - a methodological approach. *Br J Sports Med.* 2003;37(5):384-92.
2. Maffulli N, Longo UG, Gougoulias N, Caine D, Denaro V. Sport injuries: a review of outcomes. *Br Med Bull.* 2011;97(1):47-80.
3. Beynnon BD, Vacek PM, Murphy D, Alosa D, Paller D. First-time inversion ankle ligament trauma - The effects of sex, level of competition, and sport on the incidence of injury. *Am J Sports Med.* 2005;33(10):1485-91.
4. Foss KDB, Myer GD, Hewett TE. Epidemiology of basketball, soccer, and volleyball injuries in middle-school female athletes. *Phys Sportsmed*. 2014;42(2):146-53.
5. Kilic Ö, van Os V, Kemler E, Barendrecht M, Gouttebarge V. The "Sequence of Prevention" for musculoskeletal injuries among recreational basketballers: a systematic review of the scientific literature. *Phys Sportsmed*. 2018;16:1-16.
6. Drakos MC, Domb B, Starkey C, Callahan L, Allen AA. Injury in the national basketball association: a 17-year overview. *Sports Health*. 2010;2(4):284-90.
7. Waterman BR, Belmont PJ, Cameron KL, DeBerardino TM, Owens BD. Epidemiology of ankle sprain at the United States Military Academy. *Am J Sports Med.* 2010;38(4):797-803.
8. Starkey C. Injuries and illnesses in the National Basketball Association: A 10-year. *J Athl Train.* 2000;35(2):161-7.
9. Murphy DF, Connolly DAJ, Beynnon BD. Risk factors for lower extremity injury: a review of the literature. *Br J Sports Med*. 2003;37(1):13-29.
10. Newman JS, Newberg AH. Basketball Injuries. *Radiol Clin North Am.* 2010;48(6):1095-111.
11. Borowski LA, Yard EE, Fields SK, Comstock RD. The Epidemiology of US High School Basketball Injuries, 2005-2007. *Am J Sports Med*. 2008;36(12):2328-35.
12. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: Summary and recommendations for injury prevention initiatives. *J Athl Train*. 2007;42(2):311-9.
13. Guyette R. Facial injuries in basketball players. *Clin Sports Med*. 1993;12(2):247-64.
14. Harmer PA. Basketball injuries. *Med Sport Sci.* 2005;49:31-61.
15. Cumps E, Verhagen E, Meeusen R. Prospective epidemiological study of basketball injuries during one competitive season: Ankle sprains and overuse knee injuries. *J Sport Sci Med.* 2007;6(2):204-11.
16. Messina DF, Farney WC, DeLee JC. The incidence of injury in Texas high school basketball - A prospective study among male and female athletes. *Am J Sports Med.* 1999;27(3):294-9.
17. Waterman BR, Belmont PJ, Cameron KL, Svoboda SJ, Alitz CJ, Owens BD. Risk Factors for Syndesmotic and Medial Ankle Sprain Role of Sex, Sport, and Level of Competition. *Am J Sports Med.* 2011;39(5):992-8.
18. McKay GD, Goldie PA, Payne WR, Oakes BW. Ankle injuries in basketball: injury rate and risk factors. *Br J Sports Med*. 2001;35(2):103-8.
19. Narazaki K, Berg K, Stergiou N, Chen B. Physiological demands of competitive basketball. *Scand J Med Sci Sports.* 2009;19(3):425-32.
20. Deitch JR, Starkey C, Walters SL, Moseley JB. Injury risk in professional basketball players. *Am J Sports Med*. 2006;34(7):1077-83.

21. Busfield BT, Kharrazi FD, Starkey C, Lombardo SJ, Seegmiller J. Performance outcomes of anterior cruciate ligament reconstruction in the National Basketball Association. *Arthroscopy.* 2009;25(8):825-30.
22. Harris JD, Erickson BJ, Bach Jr BR, Abrams GD, Cvetanovich GL, Forsythe B, *et al*. Return-to-sport and performance after anterior cruciate ligament reconstruction in National Basketball Association players. *Sports Health*. 2013;5(6):562-8.
23. Bonato M, Benis R, La Torre A. Neuromuscular training reduces lower limb injuries in elite female basketball players. A cluster randomized controlled trial. *Scand J Med Sci Sports.* 2017;28(4):1451-60.
24. ACB. Página web oficial de la Asociación de Clubes de Baloncesto (consultado 21-11-2014). Disponible en: www.acb.com.
25. Orchard J, Rae K, Brooks J, Hagglund M, Til L, Wales D, *et al*. Revision, uptake and coding issues related to the open access Orchard Sports Injury Classification System (OSICS) versions 8, 9 and 10.1. *Open Access J Sports Med*. 2010;1:207-14.
26. Fuller CW, Ekstrand J, Junge A, Andersen TE, Bahr R, Dvorak J, *et al*. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med.* 2006;40(3):193-201. Epub 2006/03/01.
27. Dick R, Hertel J, Agel J, Grossman J, Marshall SW. Descriptive epidemiology of collegiate men's basketball injuries: National Collegiate Athletic Association injury surveillance system, 1988-1989 through 2003-2004. *J Athl Train*. 2007;42(2):194-201.
28. Sánchez F, Gómez A. Epidemiología de las lesiones deportivas en baloncesto. *Cuadernos de psicología del deporte*. 2009;9:61.
29. Colliander E, Eriksson E, Herkel M, Skold P. Injuries in Swedish elite basketball. *Orthopedics.* 1986;9(2):225-7.
30. Read PJ, Hughes J, Stewart P, Chavda S, Bishop C, Edwards M, *et al*. A needs analysis and field-based testing battery for basketball. *Strength Cond J.* 2014;36(3):13-20.
31. DeHaven KE, Lintner DM. Athletic injuries: comparison by age, sport, and gender. *Am J Sports Med.* 1986;14(3):218-24.

Effects of a HIIT protocol including functional exercises on performance and body composition

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Summary

Introduction: High Intensity Interval Training (HIIT) is one of the most effective ways to improve metabolic and cardiorespiratory factors, as well as to increase physical performance. Running or cycling HIIT protocols have been usually performed, but there are few research related to the effects of a HIIT protocol including functional strength exercises
Objectives: To compare the effects of two different HIIT protocols on the performance and the body composition.
Meterial and Method: 14 young males (years: 21,67 ±1,61; height 1,73 ± 0,06 m; weight: 76,07 ± 12,96 kg) took part in the study and they were divided into two randomly balanced groups: Cycling Group (GC) and Functional Training Group (GEF). Both groups worked out 2 days a week during a 4-week-period. GC performed 4 rep. x 30 seconds of bicycle sprint with 3 minutes recovery time. GEF performed a trial based on 30" work (high intensity)/15"rest, with 6 functional strength exercises consisting of elliptical bike, battle rope, agility ladder, kettlebell, burpees and jumps. These exercises were repeated 3 times in combination with 3 minutes recovery time. The following measurements were carried out before and after the training: Body composition, maximum oxygen uptake, T-test, maximum and mean power on cycle ergometer, blood lactate, as well as hear rate, blood pressure and hemoglobin.
Results: Significant changes were observed in the values referred to VO2max, maximum power, fat weight and fat percentage for both groups. Nevertheless, no significant difference was observed between groups.
Conclusion: A HIIT program based on functional strength exercises improved aerobic, anaerobic performance and body composition in a similar way than the HIIT program on a bicycle.

Key words:
HIIT. Functional training. Body composition. Maximum oxygen uptake. Power.

Efectos de un protocolo HIIT con ejercicios funcionales sobre el rendimiento y la composición corporal

Resumen

Introducción: El entrenamiento interválico de alta intensidad (HIIT) es uno de los medios más eficaces para mejorar la función metabólica y cardiorrespiratoria, así como para incrementar el rendimiento físico. Tradicionalmente se han utilizado protocolos HIIT basados en la carrera o el ciclismo, sin embargo pocos estudios han tratado de analizar los efectos de un protocolo HIIT que incluya ejercicios funcionales de fuerza.
Objetivos: Comparar los efectos sobre el rendimiento y la composición corporal de dos protocolos diferentes de HIIT.
Material y método: 14 varones jóvenes (edad: 21,67±1,61 años; altura: 1,73 ± 0,06 metros; peso: 76,07 ± 12,96 kg) participaron en el estudio y fueron divididos de forma balanceada y aleatoria en dos grupos experimentales: Grupo Ciclismo (GC) y Grupo Entrenamiento Funcional (GEF). Ambos grupos entrenaron 2 d/semana durante 4 semanas. El GC realizó 4 rep. x 30 seg. de sprint en bicicleta, con 3 min. de recuperación. El GEF realizó un circuito (30"trabajo/ 15"descanso) con 6 ejercicios funcionales de fuerza (elíptica, battle rope, escalera de agilidad, kettlebell, burpees y multisaltos). Esos ejercicios fueron repetidos 3 veces combinados con 3 minutos de recuperación. Las siguientes valoraciones fueron realizadas antes y después del programa de entrenamiento: Composición corporal, consumo máximo de oxígeno, T-Test, potencia máxima y potencia media en cicloergómetro, lactato, así como valores de frecuencia cardiaca, tensión arterial y hemoglobina.
Resultados: En ambos grupos se observó un aumento significativo de los valores de VO2máx y potencia máxima, así como un descenso en el peso graso y en el porcentaje graso tras el programa de entrenamiento. Sin embargo, no se observaron diferencias significativas entre grupos.
Conclusión: Un programa HIIT basado en ejercicios funcionales de fuerza produce mejoras sobre el rendimiento aeróbico, anaeróbico y la composición corporal similares a las conseguidas por un programa HIIT de sprint repetido en bicicleta.

Palabras clave:
HIIT. Entrenamiento funcional. Composición corporal. Consumo máximo de oxígeno. Potencia.

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Introduction

High-Intensity Interval Training (HIIT) involves intermittent maximal or supramaximal exercise (85-95% HRmax), interspersed with recovery periods[1–4]. Despite having a shorter duration than continuous aerobic training, training of this kind has proven effective when it comes to achieving cardiovascular, metabolic and skeletal muscle improvements[5–7]. HIIT, therefore, is an effective alternative to traditional endurance training because it requires less time and permits a greater volume of high-intensity exercise than continuous exercise[2].

HIIT protocols vary in terms of the type of activity, the intensity and the duration of the periods of activity and recovery. Most previous studies have used HIIT workouts with cycle ergometers and bursts of exercise lasting 10-30 sec. at 90-100% HRmax, repeated 4-6 times and with recovery periods of 1-4 min[8,9]. The study conducted by Whyte *et al*.[10] investigated the effects of HIIT on metabolic and vascular risk factors in sedentary men. The protocol consisted of 2 weeks of 6 sessions of 4-6 repeats of sprints on a cycle ergometer at "all-out" intensity lasting 30 seconds with recovery periods of 4.5 minutes between each repetition. A significant decrease in body weight and waist circumference, together with an increase in VO_2max and improved insulin sensitivity were observed. Rhodes[11] evaluated changes in aerobic and anaerobic metabolism produced by a HIIT workout programme on a cycle ergometer after daily training for 2 weeks involving bouts of exercise at maximum intensity lasting 15-30 seconds with breaks of 45-30 seconds, discovering significant increases in VO_2max and peak power. These studies showed that the adaptations produced depended on the relationship between work and rest. Buchheit *et al*.[12] suggested that in short HIIT workouts, the relationship between work and rest is crucial to maximising exercise time over 90% VO_2max and achieving greater adaptations. They concluded that work to rest ratios of >1 (i.e. exercise times which are longer than rest periods) were better suited to keeping exercise intensities above 90% VO_2max. Short exercise intervals with recovery periods longer than bouts of exercise, however, seemed to improve other physiological parameters, such as VT1, VT2 and anaerobic capacity[13].

Other HIIT programmes based on circuits of strength exercises also exist. Emberts *et al*.[14] showed that a HIIT training session based on the regime designed by Tabata *et al*.[15] consisting of four series x 4 minutes of functional strength exercises led to heart rate, VO_2max, lactate and RPE values above the range set by the American College of Sports Medicine[16] to improve breathing capacity. They also concluded that an intense session of HIIT involving kettlebells caused greater caloric expenditure than a session of repeated cycling sprints and proved effective in stimulating metabolic and cardiorespiratory responses[17].

Not many studies, however, have tried to investigate the effects of HIIT training programmes based on functional exercises (jumping, burpees, lunges, etc.) on performance and health. Buckley *et al*.[18] compared the effects of 6 weeks of training with a rowing HIIT programme with a multimodal form of HIIT based on strength exercises. Their results showed that the multimodal, strength-based HIIT programme led to similar aerobic and anaerobic adaptations to and greater increases in muscle performance than the HIIT rowing programme.

Therefore, the objective of this study was to analyse the long-term effects of a HIIT programme based on functional exercises on performance and body composition, and to compare such a programme with the effects produced by a cycling HIIT programme.

Material and method

Subjects

A total of 14 young men voluntarily took part in the study (age: 21.67±1.61 years old; height: 1.73 ± 0.06 metres, weight: 76.07 ± 12.96 kg).

All the subjects were healthy and physically active, but did not do any kind of specific training on a regular basis. They were all asked to maintain the diets they were following at the time and not to take any supplements. Each subject was informed of the procedure to be followed during the study and they all gave their informed consent in writing. The experiment was developed and carried out with the approval of the Committee of Biomedical Ethics at the University of Extremadura (Spain), respecting the criteria set out in the 2008 Declaration of Helsinki.

Experimental design

The study was conducted over a period of 6 weeks; the first and the last week were used for measurements and the other 4 weeks to follow the training programmes. The experimental design was based on a cross sectional study, in which the 14 participants were randomly divided into two groups: a Functional Training Group (FTG), which did HIIT using a strength circuit, and a Cycling Group (CG), which did HIIT based on cycling. Both programmes were high intensity and involved incomplete recovery times. These protocols were chosen because previous research had shown that the relationship between work and rest used in this study proved effective at causing cardiorespiratory and metabolic adaptations[17].

Each training protocol was carried out twice a week, increasing the training volume in the last two weeks. The two protocols started with a warm-up to favour joint mobility (ankles, knees, hips, shoulders and neck), followed by 5 minutes of cycling at 50-60 rpm.

The FTG followed a training protocol mainly made up of functional exercises involving the major muscle groups.

This consisted of a circuit with 6 different exercises. Each exercise lasted 30" at "all-out" effort, while the rest between exercises lasted 15". On completing the circuit, they rested for 3 minutes (Figure 1). The circuit was repeated 3 times in each session in the first 2 weeks. Then in the last two weeks, it was completed 4 times per session. The workout consisted of the following exercises: elliptical trainer, battle ropes alternating squats and waves, agility ladder, swing kettlebell (10-12 kg), burpees and multi jumps with hurdles.

The CG did HIIT based on cycling, consisting of four repeats of 30-second sprints on a bicycle with power meter (Cycle Ops400 pro, Saris Cycling Group, USA) at between 100 and 120rpm, with a load equal to 100w above the average power of each subject and three minutes'

Figure 1. Diagram - summary of the circuit used in the FTG training protocol.

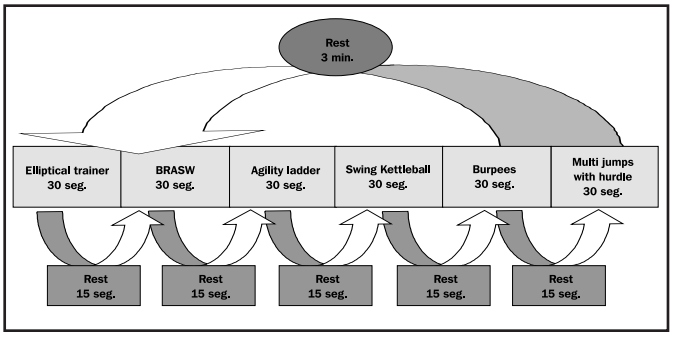
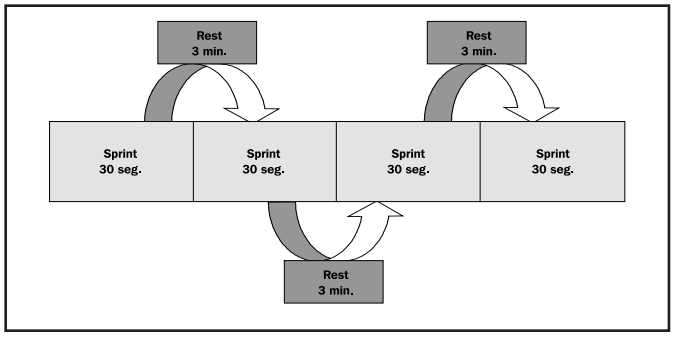


Figure 2. Diagram - summary of the characteristics of the CG training protocol.



rest between each sprint (Figure 2). Each subject's average power was obtained from measurements taken before the training sessions, in the first week. The number of repetitions of the sprints was increased to 6 in weeks 3 and 4.

Measurements

Measurements were taken before and after the 4 weeks of training sessions, in the first and last week of the study, on two different days, with at least 48 hours in between to rule out the influence of fatigue.

On the first day, the subjects were asked to come to the laboratory to have anthropometric measurements taken, according to the criteria established by ISAK[19]. Their height and body weight were measured using a portable stadiometer (Seca 213, Germany) and their body mass index (weight/height^2) was calculated. Their skinfolds and muscle circumferences were also measured in order to estimate their muscle mass and fat mass percentages using anthropometric equations[20].

The subjects were then taken to a sports hall where they performed the T-test and Yo-Yo test.

The T-test allowed us to measure their agility and speed of movement. This test was performed prior to the Yo-Yo test to prevent fatigue from bearing an influence. The T-test was carried out with forward, sideways and backward movements. 4 cones were required. To perform the test, cone A was used as a starting point, cone B was placed 10 yards (9.14 metres) in front of it and cones C and D were placed 5 yards (4.57 metres) to each side of cone B. Photocells (Chronojump; Boscosystem; Spain) were placed at cone A to record the time it took to perform the test. Each participant did the test twice and their best time was chosen.

The Yo-Yo test was used to indirectly measure VO_2max by subsequently applying a set of calculations[21]. This test consisted of running a distance of 20 metres and back, with breaks of 10 seconds in between each shuttle. To establish distances, we used a tape measure and employed a computer with speakers so that the subjects could hear properly. The test ended when each individual could no longer keep up pace.

On the second day, and in all events after 48 hours of rest, the subjects were asked to return to the laboratory, where their blood pressure was taken using a sphygmomanometer, their total haemoglobin was measured using a specific analyser (HemoCue 201, Angeholm, Sweden) and a test was performed on a bicycle with power meter (Cycle Ops400 pro, Saris Cycling Group, USA) to measure their average and maximum power during anaerobic exercise.

To measure their average anaerobic power, the subjects had to maintain maximum effort on the bicycle for 60 seconds and the average watts maintained in this period were recorded. Maximum power was determined on the basis of the peak power (measured in watts) achieved during the first 10 seconds of exercise. The subjects started with a 5 minute warm-up pedalling at 50-60 rpm. Then, just before the 60-second test, they were told to increase their pedalling rate to 120 rpm and the resistance of the power meter was raised, establishing a target power of 500 watts. During the test, the subjects had to maintain a rate of over 120 rpm, so the load was gradually reduced throughout so the rate did not drop. On completing the test, lactate samples were taken and analysed in a lactate analyser using Lactate Scout + (which has a margin of error of 0.2 mmol). During the test itself, maximum heart rate reached and average heart rate during the 60 seconds were recorded. These figures were obtained using a heart rate monitor (PowerCal, CycleOps, USA).

Statistical analysis

When all the data had been collected, the statistics program SPSS 19.0 for Windows was used to analyse them.

The Shapiro-Wilk test was applied to verify normal data distribution and Levene's test was used to assess the equality of variances.

Since the sample consisted of a small number of subjects and the aforementioned requirements were not met, non-parametric tests were used. The comparisons between the conditions of intervention (FTG *vs* CG) for each variable were subjected to the Mann-Whitney U test and the differences in subjects were studied using the Wilcoxon test.

The level of significance was set at $p \leq 0.05$, with a confidence level of 95%. Mean and standard deviation (SD) were used as descriptive statistics. The data were expressed as the mean ± standard deviation.

Limitations

This research has certain limitations. The number of participants was small, thereby conditioning the power of the study. Furthermore, the subject's diets were not comprehensively controlled and during

the training sessions, the participants reported that they had exerted themselves to maximum intensity, but no physiological data to quantify internal load, such as heart rate, lactate concentrations, CK or LDH, were taken.

Results

Table 1 shows the performance values. In the FTG, significant increases in VO_2max ($p = 0.013$) and maximum power ($p = 0.040$) were observed. Significant increases in VO_2max ($p = 0.011$) and maximum power ($p = 0.015$) were also noted in the CG, as was an increase in average power ($p = 0.019$). However, no significant differences were observed between the groups.

Table 2 shows the body composition and anthropometry values. In the FTG, significant decreases were observed in fat weight ($p = 0.047$) and fat percentage ($p = 0.049$). Similar results were observed in the CG, with significant decreases in both fat weight ($p = 0.025$) and fat percentage ($p = 0.022$). No significant differences were observed between the groups.

Table 3 shows the blood pressure and haemoglobin values. No significant differences were observed.

Discussion

The results of this study show that, regardless of the type of protocol used (functional exercises or cycling), HIIT improves performance and body composition parameters.

An increase in VO_2max was observed after training in both groups. Other studies have also shown that HIIT (4-6 sessions per week) over several weeks improves VO_2max in active people[4,22,23].

This improvement in VO_2max may be due just as much to adaptations in muscle oxidative potential as it is to increases in mitochondria and mitochondrial enzyme activity, permitting greater use of the energy available[24].

Furthermore, the increase in cardiac contractility and pumping capability resulting from high-intensity exercise could also explain the increase in VO_2max through an increase in stroke volume[25,26].

Table 1. Performance values (Mean ± SD).

	FTG (n=7)		CG (n=7)	
	Pre	Post	Pre	Post
T-test (sec.)	10.03 ± 0.35	10.01 ± 0.41	10.44 ± 0.81	10.32 ± 0.69
VO_2max (ml x min/kg)	44.96 ± 1.69	47.31 ± 3.07*	45.37 ± 3.91	49.21 ± 5.79*
Maximum power (W)	573.50 ± 37.56	643.66 ± 54.68*	572.71 ± 134.82	684.42 ± 128.20*
Average power (W)	312.82 ± 32.12	329.66 ± 31.77	295.85 ± 67.77	336.71 ± 57.12*
Maximum HR (ppm)	183.33 ± 3.55	180.33 ± 5.60	178.57 ± 4.57	181.00 ± 6.00
Average HR (ppm)	176.50 ± 5.35	173.50 ± 4.54	169.14 ± 7.88	172.42 ± 11.47
End lactate (mmol/L)	14.40 ± 1.88	12.43 ± 2.22	13.08 ± 2.08	13.90 ± 3.62

*Significant difference between groups ($p \leq 0.05$).

Table 2. Body composition and anthropometry values (Mean ± SD)

	FTG (n=7)		CG (n=7)	
	Pre	Post	Pre	Post
Weight (kg)	75.38 ± 9.89	75.03 ± 9.99	76.67 ± 15.92	76.64 ± 15.05
BMI	25.15 ± 2.79	25.03 ± 2.79	24.98 ± 3.95	24.97 ± 3.59
Muscle weight (kg)	36.17 ± 4.70	36.28 ± 5.06	36.67 ± 8.26	37.19 ± 7.47
Muscle %	48.03 ± 1.95	48.37 ± 2.18	48.14 ± 3.61	48.65 ± 3.85
Fat weight (kg)	10.35 ± 2.59	9.98 ± 2.47*	10.98 ± 4.33	10.44 ± 4.36*
Fat %	13.61 ± 2.00	13.20 ± 2.03*	14.09 ± 3.96	13.33 ± 4.12*

*Significant difference between groups ($p \leq 0.05$).

Table 3. Blood pressure and haemoglobin values (Mean ± SD)

	FTG (n=7)		CG (n=7)	
	Pre	Post	Pre	Post
Systolic pressure (mmHg)	116.33 ± 8.64	120.16 ± 16.57	120.00 ± 8.96	122.42 ± 14.16
Diastolic pressure (mmHg)	64.33 ± 10.83	67.66 ± 10.09	64.42 ± 9.39	72.42 ± 10.13
Haemoglobin (g/dL)	14.40 ± 1.59	13.78 ± 0.40	14.00 ± 1.37	14.31 ± 1.33

After training, increases in maximum power and average power (in the latter case, only in the CG) on the bicycle with power meter were also observed. Most previous studies involving short-term high-intensity interval training show improvements in maximum and average power[27,28]. Such improvements could be explained by the peripheral adaptations that HIIT causes, such as improvements in the rapid replenishment of phosphocreatine (PC) stores and optimisation of the role played by oxymyoglobin as an intracellular oxygen store[12].

In the initial phase of exercise of this kind, oxygen does not reach the values of the real demand for it due to delayed VO_2 kinetics. Consequently, the energy needed for ATP resynthesis must be obtained from stored intracellular oxygen and/or via the anaerobic pathway, oxymyoglobin and phosphocreatine playing important roles.

Other research concludes that improved power levels may be due to neuromuscular adaptations, with an increase in the recruitment or activation of motor units[29], a significant increase in type IIa fibres and a decrease in type I fibres[30].

An increase in average power was only observed in the CG. This could be because the CG did cycling training, so the evaluation test carried out was more specific for this group than it was for the FTG. Previous studies conclude that the results of evaluation tests are better when more specific tests involving mechanical components similar to those used in training are employed[31,32]. On this basis, we can say that average power only increased in group B (the group which trained on bicycles) due to the specificity of the test chosen to measure power.

As for the body composition measurements, decreases in fat weight (kg) and body fat percentage were observed. Similar results have been obtained in previous studies in which decreases in fat percentage were recorded after monitored HIIT programmes involving a cycle ergometer[33-35].

According to several authors, this decrease in fat mass could be due to increases in catecholamines[36], the growth hormone[37] and β hydroxyacyl-CoA dehydrogenase activity[38]. These factors play an important role in the stimulation of lipolysis and the release of subcutaneous and intramuscular fat tissue. Boutcher[8], meanwhile, concluded that after HIIT, there is an increase in the oxidation of fatty acids due to the need to remove lactate and hydrogen ions, and resynthesize muscle glycogen.

Finally, no significant difference was observed between one group and the other in terms of performance and body composition. While it is true that few studies have examined the effects produced by functional strength exercise HIIT, those studies reviewed obtained results similar to ours. Buckley *et al*.[18] concluded that multimodal HIIT including strength exercises caused the same aerobic and anaerobic adaptations as rowing HIIT. In the same line, McRae *et al*.[39] studied the effects of HIIT based on full body movement (burpees, jumps, mountain climbers, etc.) after 4 weeks of training, finding improvements in aerobic capacity similar to those produced by continuous treadmill training.

This similarity could be because both protocols involved very high intensities and the physiological adaptations were similar. We should not ignore the fact that HIIT has consistently demonstrated increases in aerobic and anaerobic performance compared with aerobic endurance exercise[40,41]. This could indicate that the exercise intensity variable may play a more important role than the type of exercise in training of this kind, although more research is required in this area. Our research, however, has certain limitations. The number of participants was small, thereby conditioning the power of the study and meaning that the results should be interpreted with caution, especially if intending to extrapolate them to other contexts. Furthermore, the subject's diets were not comprehensively controlled and during the training sessions, the participants reported that they had exerted themselves to maximum intensity, but no physiological data to quantify internal load, such as heart rate, lactate concentrations, CK or LDH, were taken. Therefore, more research needs to be carried out to find out more about the physiological, metabolic and functional-anatomical effects that HIIT protocols based on functional strength exercises can have on the body.

Conclusions

We can conclude that a HIIT programme based on functional strength exercises led to improvements in aerobic and anaerobic performance and body composition similar to those achieved with a HIIT programme involving repeated cycling sprints. These findings may have important implications for the way in which personal trainers and fitness specialists design sessions and plan training.

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Conflict of Interests

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

Bibliografía

1. Tucker WJ, Sawyer BJ, Jarrett CL, Bhammar DM, Gaesser GA. Physiological Responses to High-Intensity Interval Exercise Differing in Interval Duration. *J Strength Cond Res.* 2015;29(12):3326-35
2. Billat VL, Slawinski J, Bocquet V, Demarle A, Lafitte L, Chassaing P, *et al*. Intermittent runs at the velocity associated with maximal oxygen uptake enables subjects to remain at maximal oxygen uptake for a longer time than intense but submaximal runs. *Eur J Appl Physiol.* 2000;81(3):188–96.
3. Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle: Part II: Anaerobic energy, neuromuscular load and practical applications. Vol. 43, *Sports Medicine.* 2013. p. 927–54.
4. Laursen PB, Jenkins DG. The scientific basis for high-intensity interval training: optimising training programmes and maximising performance in highly trained endurance athletes. *Sports Med.* 2002;32(1):53–73.
5. Gibala MJ, Little JP, Macdonald MJ, Hawley JA. Physiological adaptations to low-volume, high-intensity interval training in health and disease. *J Physiol.* 2012;5(March 2012):1077–84.
6. Little JP, Gillen JB, Percival ME, Safdar A, Tarnopolsky MA, Punthakee Z, *et al.* Low-volume high-intensity interval training reduces hyperglycemia and increases muscle mitochondrial capacity in patients with type 2 diabetes. *J Appl Physiol.* 2011;111(6):1554–60.
7. Moholdt T, Madssen E, Rognmo Ø, Aamot IL. The higher the better? Interval training intensity in coronary heart disease. *J Sci Med Sport*. 2014;17(5):506–10.
8. Boutcher SH. High-intensity intermittent exercise and fat loss. *J Obes* (revista electrónica) 2011; 2011:868305 (consultado 1209/2017). Disponible en: https://www.hindawi.com/journals/jobe/2011/868305/

9. Gibala MJ, McGee SL. Metabolic adaptations to short-term high-intensity interval training: a little pain for a lot of gain? *Exerc Sport Sci Rev.* 2008;36(2):58–63.
10. Whyte LJ, Gill JMR, Cathcart AJ. Effect of 2 weeks of sprint interval training on health-related outcomes in sedentary overweight/obese men. *Metabolism*. 2010 Oct;59(10):1421–8.
11. Rodas GA. Short training programme for the rapid improvement of both aerobic and anaerobic metabolism of both aerobic and anaerobic metabolism. *Eur J Appl Physiol.* 2000;82(5):480-6.
12. Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle: Part I: Cardiopulmonary emphasis. *Sports Med*. 2013 May;43(5):313-38.
13. Laursen P, Kitic C, Peake J, S Coombes J, G Jenkins D. Influence of High-Intensity Interval Training on Adaptations in Well-Trained Cyclists. Vol. 19, *Journal of strength and conditioning research* / National Strength & Conditioning Association. 2005. p. 527-33.
14. Emberts T, Porcari J, Doberstein S, Steffen J, Foster C. Exercise intensity and energy expenditure of a tabata workout. *J Sport Sci Med*. 2013;12(3):612–3.
15. Tabata I, Nishimura K, Kouzaki M, Hirai Y, Ogita F, Miyachi M, *et al.* Effects of moderate-intensity endurance and high-intensity intermittent training on anaerobic capacity and VO_2max. *Med Sci Sport Exerc*. 1996;28(10):1327–30.
16. Thompson WR, Gordon NF, Pescatello LS. ACSM's guidelines for exercise testing and prescription. 9th ed. 2014. *J Can Chiropr Assoc*. 2014; 58(3):6-10.
17. Williams BM, Kraemer RR. Comparison of Cardiorespiratory and Metabolic Responses in Kettlebell High-Intensity Interval Training Versus Sprint Interval Cycling. *J Strength Cond Res.* 2015;29(12):3317–25.
18. Buckley S, Knapp K, Lackie A, Lewry C, Horvey K, Benko C, *et al.* Multimodal high-intensity interval training increases muscle function and metabolic performance in females. *Appl Physiol Nutr Metab*. 2015;40(11):1157-62.
19. Stewart A, Marfell-Jones M, Olds T, de Ridder H. International standards for anthropometric asessment. Lower Hutt, New Zealand. International Society for the Advancement of Kinanthropometry, 2011. 51.
20. Alvero Cruz JR, Cabañas M, Herrero de Lucas A, Martínez Riaza L, Moreno Pascual C, Porta Manzañido J, *et al.* Protocolo de valoración de la composición corporal para el reconocimiento médico-deportivo. Documento de consenso del grupo español de cineantropometría de la federación española de medicina del deporte. *Arch Med Deporte.* 2010. XXVII(139): 330-44.
21. Bangsbo J, Iaia FM, Krustrup P. The Yo-Yo Intermittent Recovery Test: A Useful Tool for Evaluation of Physical Performance in Intermittent Sports. *Sport Med*. 2008;38(1):37–51.
22. Helgerud J, Hoydal K, Wang E, Karlsen T, Berg P, Bjerkaas M, *et al*. Aerobic high-intensity intervals improve VO2max more than moderate training. *Med Sci Sports Exerc.* 2007;39(4):665–71.
23. Astorino TA, Edmunds RM, Clark A, King L, Gallant RA, Namm S, *et al.* Highintensity interval training increases cardiac output and VO_2max. *Med Sci Sports Exerc.* 2016;49(2):265–73.
24. Tschakert G, Hofmann P. High-intensity intermittent exercise: Methodological and physiological aspects. *Int J Sports Physiol Perform.* 2013;8(6):600–10.
25. Helgerud J, Høydal K, Wang E, Karlsen T, Berg P, Bjerkaas M, *et al*. Aerobic high-intensity intervals improve VO_2max more than moderate training. *Med Sci Sports Exerc.* 2007;39(4):665–71.
26. Bassett DR, Howley ET. Limiting factors for maximum oxygen uptake and determinants of endurance performance. *Med Sci Sports Exerc.* 2000;32(1):70–84.
27. Astorino TA, Allen RP, Roberson DW, Jurancich M. Effect of high-intensity interval training on cardiovascular function, VO_2max, and muscular force. *J Strength Cond Res.* 2012;26(1):138–45.
28. Burgomaster KA, Hughes SC, Heigenhauser GJF, Bradwell SN, Gibala MJ. Six sessions of sprint interval training increases muscle oxidative potential and cycle endurance capacity in humans. *J Appl Physiol.* 2005;98(6):1985–90.
29. Van Cutsem M, Duchateau J, Hainaut K. Changes in single motor unit behaviour contribute to the increase in contraction speed after dynamic training in humans. *J Physiol.* 1998;513:295–305.
30. Farzad B, Gharakhanlou R, Agha-Alinejad H, Curby DG, Bayati M, Bahraminejad M, *et al.* Physiological and performance changes from the addition of a sprint interval program to wrestling training. *J Strength Cond Res.* 2011;25(9):2392–9.
31. Rossi FE, Schoenfeld BJ, Ocetnik S, Young J, Vigotsky A, Contreras B, *et al.* Strength, body composition, and functional outcomes in the squat versus leg press exercises. *J Sports Med Phys Fitness* (revista electrónica) 2016; Oct 13 (consultado 0910/2017). Disponible en: https://www.minervamedica.it/en/journals/sports-med-physical-fitness/article.php?cod=R40Y9999N00A16101304.
32. Roberts JA, Alspaugh JW. Specificity of training effects resulting from programs of treadmill running and bicycle ergometer riding. *Med Sci Sports.* 1972;4(1):6-10.
33. Dunn SL. Effects of exercise and dietary intervention on metabolic syndrome markers of inactive premenopausal women, Doctoral dissertation, University of New South Wales (documento electrónico) 2009 (consultado 1110/2017). Disponible en: http://unsworks.unsw.edu.au/vital/access/manager/Repository/unsworks:7345.
34. Trapp EG, Chisholm DJ, Boutcher SH. Metabolic response of trained and untrained women during high-intensity intermittent cycle exercise. *Am J Physiol Regul Integr Comp Physiol.* 2007;293(6):R2370–75.
35. Tremblay A, Simoneau JA, Bouchard C. Impact of exercise intensity on body fatness and skeletal muscle metabolism. 1994;43 (1):814–18.
36. Bracken RM, Linnane DM, Brooks S. Plasma catecholamine and nephrine responses to brief intermittent maximal intensity exercise. *Amino Acids.* 2009;36(2):209–17.
37. Nevill ME, Holmyard DJ, Hall GR, Allsop P, Van Oosterhout A, Burrin JM, *et al.* Growth hormone responses to treadmill sprinting in sprint and endurance-trained athletes. *Eur J Appl Physiol Occup Physiol.* 1996;72(5–6):460–7.
38. Tremblay A, Simoneau JA, Bouchard C. Impact of exercise intensity on body fatness and skeletal muscle metabolism. *Metabolism*. 1994;43(7):814–18.
39. McRae G, Payne A, Zelt JGE, Scribbans TD, Jung ME, Little JP, *et al*. Extremely low volume, whole-body aerobic–resistance training improves aerobic fitness and muscular endurance in females. *Appl Physiol Nutr Metab.* 2012;37(6):1124–31.
40. Gist NH, Fedewa M.V., Dishman RK, Cureton KJ. Sprint interval training effects on aerobic capacity: A systematic review and meta-analysis. *Sport Med.* 2014;44(2):269–79.
41. Hazell TJ, MacPherson REK, Gravelle BMR, Lemon PWR. 10 or 30-s sprint interval training bouts enhance both aerobic and anaerobic performance. *Eur J Appl Physiol.* 2010;110(1):153–60.

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The "medicalization" of mountain rescue teams: a social and economic approach based on mortality evolution in the Central Pyrenees

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Summary

Introduction: Mountaineering improve the physical and mental health of people who practices it. All sports have a collateral not wished effects: accidents and sport injuries. Although mountain rescue operations involve logistic and environmental difficulties that expose everybody to important risks, alpine countries have joined sanitary people in these rescue operations because they know shorten times of medical intervention and an appropriate treatment in place diminish mortality and sequels, and consequently, social and sanitary expenses. Many mountain regions in Spain have not medical services in mountain rescue teams.
The facts of mountain casualties: There were 5,4 fatalities for every 100 rescued people in mountains in Spain. There were 3,5 fatalities for every 100 rescued people in Aragon. 6,3% of rescued patients suffered polytraumatisms. 63,7% of rescued people in mountains in Aragon presented a NACA index ≥ III (that means they need medical assistance in the place of the accident). 11,3% of people rescued in Aragon between 1999 and 2008 had a Glasgow Index among 13 and 9 and 12,9% had a Glasgow Index < 9. Mountain rescue operations are medicalized in Aragon since 1998.
Also, mountain rescues are medicalized in Asturias, Cantabria y Castilla-León.
Effects of medicalized mountain rescue operations: There are important differences between some regions in Spain about medical services in mountain rescues. Medicalization means to have a doctor or nurse specifically trained in Mountain Emergency Medicine integrated in rescue teams. This improves the efficiency of first treatments on the field, despite the difficulties of access, improving survival and diminishing morbidity. In Aragon, the rate of average mortality has changed from 9,32% before the medicalization of mountain rescue to 3,45% during medicalization with CUEMUM physicians and nurses, which supposes a decrease of 62% in 15 years. Whereas the rate of mortality in Spain was changed to 8,8% to 6,8% in the same period what supposes a decrease of 12,5%.
Cost-benefit analysis: We calculate downwards that mountain casualties in Spain costs more than 375 million € per year. They overcome 50 million € per year in Aragon. This region has save of more than 175 million € with this decrease of mortality of 62%.
Conclusions: Medicalization of mountain casualties is a human right and a duty with clear social and sanitary benefits. The medical assistance on the field diminishes morbidity and mortality and the public expenditure. Spain must to improve the prevention and to guarantee the medicalization of mountain rescues in the whole Spanish regions with nurses and physicians trained in Mountain Emergency Medicine.

Key words:
Medicalization. Cost analysis. Mountaineering accidents.

Medicalizar los equipos de rescate en montaña: justificación socio-económica en base a la evolución de la mortalidad en el Pirineo Central

Resumen

Introducción: El montañismo mejora la salud física y mental de las personas que los practican contribuyendo a lograr un menor gasto socio-sanitario. Todos los deportes tienen efectos colaterales no deseados: accidentes y lesiones. Las operaciones de rescate en montaña implican dificultades logísticas y ambientales que exponen a numerosos e importantes riesgos, pero se han incorporado sanitarios en estas operaciones de rescate ya que acortar los tiempos de intervención médica y el tratamiento apropiado *in situ* disminuyen la morbi-mortalidad de los accidentados. En España hay muchas Comunidades Autónomas (CCAA) sin rescate en montaña medicalizado.
La realidad de los accidentes de montaña: En España hay 5,4 muertos por cada 100 rescatados en montaña. En Aragón, se contabilizan 3,5 muertos/100 accidentados rescatados. El 11,3% de los rescatados en Aragón entre 1999 y 2008 presentaba un índice Glasgow entre 13 y 9 y el 12,9% tenían un Glasgow < 9 (grave). Un 6,3% de los pacientes rescatados sufrieron politraumatismos. Un 63,7% de los rescatados presentaban un índice de gravedad NACA≥III que hace referencia a pacientes que requieren asistencia médica en el lugar del accidente. En Aragón se medicaliza el rescate en montaña desde 1998. También están medicalizados estos rescates en Asturias, Cantabria y Castilla-León.
Los efectos de la medicalización del rescate en montaña: Existen claras diferencias entre las prestaciones que establecen unas CCAA y otras. La "medicalización del rescate" supone un médico o enfermera específicamente formado en Medicina de Urgencias en Montaña integrado en los equipos de rescate. Esto mejora la eficacia del primer tratamiento en el lugar del accidente, por difícil que sea el acceso, mejorando la supervivencia y disminuyendo la morbilidad. En Aragón, la tasa de mortalidad media ha pasado del 9,32% antes de la medicalización del rescate al 3,45% en los 15 años de rescate medicalizado con médicos y enfermeras CUEMUM, lo que supone una disminución del 62%. Mientras que la tasa de mortalidad media en España en el mismo periodo ha pasado del 8,8% al 6,8%; lo que supone una disminución del 12,5%.
La relación coste-beneficio: Calculamos a la baja que los accidentes de montaña en España cuestan más de 375 millones € al año. En Aragón estimamos que superan los 50 millones € al año. La disminución de la tasa de mortalidad en un 62% ha supuesto un ahorro de más de 175 millones €.
Conclusiones: La medicalización del rescate es un derecho y un deber con claros beneficios socio-sanitarios. La asistencia médica *in situ* disminuye la morbi-mortalidad y el gasto público. España debe mejorar la prevención, además de garantizar la medicalización de los rescates en todo el territorio con sanitarios formados en Medicina de Urgencias en Montaña.

Palabras clave:
Medicalización. Análisis económico. Accidentes de montaña.

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Introduction

Moscoso defines mountaineering as *"those physical activities which consist of progressing, ascending or otherwise, over mountainous terrain and are consciously performed in order to maintain or improve the health (physical and/or mental), interact with others, evade everyday life, experience sensations produced by the practice itself or, finally, to excel oneself and/or compete"*[1].

Sport improves the health[2,3], but all sports involve injuries or accidents. Mountaineering is not the sport with most accidents or injuries. In most cases, it consists of a form of "adventure sport" or "active tourism", which, when performed responsibly, is less dangerous than other sports not classified a priori as "high-risk" activities. It should be noted that:

According to the Royal Society for the Prevention of Accidents (ROSPA), in the UK, playing football or cricket involves a greater risk of injury than hiking or rock climbing[4].

A micromort (MMI) is a unit of risk defined as a one-in-a-million chance of death. According to Blastand and Spiegelhatler,[3] the probability of dying travelling 100 km by motorcycle is 10 in a million (10 MM), running a marathon 7 MM, cutting down trees for one day 6 MM, climbing for one day 3 MM and skiing for two days 1.5 MM.

The problem with mountaineering is that an accident or injury in a difficult, isolated and hostile environment can involve serious consequences or even death. The implications of a sprain in a sports centre are not the same as those of a sprain at 3,000 metres, in bad weather and near nightfall.

Following the results of emergency assistance in the field during the Korean and Vietnam wars, numerous studies have shown that the early management of many potentially lethal medical conditions, particularly cardiovascular conditions, but also those related to traumatic injuries, decreases mortality and significantly reduces sequelae (morbidity). Consequently, shortening the intervention times involved in providing appropriate treatment has been the chief objective of medical care out of the hospital environment in developed countries since the 1960s[5].

Mountain accidents have a high impact in terms of premature death and loss of health or quality of life in a significant number of people, most of them young[6-9]. Consequently, the Alpine countries have not hesitated to include medical professionals in their mountain rescue teams, but *are there objective grounds and evidence supporting the widescale applicability of this measure?* Not just any healthcare professional is suitable for this job, however, because the incorporation of medical specialists in mountain rescue teams requires that they be suitably trained in emergency medicine out of hospital environments, possess sufficient knowledge and skill to progress safely and quickly on mountains, in snow, on cliff faces, in ravines and in caves, and have the ability to work closely and safely with the mountain rescue specialists they accompany[10,11]. This calls for specific training with the involvement of many institutions, because these professionals will be providing their services in the public sphere. On the face of it, *is it worth the institutional and economic effort that all this requires?*

The reality of mountain accidents

In Spain, there is no official record of mountain accidents, even though ever since the 2010 National Mountain Safety Congress, a Mountain Accident Observatory, one of the conclusions of Nerín's thesis in 2002,[12] has been demanded. According to the theses of Sánchez[13] and Villota[14] on rescues throughout Spain in 2013, 3,000 people are rescued in the mountains each year, there being Autonomous Communities in which groups other than the Guardia Civil (Spanish military body with police duties) carry out rescue work. If we consider that mountain rescues represent[12] 5-10% of all accident victims (who also consume health and social, but not rescue resources), Sánchez [13] estimates 60,000 mountain accidents a year.

According to a 2014 Aragonese economic report[15], active mountain tourism accounted for 10% of GDP: €3,350.20 million. Aragon, like other Spanish Autonomous Communities, sells nature, mountain and adventure tourism, which generates evident wealth and development in many of its districts. Due to the damage they cause and the human and economic cost they entail, mountain accidents are an undesired side effect of Mountain Tourism. That it is possible to apply methods of prevention and control, and that these methods are not being applied properly should be considered a public health problem in Aragon[12].

There seems to be no interest in the economic impact that mountain accidents have on a country or region even though mountaineering has proven beneficial effects on people's physical and mental health, and mountain tourism is an important economic driver. It is even more difficult to express the suffering of the victims of serious accidents, be they at work, on the road or in the mountains, in economic terms. No amount of money can compensate for the loss of a relative or a permanent disability.

The Guardia Civil carries out between 40 and 45% of all the mountain rescues it performs in Spain in Aragon. According to data provided by the Mountain Headquarters of the Guardia Civil, there are 7 deaths/100 accident victims among those rescued by the Guardia Civil in Spain. If we look at the figures of all the rescue groups in Spain, there are 5.4 deaths per 100 rescued. In Aragon, there 3.5 deaths/100 accident victims rescued. To get an idea of the seriousness of the problem, compare these figures to road safety statistics: in Spain, there are 4 deaths/100 traffic accidents[16].

Of the 2,135 clinical reports of patients rescued in Aragon between 1999 and 2008, Soteras[8] considers that 63.7% of rescues had a NACA severity score of ≥III, which refers to patients who require medical assistance at the scene of the accident, according to Schuster[17] and Kaufmann,[6] 67% of these had trauma-related problems, while the rest had medical or environmental conditions. Another severity index is the Glasgow scale. 11.3% of those rescued had a score between 13 and 9 (moderate severity) and 12.9% had a Glasgow score of <9 (severe). 6.3% of patients suffered multiple injuries. Only 13% of those rescued by helicopter emergency medical services could be considered uninjured. Soteras insists that rescue services with medical care should be available 24 hours a day; despite the infrequency of accidents requiring on-the-spot assistance, these rescue operations are much longer and complex than normal ones. Gosteli *et al.*[18] also indicate that the median time on

site for rescue teams in high-energy mountain accidents, characterised by a large proportion of severe traumas and axial injuries, is greater and that half of these cases involve at least one environmental or site-related difficulty. The authors conclude that these interventions are longer and more complex. Chen *et al*.[19] show that criteria such as a Glasgow score of <13, with a respiratory rate of less than 10 or more than 29 respirations per minute, or the presence of haemo- or pneumothorax warrant HEMS intervention because it leads to a 22% increase in the likelihood of survival (OR 1.22, 95% CI 1.03-1.45, $p = 0.02$).

In Aragon, mountain rescue has been "medicalized" since 1998 (with placement students studying Mountain Emergency Medicine Specialisation University Courses (CUEMUM) and, since 1999, professionals). CUEMUM medical staff also take part in mountain rescues in Asturias, Cantabria and Castile-Leon.

The effects of "medicalizing" mountain rescue

One important issue centres on the fact that the medical personnel need to be mentally and physically prepared to take part in difficult rescues, because such operations not only imply logistical difficulties[20], but also last longer and involve greater severity[5-7,9]. In order to address such situations, they require regulated, specialized training in both organised rescue and mountaineering techniques, in addition to HEMS training according to the recommendations of the International Commission for Alpine Rescue, which insists on training in emergency situations, mountain-specific training and air and ground rescue training[10,21]. The fact that Aragon has doctors and nurses trained to work with mountain rescue groups is thanks to the CUEMUM, initiated by Dr José Ramón Morandeira in 1996, which trained 400 health specialists in 18 years. Since 2016, CUEMUM training has been resumed through the *Official Master's Degree in Emergency Medicine in Mountain and Inhospitable Environments* (MUMMI) at Universidad Camilo José Cela, which is recognised throughout the European Higher Education Area (EHEA): http://www.jrmorandeira.org/formacion

When we refer to *"medicalizing rescue services"*[21], we do not mean that the medical professionals need to be professional rescuers; we mean that a doctor or nurse specifically trained in Mountain Emergency Medicine according to internationally accepted criteria goes to the site of the accident and attends to the injured person there, be it on a rock face, the top of a mountain, a ravine, cave or a snow-laden slope, where emergency training or HEMS (Helicopter Emergency Medical Service) training is not sufficient. That is to say, we refer to medical professionals who are[8,10,21]:

- Comfortable in exposed situations
- Aware of their own safety
- Able to work under extreme conditions

Article 43 of the Spanish Constitution states: "*The right to health protection is recognised. It is incumbent upon the public authorities to organize and safeguard public health through preventive measures and the provision of the necessary assistance and services (…)*". It should be noted that *"the right to health"* is linked with something so essential and so unconditionable as the right to life. In fact, this is the principle of taking charge of the medical care of the population, including those suffering from diseases derived from tobacco, drugs, alcohol, obesity and a sedentary lifestyle, even though these are the result of 'recklessness' and 'risky behaviour' as far as health is concerned. Most mountaineering activities are aerobic physical activities, suitable for gaining physical fitness, losing weight and reducing the risk of cardiovascular disease. Yet public opinion, the insurance companies and the government itself tend to mistakenly consider them a form of 'risk behaviour'.

The study *Actividad física y prevalencia de patologías en la población española* (Physical activity and prevalence of disease in the Spanish population)[2] shows that *"increasing physical activity in the Spanish population could reduce health spending by 10% and lead to annual savings of 5,000 million euros"*. If members of the public suffer injuries or illnesses as a result of physical activity in mountain environments -which helps reduce health spending by improving physical and mental health-, shouldn't the public health system guarantee care with the necessary diligence and with the same guarantees in all the country's Autonomous Communities?

If we refer to the General Health Act (14/1986 of 25 April), Article 3.2 states: *"Public health care shall be given to the entire Spanish population. Access and health services shall be provided in conditions of effective equality"*. This is argument enough to demand the provision of "medicalized" rescue services in all the Autonomous Communities, while in fact they only exist in Asturias, Cantabria, Castile-Leon and Aragon. The Autonomous Communities are responsible for: Health Planning, Public Health and Health Care.

However, clear differences can be observed between the services established in different Communities regarding the provision of medical care as part of mountain rescue. If we put ourselves in the shoes of those in charge of health and civil protection, we should wonder if it is necessary for health professionals to reach the victim of the accident instead of waiting for the rescue to bring him or her to them? Isn't the shortening of rescue and transfer times thanks to helicopter rescue enough to assist those who suffer mountain accidents?

- On the one hand, if we look specifically at HEMS rescue operations in mountainous and remote areas, studies show that at least two thirds of rescues require the use of mountaineering techniques to access and evacuate the victim[21-23]. Therefore, health professionals involved in mountain emergency services need specific training in Mountain Emergency Medicine in order to be able to provide health care at the site of the accident[8,10,11,21].
- On the other hand, according to Cowley[24], most victims of traumatic accidents could be saved if bleeding and blood pressure are controlled in less than an hour. The Golden Hour is an undisputed healthcare quality criterion in all developed countries. The European HEMS system pursues this goal; survival in isolated and hostile environments also depends on helicopters significantly shortening intervention times[25]. This optimal response time supposes arrival at the scene of the accident, treatment in the field and transfer to the appropriate hospital in less than an hour, having stabilised the patient using PHTLS and AMLS techniques.
- But there are circumstances in mountain emergencies which make the urban HEMS *"golden hour"* target impossible. Therefore, the

presence of a mountain emergency doctor/nurse greatly improve the victim's chance of survival. It is considered that this *"golden hour"* can be safely extended when there is a doctor at the accident site, as demonstrated by Osterwalder's study[26] comparing two groups of trauma patients. And as also shown by Durrer[27,28], who indicates that the presence of doctors trained in air mountain rescue improves the effectiveness of primary treatment at the accident site, even in areas which are difficult to access[25]. The results of Soteras' study[8] support the evidence which indicates that the presence of doctors trained in air mountain rescue improves the effectiveness of primary treatment at the accident sites, however difficult access may be, improving the chance of survival and reducing morbidity. We are not talking about a HEMS helicopter "waiting" for the sick or injured person to be retrieved, but a mountain emergency doctor/nurse who forms part of a mountain rescue team treating the patient at the scene. This is what allows the *"golden hour"* to be *"extended"*.

Sanz29 reports the views of the groups involved in Aragon (Guardia Civil mountain rescue team members, members of mountain military units, health professionals from mountain health centres and CUEMUM doctors/nurses belonging to the 061 mountain emergency medical unit (UME)), shown here in Table 1: *"All the actors surveyed highlighted a reduction in health complications and mortality as a result of the current rescue with medical care service in operation in Aragon, where the technical part of the work is performed by the Guardia Civil mountain rescue groups and health care is provided at the accident site by specialised staff belonging to the Aragon Emergency Health Service (trained in Mountain Emergency Medicine)".*

The opinions of those directly involved (which rarely coincide with the opinions of those who manage public health, who know little about the reality on the ground) are confirmed by concrete figures in the graphs describing the evolution of the mortality rate in Aragon and in Spain (Figures 1 and 2), produced using data provided by the Mountain Guardia Civil. Between 1981 and 1998, the annual mortality rate in Aragon was much higher than the mortality rate in Spain as a whole. Since medical professionals started to form part of the mountain rescue teams in Aragon, the mortality rate there has significantly dropped beneath the figures for Spain and even holds at 50% lower than the average rate in the country. The only Guardia Civil mountain rescue groups which include CUEMUM doctors and nurses are those in Aragon.

Let us take a more detailed look at the effect which "medicalization" has had on mountain rescue operations in Aragon. If we analyse the figures of casualties rescued, as provided by the Headquarters of the

Table 1. Opinions of the groups involved in Aragon[29].

Agent	Reduction of health complications	Reduction of mortality
GREIM	Between 81% and 90%	Between 81% and 90%
GMAM	Between 51% and 60%	Between 21% and 30%
Sabiñánigo (Huesca) UME Health Professionals	Between 91% and 100%	Between 91% and 100%
Health Professionals at Huesca Health Centres located in mountain areas	Between 61% and 70%	Between 91% and 100%

GREIM - Guardia Civil Mountain Rescue and Intervention Groups.
GMAM - High Mountain Military Group at the Mountain and Special Operations Military School in Jaca (Huesca).
Sabiñánigo UME - 24-hour Advanced Life Support Unit where the mountain rescue health professionals are based.

Figure 1. Deaths per 100 mountain accident victims rescued by the Guardia Civil in Aragon.

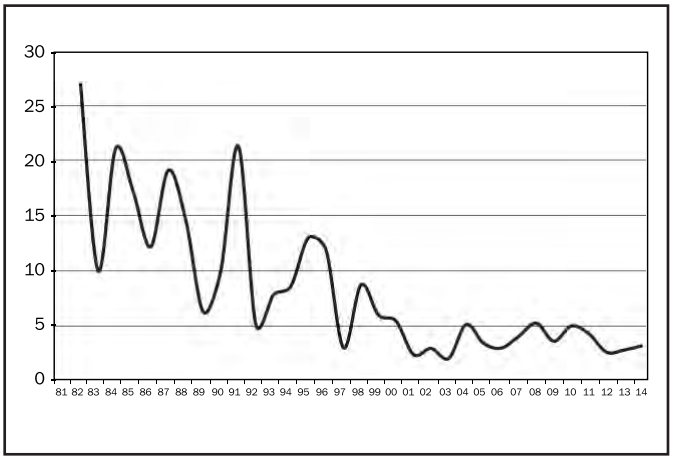
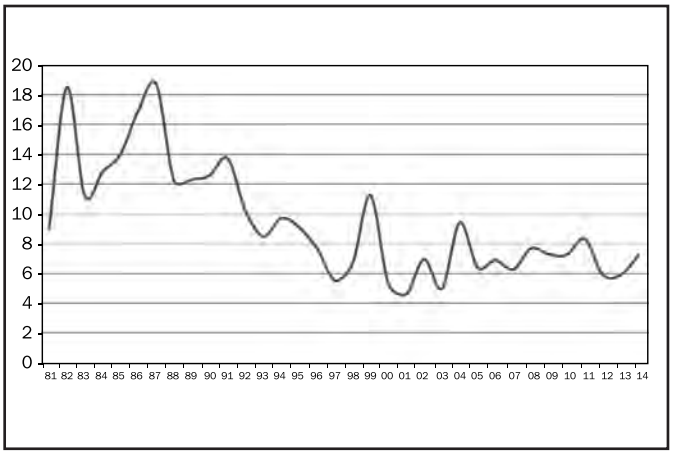


Figure 2. Deaths per 100 mountain accident victims rescued by the Guardia Civil in Spain.



Mountain Guardia Civil in Aragon, the average mortality rate (deaths per 100 injured rescued) fell from 9.32% (between 1990 and 1999) *prior to the introduction of medical professionals in rescue teams to 3.45% (between 2000 and 2014) in the 15 years of rescue with CUEMUM doctors and nurses; a 62% drop*. Meanwhile, the average mortality rate in Spain fell from 8.8% (between 1990 and 1999) to 6.8% (between 2000 and 2014); a 12.5% decrease. This drop can be explained by the impact of the lower mortality rate in the mountains of Aragon on the total figures of the Guardia Civil rescues carried out in Spain.

Meyer *et al*.[30] demonstrated the effectiveness of HEMS in reducing morbidity and the average time spent in hospital. When HEMS services were combined with the creation of "Trauma Centres", the mortality rate among the most seriously injured fell[16] from 50 to 39%. Therefore, the provision of medical care at mountain accident sites (almost 3,000 rescued in Spain, according Villota and Sanchez) reduces morbidity and mortality by rather more than one person by prolonging the *"golden hour"*, as evidenced by the evolution of the mortality rate in Aragon since 1999.

Costs and benefits

These figures take us to the cost-benefit analysis conducted by Sanz[29] on accident victims rescued by the Guardia Civil in Aragon, where almost half the rescues carried out in Spain take place.

Costs

According to figures provided by Guardia Civil mountain rescue specialists in Aragon, one helicopter flight hour costs around 3,000 euros and approximately three flight hours are needed to complete an operation. In Aragon, Guardia Civil helicopter flight hours in 2013 accounted for an annual "bill" of over two million euros. To this, we need to add the cost of rescue personnel, the doctor or nurse belonging to the emergency health service and the material resources used. The cost of rescues and Guardia Civil mountain rescue teams is met by the Spanish Government's Ministry of the Interior.

Table 2 shows the estimated cost of technical rescue operations performed by the mountain Civil Guard according to type of rescue.

The approximate costs, calculated from an optimistic perspective (according to the Government of Aragon's annual remuneration tables for 2013 by professional levels, without the work post supplement, special availability supplement, three-yearly bonuses or inclusion of the 13th and 14th monthly payments), according to the professional involved (excluding the consumption of the specific vehicles and material for mountain rescue) are shown in Table 3.

The additional cost of the Aragon Emergency Medical Service's Special Mountain Rescue Unit compared to a conventional Emergency Medical Unit is 182,192 euros per year according to Soteras[8]. This includes: 3 more doctors, training time and night-time rescue hours, the health professionals' personal equipment, the collective equipment and the specific health equipment for mountain rescues. This cost is borne by the Aragon Health Service, although the health care bill is being passed on to some of those injured.

Table 2. Mean cost of a rescue operation.

Type of rescue	With helicopter	On foot
Short duration[1]	€3,534.30	€1,439.90
Medium duration[2]	€12,828.20	€4,057.90
Long duration[3]	€27,881.70	€15,708

[1]Short rescue: one that is resolved in a day.
[2]Medium rescue: one that is resolved in two days.
[3]Long rescue: one that is resolved in a week.
Source: Mountain Guardia Civil.

Table 3. Cost of the professionals involved[8].

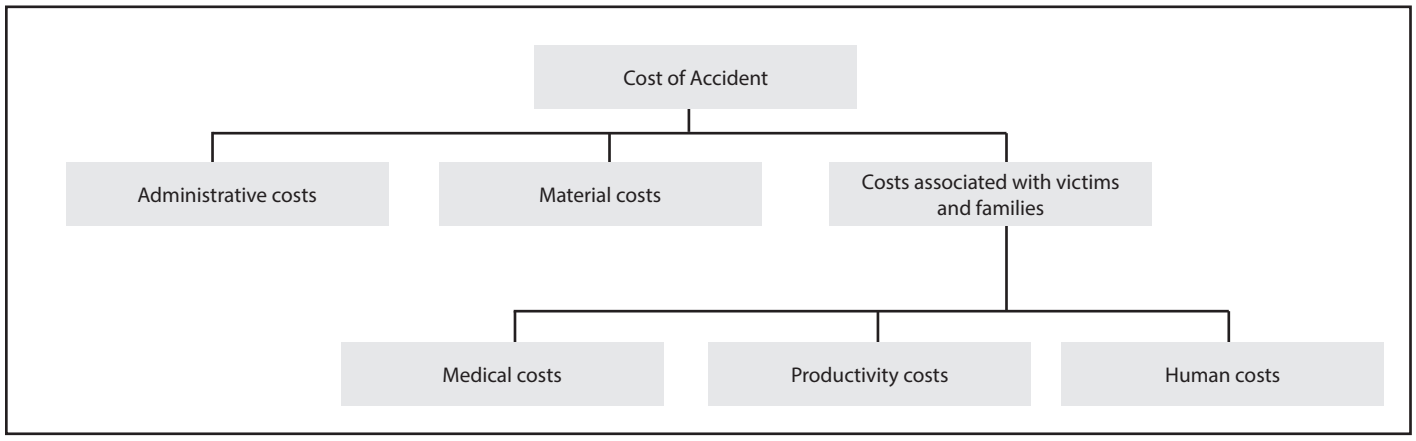
Professional involved	Net cost/hour
Doctor: 061 UME-Sabiñánigo	€10.78
Nurse: 061 UME-Sabiñánigo	€8.74
Mountain Guardia Civil	€8.05
Medical transport technical staff	€7.06

Sabiñánigo UME - 24-hour Advanced Life Support Unit where the mountain rescue health professionals were based until 2017.

But these are the costs that the Government of Aragon, the national press and public opinion always refer to; what we could call the "visible" part of the "iceberg" of the cost of accidents, a fraction of the actual costs described in an example provided later on in this article. First, let us analyse the diagram (Figure 3) of the Fundación Instituto Tecnológico para la Seguridad del Automóvil (Automobile Safety Technological Institute Foundation)[31] for road accidents, adapting it to our context.

- *Administrative costs.* These include the hours of the police, judges, lawyers, insurance companies, mountaineering federations, etc. to 'administratively manage' accidents: reports, forms, trials and procedures which may be required.
- *Material costs.* These refer to the costs of repair or replacement of the accident victim's mountain equipment and belongings, and the loss or damage of other "apparatus" (paragliders, mountain bikes, etc.); there are not usually infrastructure repair costs, as occurs with traffic accidents.
- *Costs associated with the accident victims.* These account for the largest amounts:
  - *Medical costs:* healthcare on site, hospital and/or outpatients care, and care following discharge and throughout the recovery and rehabilitation process.
  - *Costs of lost production* as a result of sick leave or throughout the victim's remaining working life, truncated by the accident (if the result is the death or total disability of the victim). The average age of mountain accident victims in Aragon is between 34 and 43[8,29]. If these people stop producing (due to death or sick leave), this adds up to huge losses for society, precisely when they are "returning" the investment made in education, health, etc. over 25 years and have a productive life ahead of them.

Figure 3. Cost of accidents[16].



- *Human costs:* those associated with the suffering of victims and their loved ones, due either to death or disability. The cost of lifelong dependency (paraplegia, tetraplegia, amputations, brain injuries, etc.) should be added to these costs.

In a period of ten years (1998-2007), traffic accidents have accounted for a total cost to Spanish society of between 105,000 and 144,000 million euros[16]. An average cost was calculated at 12,500 million euros per 100,000 traffic accidents in Spain between 1998 and 2007[16]. If we establish a parallel in terms of the cost of injuries, deaths and disabilities, even though the death rate in mountain accidents is higher than that of traffic accidents, there is still no 30-day follow-up of mountain accidents -as Iglesias is doing in Asturias[32]- and many accident victims are not rescued, we can optimistically estimate that mountain accidents in Spain cost more than 125 million euros per year (on the basis of 1,000 people rescued by the Guardia Civil), 375 million if we consider the figures of Sánchez[13] and Villota[14]. If between 400 and 500 victims a year are rescued in Aragon, we can estimate the figure at around 50 million euros a year.

Benefits

The benefits are mostly intangible, difficult to quantify with market prices and hard to specify in the absence of longitudinal epidemiological studies of *"failure to provide extra-hospital care on-site"*. At the same time, it is not possible to express the suffering of the victims of serious or fatal accidents and their relatives in economic terms. Be that as it may, we are talking about saving lives and reducing sequelae.

Cost-benefit ratio

We can calculate the cost of *rescuing* a mountain accident victim *with on-the-spot medical care* at between 3,000 and 30,000 euros, depending on the duration of the operation and whether or not the support of a rescue helicopter and the emergency service's HEMS (which can be calculated at between 3,000 and 6,000 euros per intervention -according to the rates of the Government of Aragon) is required to evacuate the patient to a tertiary referral hospital once he/she has been stabilised at the scene of the accident by the rescue team doctor and evacuated to safety by the rescue team.

To this initial intervention, it is necessary to add *hospital care*, time *spent in hospital, rehabilitation, time off work, insurance* payments and the cost of *replacement* at work. Taking into account that[8] the median age of accident victims treated between 1999 and 2008 was [34] (interquartile range: 26 to 47), and that victims aged between 3 and 95 years were rescued, the cost of a mountain accident grows exponentially.

In 2014, the average federated mountaineer circulating in the Aragonese mountains was 43 years old[29], had university-level studies and was a member of the active working population. If this "typical user" suffers a serious accident, the social cost (what the dead or disabled person stops producing, plus the resources he/she "consumes") is very high.

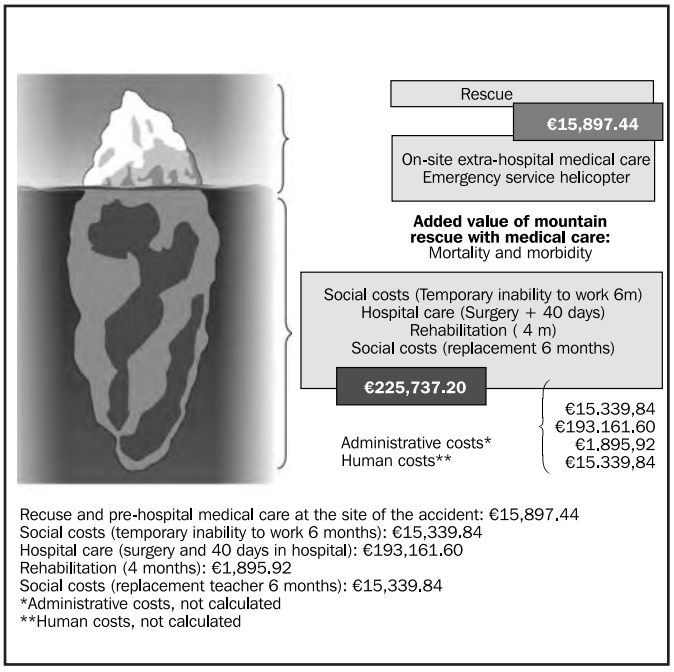
Let us take the example of a "typical mountaineer" who is 42 years old, educated to degree level, has suffered a broken pelvis and is attended to by a CUEMUM doctor or nurse from the moment in which the Guardia Civil rescue helicopter arrives, thereby allowing him to be stabilised haemodynamically while a long, difficult rescue operation is carried out on the face of Coll de Ladrones. Such a rescue means that he can reach a public tertiary hospital with surgical intensive care unit in Zaragoza in optimal conditions to be operated on (Aragon Health Service prices). On the other hand, the same patient has a good chance of reaching the hospital dead, in a state of practically irreversible shock or with paraplegia if he does not receive medical care in that first "golden hour" -extended in mountain accidents if there is a health professional at the site with specific training, as previously explained.

The breakdown of the costs involved in this example are shown in Figure 4.

The rescue and pre-hospital medical care of this polytraumatized patient costs €15,897. However, the real expense comes from the health care and social costs needed later: €225,737.

The social cost of a deceased person[33] is calculated according to the working years of life lost, among other indices. Given that the current

Figure 4. Breakdown of mountain accident costs in the example.



retirement age is 67, the approximate cost to society of the death in a mountaineering accident of a 42-year-old would be 875,000 euros (= 35,000 euros annual gross salary x 25 working years), to which the human cost, investments previously made in him/her, life insurance and human costs should be added. The bereavement benefits paid by the federation's insurance policy in the event of accidental death in the mountains stand at 6,000-9,000 euros. Another cost to be taken into account arises if a third party is involved (such as a company that provided services), from which additional financial compensation could be claimed, although, of course, by no means would this compensate for loss of production or, less still, the human costs incurred.

We can also refer to[33] the Value of a Statistical Life (VSL) in Spain. The value of the life of a normal person is estimated at 1.3 million euros, which, after adding the net losses and medical and ambulance costs, gives us a Value of a Prevented Fatality (VPF) of 1.4 million euros. Using the hedonic wage method (revealed preferences), Riera[34] calculates a VSL range between €2 and €2.7 million. This VSL[3] is 1.6 million GBP in the UK (€1.8 million) and €5.2 million in the USA ($6.2 million).

The estimated cost of permanent disability in Spain is €2,434,740, not counting indirect costs (health care, social care, caregiver, family, accessibility infrastructure at home and environment, etc.).

6.3% of rescued mountain accident victims in Aragon[8] between 1999 and 2008 had multiple injuries. If these patients had not received medical care on-site, many of them would have arrived dead at the hospital or have been left with serious sequelae. That the mortality rate in Aragon has decreased by 62% in fifteen years represents a saving of more than 175 million euros, to which the benefit of not losing a parent, husband or son must be added, not to mention the unknown number of people who have avoided suffering a more or less serious disability, with everything that entails. Meanwhile, the estimated additional cost of the Sabiñánigo Emergency Medical Unit (UME) between 2000 and 2014 stood at approximately 2.7 million euros. The economic benefit is substantial. The moral and social benefit is incalculable.

The training of mountain emergency doctors and nurses costs around 15,000 euros (university tuition, travel and lodging, insurance, mountain materials and equipment), the Guardia Civil making a significant investment (human resources, materials and infrastructure) to train these professionals which is not passed on in tuition fees. Considering that these health professionals are going to carry out their work in the public sphere, their training should be subsidised by the government.

The origin of the absurd idea of not "medicalizing" rescue services and not investing in the training of health professional lies in the fact that everything is considered a "cost", when it is clearly an "investment for the future" due to: the very significant reduction in costs to society implied, the lives saved, the reduction of sequalae, the added value of quality that health care for accident victims means for mountain tourism and the safety that training in Mountain Emergency Medicine implies for health professionals, accident victims and rescuers.

In all events, public investment should be made according to a cost-benefit criterion[3] which is often not applied or even known. It is relatively easy to estimate the cost of implementing a mountain safety campaign, but it is not so easy to assign a specific economic value to the savings made by preventing mountain accidents.

Tourism in Aragon generates over 3,000 million euros a year. Active tourism is an economic engine in all the mountainous regions of Spain and we should not forget that Spain is the second most mountainous country in Europe after Switzerland. It would be profitable to invest in providing "medicalized" rescue services to ensure a lower morbidity and mortality rate associated with mountain accidents, an undesired side effect of mountain tourism. You cannot sell mountain activities and then shy away when it comes to providing accident victims with on-site medical care. The study being carried out in Asturias[32] shows the clear benefits of "medicalized" mountain rescue operations in terms of human costs.

The cost-benefit ratio provides a sufficiently strong case on which to base the claim that the costs of the mountain operation (rescue and health care provided by doctors or nurses trained in Mountain Emergency Medicine) are more than justified and amply "pay off" if the victim does not die, is not paralysed and can return to his/her active working life. The example given shows that the costs of rescue with on-site medical care represent between 5 and 10% of the total costs of a serious accident, so there is no basis for beating around the bush as to whether the victim should be charged for the rescue operation or not. Furthermore, if we apply commercial terms, you cannot sell a product (mountain tourism) and then fail to guarantee an adequate after-sales service (rescue services with medical care).

The autonomous and central governments are unable to address this issue with the necessary rigour. The question forever under debate

is whether to *'charge for rescue operations' and/or 'charge for the extra-hospital health care involved',* when:

- these costs are the least important in the overall calculation of the cost of mountain accidents,
- analgesia at the site of the accident is a human right,
- the accident victims were doing physical exercise -which improves their health and reduces health spending-,
- and not raising the alarm to be rescued (so as not to be financially penalised) would exacerbate the consequences of the accident.

Charging for rescue operation benefits neither the victim not society. Prevention and training are the way forward. Those who advocate penalties are unaware of the full picture. The main topic for discussion, one which is not addressed, should be whether to *"provide mountain accident rescue services with trained medical professionals in all the Autonomous Communities",* because such a measure would entail significant human and economic benefits for society and the public coffers by reducing the deaths of and sequelae suffered by accident victims.

But we should also point out that *"on-site medical assistance"* is not everything. In 1996, Dr Morandeira said that *"the best rescue is the one which does not need to carried out because the accident has not taken place".* There is still much to be done in the field of prevention, risk management and the training of mountain climbers and tourists. The launch of a *National Plan for the Prevention of Mountain Accidents and a Spanish Mountain Health and Safety Observatory* by the Spanish Federation of Mountain Sports and Climbing (FEDME) and the Higher Sports Council (CSD) to coordinate the actions of the institutions and groups involved in mountain sports is still a pending issue and an urgent necessity.

Conclusions

- Sporting activities in the natural environment improve the physical and mental health of those who pursue them, helping to reduce social and health spending, and creating wealth and stabilising the population in mountain areas which would otherwise be doomed to poverty and depopulation. These sporting activities have unwanted side effects, accidents, which account for an estimated cost, calculated as a minimum, of 375 million euros a year in Spain; but what is truly expensive are the deaths and consequences suffered by accident victims, not the rescue operations.
- The provision of "medicalized" rescue services and analgesia at the accident site are a human right and a duty of the authorities.
- The provision of "medicalized" rescue services significantly reduces morbidity and mortality in mountain accident scenarios and, consequently, the cost of the accidents themselves. In Aragon, the provision of "medicalized" rescue services has led to a 62% reduction in mortality over the last 15 years and a non-quantifiable reduction in morbidity.
- The doctors and nurses involved in "medicalized" mountain rescue should meet the requirements set by the international community and the European Higher Education Area in order to ensure the safety of the operation and guarantee proper patient care in the field.
- "There is still much to do in terms of prevention, training and medical care. We understand that it is not a question of charging for the costs of rescue operations or on-site medical care, but of increasing safety to reduce the risk and, if accidents happen, of providing "medicalized" rescue services in all mountain regions involving doctors and nurses with post-graduate training in Emergency Medicine in Mountain and Inhospitable Environments".
- The creation of a Spanish Mountain Health and Safety Observatory with an annual budget and a stable team of specialists in the field, not politicians, is an urgent necessity in order to plan preventive and mitigating measures.

Conflict of Interests

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

Bibliography

1. Moscoso D. *La montaña y el hombre en los albores del siglo XXI.* Zaragoza. Barrabés Editorial; 2002. 1ª edición. p.42
2. Aragonés MT, Clemente MT, Fernández Navarro P, Ley V. Actividad física y prevalencia de patologías en la población española. Publicaciones Ministerio de Educación, Cultura y Deporte. Madrid, 2016. Sede electrónica. (Consultado 06/11/2017). Disponible en: https://sede.educacion.gob.es/publiventa/detalle!buscaAutor.action?codAutor=12868
3. Blastland M, Spiegelhalter D. *The norm chronicles. Stories and numbers about danger and death.* New York. Basic Books; 2014. p.317, p.8 y p.314-15.
4. Doulgas E. How dangerous are climbing and hill walking. 2014. (Consultado 06/11/2017) Disponible en: https://www.thebmc.co.uk/how-dangerous-are-climbing-and-hill-walking
5. Cowley RA. An economical and proved helicopter program for transporting the emergency critically ill and injured patient in Maryland. *J Trauma.* 1973; 13(12):1029-38.
6. Kaufmann M, Moser B, Lederer W. Changes in Injury Patterns and Severity in a Helicopter Air- Rescue System Over a 6-Year Period. *Wilderness Environ Med.* 2006;17(1): 8–14.
7. Schöffl V, Morrison A, Hefti U, Ullrich S, Küpper T. The UIAA Medical Commission Injury Classification for Mountaineering and Climbing Sports. *Wilderness Environ Med.* 2011 Mar;22(1):46–51.
8. Soteras I. Rescate Aéreo Medicalizado en Montaña. Análisis clínico-epidemiológico retrospectivo durante 9 años de actividad. Modelo Aragonés. Tesis Doctoral. Universitat de Girona. 2012. (Consultado 06/11/2017). Disponible en: https://www.educacion.gob.es/teseo/mostrarRef.do?ref=998784
9. Ausserer J, Moritz E, Stroehle M, Brugger H, Strapazzon G, Rauch S, *et al.* Physician staffed helicopter emergency medical systems can provide advanced trauma life support in mountainous and remote areas. *Injury.* 2017 Jan;48(1):20-25.
10. Rammlmair G, Zafren K, Elsensohn F. Qualifications for emergency doctors in mountain rescue operations. En: Elsensohn F (ed.). *Consensus Guidelines on Mountain Emergency Medicine and Risk Reduction*. Lecco: Casa Editrice Stefanoni; 2001. p. 65-70.
11. Tomazin I, Ellerton J, Reisten O, Soteras I, Avbelj M. Medical Standards for Mountain Rescue Operations Using Helicopters: Official Consensus Recommendations of the International Commission for Mountain Emergency Medicine (ICAR MEDCOM). *High Alt Med Biol.* 2011;12(4):335-41.
12. Nerín MA, Morandeira JR. Estado actual de la prevención de los accidentes de montaña en Aragón. *CCD.* 2005;2:75-86.
13. Sánchez Hernández A. Siniestralidad en los deportes de montaña. Realidades y soluciones. Pp.205-15. En Allueva P, Nasarre JM (ed.). *Retos del montañismo del siglo XXI.* Zaragoza. Universidad de Zaragoza; 2015.pp.205-15.
14. Villota S. Accidentabilidad en montaña. Estadística de rescates en España y campañas de prevención. Tesis Doctoral. Universidad Camilo José Cela. 2017. (Consultado 16/05/2018). Disponible en: https://www.educacion.gob.es/teseo/mostrarRef.do?ref=1541319
15. Consejo económico y social de Aragón. Informe sobre la situación económica y social de Aragón Año 2014. Aprobado en sesión plenaria de 9 de julio de 2015. ISSN 1134-9034. http://www.aragon.es/OrganosConsultivosGobiernoAragon/Orga-

nosConsultivos/ConsejoEconomicoSocialAragon/AreasTematicas/Publicaciones/ci.01_Informes_Anuales.detalleConsejo#section5 Última consulta 06/11/2017. Edición íntegra www.aragon.es/cesa

16. Sedano AL. Las consecuencias del accidente. Consecuencias económicas y sociales. Ministerio del Interior. Dirección general de Tráfico. Convocatoria Promoción Interna 2013. Temario: Grupo de Materias Comunes de Movilidad Segura. ESTT – OEP Tema 11; 2013 (Consultado 06/11/2017). Disponible en: http://www.dgt.es/Galerias/la-dgt/empleo-publico/oposiciones/doc/2013/TEMA_11_Parte_Comun_mov_segura66g.doc.
17. Schuster HP. Scoring Systeme in der Notfallmedizin. *Notfallmedizin.* 1994;43:30-5.
18. Gosteli G, Yersin B, Mabire C, Pasquier M, Albrecht R, Carron PN. Retrospective analysis of 616 air-rescue trauma cases related to the practice of extreme sports. *Injury.* 2016 Jul;47(7):1414-20.
19. Chen X *et al.* Speed is not everything: Identifying patients who may benefit from helicopter transport despite faster ground transport. *J Trauma Acute Care Surg.* 2018 Apr;84(4):549-557.
20. Laskowski-Jones L et al. Extreme event medicine: considerations for the organisation of out-of-hospital care during obstacle, adventure and endurance competitions. *Emerg Med J.* 2017 Oct;34(10):680-685.
21. Küpper T, Hillebrandt D, Steffgen J, Schöffl V. Safety in Alpine Helicopter Rescue Operations - Minimal Requirements of Alpine Skills for Rescue Personnel. *Ann Occup Hyg.* 2013;57(9):1180–8.
22. Tomazin I, Kovacs T. Medical Considerations in the Use of Helicopters in Mountain Rescue. *High Alt Med Biol.* 2003;4:479-83.
23. Tomazin I. Activation and Rational Use of Rescue Helicopters. En: Elsensohn F (ed.). *Consensus Guidelines on Mountain Emergency Medicine and Risk Reduction*. Lecco: Casa Editrice Stefanoni; 2001.p.85-6.
24. Cowley RA. The resuscitation and stabilization of major multiple trauma patients in a trauma center environment. *Clin Med.* 1976;83:14-22.
25. Tomazin I, Vegnuti M, Ellerton J, Reisten O, Sumann G, Kersnik J. Factors impacting on the activation and approach times of helicopter emergency medical services in four Alpine countries. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine.* 2012;20:56. doi:10.1186/1757-7241-20-56.
26. Osterwalder J. Emergency Medicine in Switzerland. *Ann Emerg Med*. 1998; 32(2): 243-7.
27. Durrer B. Rescue operations in the Swiss Alps in 1990 and 1991. *Wilderness Env Med.* 1993;4:363-73.
28. Durrer B. Characteristics of emergency therapy in mountain accidents. *Ther Umsch.* 1993;50:228-33.
29. Sanz Gaspar, I. El coste de la supresión del Máster de Medicina de Montaña y Extrema Periferia en Aragón. [Trabajo fin de Máster]. Universidad de San Jorge, 2014. Número de registro de la propiedad intelectual Z-41-2015. Solicitud para consulta en: http://www.mecd.gob.es/cultura-mecd/areas-cultura/propiedadintelectual/registro-de-la-propiedad-intelectual/publicidad-registral.html
30. Meyer P, Rosen HB, Hall W. Fracture dislocations of the cervical spine: Transportation, assessment and immediate management. *Am Acad Orthop Surg.* 1976;25:171-83.
31. FITSA. El valor de la seguridad vial. Conocer los costes de los accidentes de tráfico para invertir en su prevención. Instituto Universitario de Investigación del Automóvil –INSIA– de la Universidad Politécnica de Madrid. Madrid 2008. (Consultado 16/11/2017). Disponible en: https://stopaccidentes.org/uploads/file/Costes_accidentes.pdf
32. Iglesias F, Sánchez I, Figaredo J, Gallego D. Características de los avisos primarios atendidos por el helicóptero de rescate de Asturias en 2016. [Trabajo fin de Máster Oficial]. Universidad Camilo José Cela, 2017.
33. Abellán JM, Martínez JE, Méndez I, Pinto JL, Sánchez FI. El valor monetario de una Vida Estadística en España. Estimación en el contexto de los accidentes de tráfico. Universidad de Murcia. Universidad Pablo Olavide. Estudio financiado por la DGT. (Consultado 16/05/2018). Disponible en: https://www.msssi.gob.es/profesionales/saludPublica/prevPromocion/Lesiones/JornadaDecenioAccionSeguridadVial/docs/InformeVVEJorgeMartinez.pdf.
34. Riera A, Ripoll AM, Mateu J. Estimación del valor estadístico de la vida en España: una aplicación del método de salarios hedónicos. Hacienda Pública Española. *Revista de Economía Pública.* 2007;181:29-48 (Consultado 06/11/2017) Disponible en: http://www.ief.es/documentos/recursos/publicaciones/revistas/hac_pub/181_RieraRipoll.PDF

High-intensity specific intermittent training (SIT) in the preparation of the tennis player

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Summary

The ability to perform actions repeatedly at high speed has a very clear relationship with the manifestation of endurance in sports such as tennis. The training in which there are interspersed periods of work of high intensity with others of recovery turns out to be a type of training more specific than continuous type. Within the interval systems, the intermittent training of high intensity (Intermittent training-IT) suppose a specially suitable method to improve aerobic and anaerobic endurance. Through this training will we be able to act on the adaptations related to the recovery between points, which has a direct relationship with the performance in the matches. In addition, the high intensity and low volume of training allows an optimal synergy with qualities such as explosive force and speed, so important in sports in which periods of work and recovery are interspersed. However, tennis has some specific characteristics that differentiate it from other intermittent sports such as brief recoveries and techniques of displacement and hitting the ball, so the use of intermittent training using typical movements of tennis (Specific Intermittent Training-SIT) is an especially suitable system. The choice of the intensity of the effort of the relationship between work and recovery times, and the degree of skill of the player are determining factors when carrying out specific training at high intensity.

In this review we try to show the interest of SIT training as a basic tool to encourage the improvements of the different factors of performance in tennis players.

Key words:
Tennis. Intermittent training. Specific training. SIT. Endurance. Recovery. Explosive strength. Elastic strength. Speed.

El entrenamiento intermitente específico de alta intensidad en la preparación del jugador de tenis

Resumen

La capacidad de realizar acciones a alta velocidad de forma repetida tiene una relación muy clara con la manifestación de la resistencia en deportes como el tenis. El entrenamiento en el que se intercalan periodos de trabajo de alta intensidad con otros de recuperación resulta un tipo de entrenamiento más específico que el de tipo continuo. Dentro de los sistemas interválicos, los entrenamientos intermitentes de alta intensidad (Intermittent Training-IT) suponen un método especialmente adecuado para mejorar la resistencia aeróbica y anaeróbica. Mediante este entrenamiento se podrá actuar sobre las adaptaciones relacionadas con la recuperación entre puntos, lo que tiene una relación directa con el rendimiento en los partidos. Además, la alta intensidad y el bajo volumen de entrenamiento permite una óptima sinergia con cualidades como la fuerza explosiva y la velocidad, tan importantes en deportes en los que se intercalan periodos de trabajo y recuperación. Sin embargo, el tenis tiene unas características específicas que lo diferencian de otros deportes intermitentes, como son las recuperaciones breves, y la técnica de desplazamiento y de golpeo de la pelota, por lo que la utilización del entrenamiento intermitente usando movimientos propios del tenis (Specific Intermittent Training-SIT), es un sistema especialmente adecuado. La elección de la intensidad del esfuerzo, de la relación entre tiempos de trabajo y recuperación y el grado de destreza del jugador, son factores determinantes a la hora de realizar entrenamientos específicos a alta intensidad.

En esta revisión se intenta mostrar el interés del entrenamiento SIT como herramienta básica para potenciar las mejoras de los diferentes factores del rendimiento en tenistas.

Palabras clave:
Tenis. Entrenamiento intermitente. Entrenamiento específico. SIT. Resistencia. Recuperación. Fuerza explosiva. Fuerza elástica. Velocidad.

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Introduction

In the course of a tennis match, a series of actions are performed at different intensities and durations, with changes of pace, turns and direction. Therefore, a variety of unique kinetic and kinematic actions occur in this sport, though there are similarities with other intermittent sports. However, the type of movement is also specific, with constant frontal, sideways and cross-step movements taking place, with variations in the length of strides to align distances with the ball, and the stable execution of hits, whilst simultaneously combining different tactical decisions related to fatigue, confidence and competitive stress.

These characteristics determine the aspects to train, and how the trainer should focus the tennis player's preparation. Tennis performance does not just depend on resistance, rather also on other factors such as explosive strength, speed, agility of movement, technique, tactics and mental factors. Yet all of these factors occur together and with great complexity, and are therefore interrelated. To assess the level of our players, as well as to prepare them, it would be useful to create multifactorial systems specific to tennis[1].

One of the most important characteristics in the manifestation of resistance, and in general, sporting performance in intermittent game sports, is the ability to repeat sprints[2]. In tennis, it is a question of repeating specific actions of the game at high intensity, and not just performing linear movements at maximum speed. To achieve the best results in this aspect, systems should be found that adapt most optimally to achieving this objective[3].

This review aims to analyse the importance of specific intermittent training (SIT) as a basic tool to boost improvements in performance of tennis players.

Methodology

To create this descriptive review article, a literary search was performed using various documental sources to locate the documents. Searches were carried out on the databases of PubMed (NLM), Cochrane Library, Scopus, Scielo, Embase and Sport Discus, as well as on the Google Academic search engine.

The search was based on articles published between January 2000 and March 2018.

The key words used to perform the review (isolated or combined), were: tennis, intermittent training, specific training, resistance and recovery.

When selecting the articles included in the review, factors considered were: the methodology, the quality of the research, and if the studies were performed on humans. Any article that was not directly related to the study object, any based on personal opinion and any that did not include valid measurement instruments, were excluded.

Specificity in tennis

Knowing the work and recovery time involved in tennis is an important factor when preparing players. Recovery time between points is set at 20 seconds for Grand Slam tournaments, and at 25 seconds for other tournaments in the professional circuit. However, often the time available is not used, generally being shorter and sometimes even closer to just 10 seconds[4]. Regarding point duration time, by analysing Grand Slam tournaments O'Donoghue & Ingram[5] discovered average times of between 6.3 and 7.7 seconds. The work: recovery ratio (W:R) oscillates between 1:2 and 1:4 on average[5,6], establishing a real play time of 20-26%[7,8]. However, often efforts are made with an above-average duration, and work-recovery ratios of 1:1 and 1:2 when long points lasting over 20 seconds are played. This is particularly interesting because the dynamics of the game, the duration of the work and recovery times, and the ratio between work and recovery, will substantially alter the magnitude of the load borne by the tennis players[9].

The intensity of play and the duration of the efforts determine the type of metabolism used. When points are very short and explosive, it is at the expense of ATP and phosphocreatine, with an aerobic recovery process during breaks, and with moderate lactate concentration clarification below 4 mmol. On other occasions, various long and intense points can occur, which cause a greater demand for oxygen consumption and for the glycolytic pathway, with higher levels of lactate production[10].

Break and work times, as well as the movement types, enable higher levels of strength to be produced in a short space of time, and the manifestation of explosive strength in the game's actions is a decisive factor in performance, and the capacity to repeat this explosive strength during the match is fundamental during play. The production of intermittent strength can generate fatigue on a central level, as well as in processes of excitation and contraction on a muscle fibre level, which can be reflected in losses of performance during the development of tennis matches[11]. This fatigue can be related to the rapid call for strength, as deterioration has been observed after stretching-shortening cycle exercises[12], or as a consequence of the frequent call for eccentric-type actions[13,14].

The displacements are not linear, and they present changes of direction, turns and speed, with special coordinative and neuromuscular patterns[15]. Continuous slowing-down and direction changing actions can lead to fatigue. In recent years, there have been hypotheses regarding a type of fatigue related to the demand for these kinds of eccentric actions, and the existence of a capacity to improve tolerance to this kind of tension in a specific way[16].

We must add that tennis has a high technical, tactical and psychological component, entailing the need to give preparation a complex focus that covers - on many occasions simultaneously - all performance factors. Within this focus, it is worth remembering that a large part of the movements are made laterally or with a crossed step, and there are continuous acceleration and deceleration actions occurring in a complex way, more often than not at the same time as the hits and tactical decisions[17,18].

Intermittent training characteristics

Despite the importance of having suitable maximum oxygen consumption values and a high lactate threshold[19], for optimum recovery between points, training sessions and matches[20], some studies have not found a direct relationship between the capacity to perform repeated

sprints or specific explosive actions within intermittent sports and the maximum oxygen consumption, whilst they have found a relationship between explosive strength and jumping capacity[20,22]. A clear relationship has been observed between explosive strength levels with running efficiency and the ability to repeat high intensity actions[23,24]. In turn, the characteristics of the game require a manifestation of explosive and specific strength[25-27]. Therefore, improvements should be made to neuromuscular characteristics to increase the performance of a specific action, and also so that these actions can be repeated over a lengthy period[28]. The systems that provide aerobic and anaerobic improvements simultaneously achieve positive synergies with the manifestation of strength and speed, making them particularly important in preparing tennis players (Table 1).

Continuous training has occasionally revealed a negative effect on the appearance of explosive strength and speed, even when used concurrently with strength training[29]. Losses have also been observed in the capacity to apply strength and power after high-intensity interval training (HIIT), for example with work and recovery times of 4 minutes: 4 minutes[30]. However, the correct handling of the intensity and duration of the effort can significantly modify this effect[31].

In order to respect the tennis-specific characteristics, training systems must be used that intersperse work phases with high intensity and, sometimes, variable intensity, with other passive rest phases, which is what occurs during play, acting on the ATP and phosphocreatine regeneration processes. From a metabolic perspective, intermittent resistance training (IT) fulfils the requisites of interspersing work with

Table 1. Most relevant studies about intermittent training.

Reference	Sample (n)	Protocol	Contribution
Castagna *et al*. 2008[21]	16 basketball players	10x30 m sprint. 30 s of recovery.	No relationship was observed between VO_{2max} and sprint repetitions.
Stojanovic *et al*. 2012[22]	24 basketball players	10x30 m. Measurement of performance loss	No relationship was observed between VO_{2ma}x and sprint repetitions. Relationship found with CMJ.
Denadai *et al.* 2017[24]	Review	16 studies on concurrent and resistance training	Positive relationship between explosive strength training and the ability to repeat sprints.
Mikkola *et al.* 2012[2]	36 untrained males (16 strength, 11 resistance, 11 concurrent)	21 weeks Strength, resistance and concurrent training	Negative effect of the continuous and concurrent training on explosive strength.
Wilson *et al.* 2012[30]	Review	21 studies on concurrent and resistance training	The mode, volume, intensity and work-recovery relationship modify explosive strength.
Dupont *et al*. 2004[31]	22 football players	10 weeks 12-15x15 s 15 s recovery 12-15x40 m 30 s recovery	Micro-intervals of recovery improve intensity, speed and resistance.
Juel *et al*. 2004[32]	6 subjects	7 weeks 15x1 min / 150% VO_{2max} They trained one leg with extensions compared to contralateral exercises	Avoids loss of speed, improving resistance and tolerance to acidity.
Belfry. 2010[33]	Different samples: 7 males 8 males 14 males	10 s high-intensity and 5 s low-intensity protocols	Increases the recruitment of type II fibres, improving their aerobic capacity.
Rozenek *et al.* 2007[34]	12 males	15:15-s / 100:50% VO_{2max} 30:30 s 30:15 s 60:15 s	Ratio 2:1 mixed work. Ratio 4:1 anaerobic work and rapid presence of fatigue.
Boutcher. 2011[35]	Review	Study on fat loss, physical fitness, resistance to insulin, and skeletal-muscle	Causes greater efficiency in the use of carbohydrates and an enhanced capacity to use fatty acids.
Gerber *et al*. 2014[36]	8 males	20 s / 150% VO_{2max}	Greater use of fatty acids. Higher post-effort expenditure.
Helgerud *et al.* 2007[37]	24 males	Long distance 70% VO_{2max} Continuous high intensity 15:15 s / al 90-95:70% 4:3 min / al 90-95:70%	Greater improvements in oxygen consumption than with continuous training with lower load volume.
Tabata *et al*. 1996[38]	7 males (continuous) 7 males (intermittent)	60 min / 70% VO_{2max} 7-8x20 s 170% VO_{2max} 10 s recovery	Intense stimulus of aerobic and anaerobic systems by training at high intensity and low volume. Intense stimulus of aerobic and anaerobic systems by training at high intensity and low volume.

recovery periods, with the option of adjusting these times to those frequently found in tennis and varying them in accordance with the training objectives.

Introducing rest periods enables greater work intensity and an effect on aerobic and anaerobic adaptations[31]. IT training sessions comprise work and recovery periods of ≤ 30 seconds, with a work-recovery ratio (W:R) that can be of 1:1, 1:1.5, 1:2, 1.5:1 or 2:1. Short, high-intensity intermittent work can limit or override losses in speed, particularly efficient in improving the buffer capacity of muscle acidity[32], whilst achieving similar or greater increases in the maximum oxygen consumption than with continuous work[37,40]. Intermittent effort protocols with very short periods of work and recovery increase the recruitment of type II fibres, acting on their aerobic capacity[33] whilst allowing for improved speed at the same time[31].

IT training has revealed important local and peripheral improvements; meaning major increases in the oxidative capacity and muscle performance[41]. Yet the ratio between work and recovery phases is also a decisive factor when it comes to causing different adaptations. In exercises with an intensity nearing maximum oxygen consumption, a mixed aerobic-anaerobic activation has been observed when the ratio is 2:1, compared to more anaerobic adaptations when this ratio is 4:1, with a quick onset of fatigue[34].

This kind of work allows for increased efficiency in the use of carbohydrates as an energy source, but also, in the past decade, it has been proven that IT and HIIT training can also increase the capacity to use fatty acids[42,35,36]. In addition there is a greater use of fats in these high-intensity exercises during the post-effort period[36].

Despite observations revealing kinetics in the faster oxygen consumption when explosive actions and sprints are carried out[43], a delay can take place in the first repetitions or intermittent exercises within a set, with an ascending trend reflected in the heart rate[44,45], which is why a precise design of the sets with adequate intermittent work-recovery periods should be established for the initial phases[46,47].

One of the advantages of interval training is the capacity to improve oxygen consumption with much lower work volumes. Helgerud *et al*. [37] indicate that high-intensity interval training such as intermittent training (15 seconds: 15 seconds) is more effective in increasing oxygen consumption than continuous training sessions, with a lower work volume.

A lower work volume would allow for less interference with determining qualities in performance, such as explosive strength and speed[48]. It is also particularly interesting to reduce the load volume, as tennis is a sport involving a high volume of technical and tactical work and a long and busy schedule of matches.

Therefore, applying the IT training sessions can have an intense effect on the metabolic systems in a mixed way, triggering important improvements to anaerobic and aerobic capacity[34] whilst preserving manifestations of strength and speed.

Intensity-specificity relationship

The possibility of performing more comprehensive work, with mixed resistance training encompassing speed and agility, with direction changes and turns, whilst also introducing technical, tactical and mental elements, is enormously beneficial in the quest to achieve high performance, though it is necessary to monitor the degree of intensity achieved with these kinds of session (Table 2).

Regarding the type of movement, turns and direction changes, these entail different neural and biomechanical behaviour, meaning that performance markers are specific[38]. Training sessions using linear sprints do not appear to have a clear relationship with improvements in movement in terms of agility and direction changes[49]. A positive relationship has been observed between explosive strength and performance in changing direction or turning, as well as in the ability to repeat these actions. At the same time, improvements have been made in explosive strength using intermittent training sessions with direction changes[50].

Various studies have observed greater intensity with higher lactate concentrations in short efforts when direction changes are included, as opposed to when they are not[51]. At the same time, the skill required to perform turns and direction changes at high speeds is decisive in tennis performance[49].

Specific team-sport and fighting-sport training sessions have revealed similar or superior intensities to running[52,56-59]. In a high-intensity HIIT-type training session (2 minute intervals of work with 90 second recovery times) revealed high intensities, similar to those seen in running, using tennis exercises[53]. Suárez Rodríguez and Del Valle[54] discovered higher heart and lactate rate values in tennis-specific exercises in both IT and HIIT sessions, compared to HIIT in running.

As with running actions, the increased volume of work – increasing the number and duration of explosive actions found in intermittent sports – reduces the anaerobic glycolytic participation, though on occasions, it is accompanied by an increase in the intervention of phosphagen metabolisms[60].

Resistance training sessions with specific and short efforts with recovery periods and motor actions pertaining to the game, can be a suitable way of improving maximum oxygen consumption without having a negative effect on game-decisive qualities, such as strength or speed in intermittent-type sports with a high technical component[56]. This will allow for an improvement in the ability to perform explosive actions whilst improving resistance[31,61,62]. This type of training session offers a good response to the concurrence of strength work with improvements in resistance and speed[63].

One strategy that could be particularly interesting, consists in performing technical and tactical work in a situation of fatigue, as this can be decisive in final performance[53,54].

With exercises using actions pertaining to the game, with continuous changes of pace, turns and direction, there is a much greater demand upon the muscle-tendon system, with an intense accumulation of mechanical work, which is why work loads should be controlled carefully[55].

One relevant factor when choosing training sessions that respect the specific motor structure of tennis is the correct execution and the effect of fatigue upon this. As well as the athlete's physical level, other factors such as the player's level of play, moment of the season, age or perception of effort should also be considered[64]. With regards to the

Table 2. Most important studies about the intensity-specificity relationship.

Reference	Sample (n)	Protocol	Contribution
Brughelli *et al*. 2008[49]	Review	Relationship between ability to change direction and strength training	Different behaviour in the movements with changes compared to linear movements.
Young *et al.* 2001[50]	36 males	6 weeks. Sprints over 20-40 m. 20-40 m with 3-5 direction changes	Linear training exercises did not reveal a relationship between improvements in agility movements and direction changes.
Lakomy, Haydon. 2004[51]	18 elite hockey players	6x40 m test Deceleration 6 m Recovery 30 s	Positive explosive strength and speed relationship with the capacity to decelerate and change direction and repeat. Improvements in explosive strength via IT with direction changes.
Dellal *et al.* 2010[52]	10 elite football players	30:30 s / 100% VO_{2max}. 15:15-s / 105-110-115%VO_{2max}. Straight line run Football exercises	Higher lactate concentrations when direction changes are introduced with football-specific actions.
Fernández-Fernández *et al*. 2011[53]	4 male tennis players 4 female tennis players	4x120 s. 90 s recovery. 95% maximum heart rate Run vs. tennis exercises	Similar intensities. Specific exercises can be used as an alternative to running. Interesting to sometimes work on the technical aspect of fatigue.
Suárez Rodríguez, del Valle. 2017[54]	13 competition-level tennis players	3x3x120 s. Recovery at 120-130 beats HIIT run HIIT forehand-backhand hits SIT forehand-backhand hits	Heart and lactate rates higher in tennis-specific exercises. Lower subjective perception of fatigue in specific efforts in terms of running exercises. Controlling intensity and loss of technical efficiency by recording hits and errors.
Hader *et al.* 2014[55]	11 team-sport players	2x10x22 m 2x10x16.5 m with two 90º changes	Working with direction changes entails intense mechanical load.

subjective assessment of fatigue using the Borg Scale, a lower perception has been observed in tennis-specific exercises compared to running work using equal or lower heart rate intensity[54].

Controlling the number of hits made, evolution during the exercise and maintenance of the motor efficiency registering the precision or number or errors made, could be a good strategy for keeping the training session suitable[54]. Fatigue will cause a progressive loss of control over technical motion and hitting quality[65], which is why specific training sessions should keep particular control over the magnitude of the load. Controlling volume and intensity, as well as choosing a suitable relationship between the work and recovery micro-intervals, will ensure optimum technical execution throughout the different sets.

Recovery training

In sports in which the most important component of resistance is the capacity to repeat high-intensity actions, recovery time between play is a useful time for the body to recompose its metabolic and neuromuscular balance, or at least part of it[60]. A good post-effort response, with a quick lowering of the heart rate, is the sign of a good adaption to specific effort, which is why suitable training targeting the specific dynamics of each sport is decisive[66]. In SIT training, type II fibres are activated and players' levels of explosive strength remain at more optimum levels, with a clear relationship shown between the capacity to generate high levels of strength and the capacity to recover between high-intensity sets (Table 3).

Intense 15-second exercises generate post-effort heart rate increments[70]. Paradoxical behaviour has been observed among tennis players with post-effort elevations in heart rate when SIT training sessions are performed compared to immediate and rapid rates in running HIIT training sessions, and the immediate but slow rates in specific HIIT training, which would reiterate the importance of specificity in terms of the dynamics of work and recovery times, as well as the motor actions specific to the game[46].

The greater activation of type II fibres produces a superior effect over the activation of the sympathetic nervous system and deactivation of the parasympathetic system[67]. This can explain the slower heart rate recovery in intermittent-type efforts and with technical actions that involve acceleration, deceleration and turns and changes of direction[68,46].

The improvement in the oxidative capacity of the muscle with the increase of oxidative enzymes, mitochondrial capacity and myoglobin concentration is, without doubt, a factor that facilitates recovery between sets. The oxygen present in the muscle fibre plays an important role in ATP resynthesis processes between points[69]. Moreover, the capacity to clear lactate and tolerate muscle acidity, as well as the resynthesis of phosphocreatine, are decisive factors in the capacity to recover from a high-intensity action and to repeat it many times[3].

As we can see, the dynamics of recovery and the factors related to it will influence the capacity to recover between points, a decisive factor in performance. At the same time, the dynamic of interspersing appropriate work and recovery periods will have an efficient effect on the tennis-specific adaptive processes.

Table 3. Most outstanding recovery training studies.

Reference	Sample (n)	Protocol	Contribution
Suárez Rodríguez, 2015[46]	15 competition-level tennis players	1-3 exercises lasting 14 min: continuous running, rallies and points. 2- 3 split exercises 3x3x2 min: one running, one hitting, one intermittent hitting. Recovery at 120-130 beats/min.	Quicker heart rate recovery is observed in running efforts than in tennis-specific exercises. Post-effort elevated heart rate in intermittent exercises.
Buchheit *et al*. 2009[67]	20 team-sport players	30:15 s test vs. continuous test	Superior effect over sympathetic activation and the parasympathetic deactivation in specific intermittent efforts.
Kang *et al.* 2007[68]	24 males 24 females	4 protocols lasting 30 min: 1- Continuous at 75 W 2- Alternating 50-100 W every 5-min 3- Alternating 100-50 W 4- Alternating 25-125 W	Slower heart rate recovery in efforts when there are changes in intensity.
Girard, Millet. 2009[69]	Review	Neuromuscular fatigue in racket sports.	Oxygen in muscle fibre is important in the resynthesis of ATP between points in a tennis match.

Therefore, by using concurrent specific high-intensity and strength training sessions, major adaptations can be achieved in resistance, strength and speed. This complex training also produces improvements in players' technical and tactical capacities. However, we believe that the load intensity used should be carefully monitored so as to achieve effective physiological effects, and motor efficiency should be controlled with an assessment of the loss of precision and quality of execution[54].

Conclusions

- High-intensity intermittent training sessions reveal a clear relationship between the appearance of explosive strength and speed and the manifestation of resistance.
- In terms of high-intensity specific intermittent training sessions, intensities are reached that are the same or greater than those in running. Pace, turns and direction changes can lead to higher physical demand, with stronger stimuli.
- The intensity and relationship between work and recovery times are decisive factors in adjusting the load.
- The perception of fatigue is usually lower in specific-type efforts, with a lower ratio with the heart rate or lactic intensity.
- Different behaviour has been observed in recovery in specific and intermittent efforts, which is why it would be advisable to act on the recovery mechanisms using training with movements and displacements specific to the game, as well as specific work and recovery times.

Conflict of interests

The authors declare to have no conflict of interest whatsoever.

Bibliography

1. Hornery DJ, Farrow D, Mujika I, Young W. Fatigue in tennis. Mechanicisms of fatigue and effect on performance. *Sports Med*. 2007;37:199-212.
2. Glaister M. Multiple-sprint work: methodological, Physiological, and experimental issues. *Int J Sports Physiol Perform*. 2008;3:107-12.
3. Bishop D, Spencer M, Duffield R, Lawrence S. The validity of a repeated sprint ability test. *J Sci Med Sport*. 2002;4:19-29.
4. Fernández-Fernández J, Méndez-Villanueva A, Pluim BM. Intensity of tennis match play. *Br J Sports Med*. 2006;40:387-91.
5. O'Donoghue PO, Ingram B. A notational analysis of elite tennis strategy. *J Sports Sci*. 2001;19:107-15.
6. Kovacs MS. Applied physiology of tennis performance. *Br J Sports Med*. 2006;40:381-85.
7. Méndez-Villanueva A, Fernández-Fernández J, Bishop D. Exercise induced homeostatic perturbations provoked by singles tennis match play with reference to development of fatigue. *Br J Sports Med*. 2007;41:717-22.
8. Fernández-Fernández J, Sanz-Rivas D, Fernández-Garcí B, Méndez-Villanueva A. Match activity and physiological load during a clay-court tournament in elite female players. *J Sports Sci*. 2008;26:1589-95.
9. Kovacs MS. Energy system-specific training for tennis. *Strength Cond J*. 2004;26:10-3.
10. Morante JC, Brotherhood JR. Automatic and behaviouralthermoregulations in tennis. *Br J Sports Med*. 2008;42:679-85.
11. Girard O, Lattier G, Maffiuletti NA, Micallef J-P. Millet GP. Neuromuscular fatigue during a prolonged intermittent exercise: Application to tennis. *J Electromyography Kinesiol*. 2008;18:1038-46.
12. Strojnik V, Komi PV. Fatigue after submaximal intensive stretch-shortening cycle exercise. *Med Sci Sports Exerc*. 2000;32:1314-9.
13. Martin V, Guillaume YM, Lattier G, Perrod L. Why does knee extensor muscles torque decrease after eccentric-type exercise?.*J Sports Med Phy Fit*. 2005;45:143-51.
14. Verrall GM, Slavotinek JP, Barnes PG. The effect of sports specific training on reducing the incidence of hamstring injuries in professional Australian Rules football players. *Br J Sports Med*. 2005;39:363-68.
15. Lees A. Science and the major racket sports: a review. *J Sports Sci*. 2003;21:707-32.
16. Matthews MJ, Heron K, Todd S, Tomlinson A, Jones P, Delextrat A, *et al.* Strength and endurance training reduces the loss of eccentric hamstring torque observed after soccer specific fatigue. *PhysTher Sport*. 2017;25:39-46.
17. Kovacs M, Roetert P, Ellenbecker E. Fixing the brakes! Deceleration: the forgotten factor in tennis specific training. *ITF Coaching Sport Sci Rev*. 2008;15:6-8.
18. Kovacs M. Movement for Tennis: The Importance of Lateral Training. *Strength Con J*. 2009;31:77-85.
19. Rampinini E, Sassi A, Azzalin A, Castagna C, Menaspà P, Cromagno D, *et al.* Physiological determinants of Yo-Yo intermittent recovery tests in male soccer players. *Eur J Appl Physiol*. 2010;108:401-9.
20. Tomlin DL, Wenger HA. The relationship between aerobic fitness and recovery from high intensity intermittent exercise. *Sports Med*. 2001;31:1-11.
21. Castagna C, Abt G, Manzi V, Annino G, Padua E, D'Ottavio S. Effect of recovery mode on repeated sprint ability in young basketball players. *J Strength Cond Res*. 2008;22:923-9.

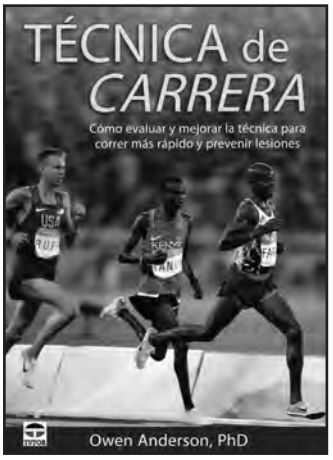
22. Stojanovic M, Ostojic SM, Calleja-González J, Milosevic Z, Mikic M. Correlation between explosive strength aerobic power and repeated sprint ability in elite basketball players. *J Sports Med Phys Fit.* 2012;52:375-81.
23. Hoff J, Helgerud J. Endurance and strength training for soccer players - Physiological considerations. *Sports Med.* 2004;34:165-80.
24. Denadai BS, de Aguiar RA, de Lima LC, Greco CC, Caputo F. Explosive training and heavy weight training are effective for improving running economy in endurance athletes: A systematic review and meta-analysis. *Sports Med.* 2017;47:545-54.
25. Elliott B. Biomechanics and tennis. *Br J Sports Med.* 2007;40:392-6.
26. Reid M, Crespo M, Lay B, Berry J. Skill acquisition in tennis: Current research and practice. *J Sci Med Sport.* 2007;10:1-10.
27. Reid M, Schneiker K. Strength and conditioning in tennis: Current research and practice. *J Sci Med Sport.* 2008;11:248-56.
28. Glaister M. Multiple sprint work. *Sports Med*. 2005;35:757–77.
29. Mikkola J, Rusko H, Izquierdo M, Gorostiaga EM, Häkkinen K. Neuromuscular and cardiovascular adaptations during concurrent strength and endurance training in untrained men. *Int J Sports Med.* 2012;33:702-10.
30. Wilson JM, Marín PJ, Rhea MR, Wilson SM, Loenneke JP, Anderson JC. Concurrent training: a meta-analysis examining interference of aerobic and resistance exercises. *J Strength Cond Res.* 2012;26:2293-307.
31. Dupont G, Akakpo K, Berthoin S. The effect of in-season, high-intensity interval training in soccer players. *J Strength Cond Res*. 2004;18:584-9.
32. Juel C, Klarskow C, Nielsen JJ, Kustrup P, Mohr M, Bangsbo J. Effect of high-intensity intermittent training on lactate and H+ release from human skeletal muscle. *Am J Physiol Endocrinol Metab.* 2004;286:245-51.
33. Belfry GR. Effects of a Short Work/Shorter Rest Intermittent Exercise on Muscle Metabolic Status, VO_2, Hemoglobin Saturation and Performance. Doctoral Thesis. Department of Exercise Science. University of Toronto. 2010. Disponible en: https://tspace.library.utoronto.ca/.../Belfry_Glen_R_201011_PhD
34. Rozenek R, Funato K, Kubo J, Hoshikawa M, Matsuo A. Physiological responses to interval training sessions at velocities associated with VO_2max *J Strength Cond Res*. 2007;21:188-92.
35. Boutcher SH. High-Intensity Intermittent Exercise and Fat Loss. *J Obesity*. Revista electrónica. 2011(consultado 0412/2017). Disponible en: https://www.hindawi.com/journals/jobe/2011/868305/
36. Gerber T, Borg ML, Hayes A, Stathis CG. High-intensity intermittent cycling increases purine loss compared with workload-matched continuous moderate intensity cycling. European *J Appl Physiol.* 2014;114:1513-20.
37. Helgerud J, Hoydal K, Wang E, Karlsen T, Berg P, Bjerkaas M, *et al.* Aerobic high-intensity intervals improve VO_2max more than moderate training. *Med Sci Sports Exerc.* 2007;39:665-71.
38. Tabata I, Nishimura K, Kouzaki M, Hirai Y, Ogita F, Miyachi M, *et al.* Effects of moderate-intensity endurance and high-intensity intermittent training on anaerobic capacity and VO_2max. *Med Sci Sports Exerc.* 1996;28:1327-30.
39. Mueller SM, Aguayo D, Zuercher M, Fleischmann O, Boutellier U, Auer M, *et al.* High-Intensity Interval Training with Vibration as Rest Intervals Attenuates Fiber Atrophy and Prevents Decreases in Anaerobic Performance. *PlosOne*. 2015; 10: e0116764.
40. Wisloff U, Ellingsen O, Kemi OJ. High-intensity interval training to maximize cardiac benefits of exercise training? *Exerc Sport Sci Rev.* 2009;37:139-46.
41. Krustrup P, Hellsten, Y, Bangsbo J. Intense interval training enhances human skeletal muscle oxygen uptake in the initial phase of dynamic exercise at high but not at low intensities. *J Physiol*. 2004;559: 335-45.
42. Perry CGR, Heigenhauser GJF, Bonen A, Spriet LL. High-intensity aerobic interval training increases fat and carbohydrate metabolic capacities in human skeletal muscle. *App Physiol Nut Met.* 2008;33:1112-23.
43. Tordi N, Perry S, Harvey A, Hughson R. Oxygen uptake kinetics during two bouts of heavy cycling separated by fatiguing sprint exercise in humans. *J. Appl Physiol.* 2003;94:533-41.
44. Tuimil JL, Iglesias E, Dopico J, Morenilla L. Efectos del entrenamiento continuo e interválico de carga externa similar sobre la frecuencia cardiaca. *Motricidad Eur J Human Mov.* 2005;12:107-18.
45. Seiler S, Hetlelid KJ. The impact of rest duration on work intensity and RPE during interval training. *Med Sci Sports Exerc.* 2005;37:1601-7.
46. Bailey SJ, Romer LM, Kelly J, Wilkerson DP, DiMenna FJ, Jones AM. Inspiratory muscle training enhances pulmonary O(2) uptake kinetics and high-intensity exercise tolerance in humans. *J Appl Physiol.* 2010;109:457-68.
47. Suárez Rodríguez D. Entrenamiento de la Resistencia en el tenis. Tesis Doctoral. Universidad de Oviedo. 2015. Disponible en: http://hdl.handle.net/10651/36701
48. Jones TW, Howatson G, Russell M, French DN. Performance and neuromuscular adaptations following differing ratios of concurrent strength and endurance training. *J Strength Cond Res.* 2013;27:3342-51.
49. Brughelli M, Cronin J, Levin G, Chaouachi A. Understanding Change of Direction Ability in Sport: A Review of Resistance Training Studies. *Sports Med*. 2008;38;1045-63.
50. Young WB, McDowell MH, Scarlett BJ. Specificity of sprint and agility training methods. *J Strength Cond Res.* 2001;15:315-9.
51. Lakomy J, Haydon DT. The effects of enforced, rapid deceleration on performance in a multiple sprint test. *J Strength Cond Res.* 2004;18:579-83.
52. Dellal A, Keller D, Carling Ch, Chaouachi A, Wong DelP, Chamari K. Physiologic effects of directional changes in intermittent exercise in soccer players. *J Strength Cond Res.* 2010;24:3219-26.
53. Fernandez-Fernandez J, Sanz-Rivas D, Sanchez-Muñoz C, de la Aleja Tellez JG, Buchheit M, Méndez-Villanueva A. Physiological responses to On Court *vs* running interval training in competitive tennis players. *J Sports Sci Med.* 2011;10:540-5.
54. Suárez Rodríguez D, del Valle Soto M. A study of intensity, fatigue and precision in two specific interval trainings in young tennis players: high-intensity interval training versus intermittent interval training. *BMJ Open Sport Exerc Med.* Revista elecrónica. 2017 (consultado 0412/2017). Disponible en: http://bmjopensem.bmj.com/content/3/1/e000250.info
55. Hader K, Mendez-Villanueva A, Ahmaidi S, Williams BK, Buchheit M. Changes of direction during high-intensity intermittent runs: neuromuscular and metabolic responses. *BMC Sports Sci Med Rehabil.* 2014;6:2.
56. McMillan K, Helgerud J, Macdonald R, Hoff J. Physiological adaptations to soccer specific endurance training in professional youth soccer players. *Br J Sports Med.* 2005;39:273-7.
57. Impellizzeri FM, Marcora SM, Castagna C, Reilly T, Sassi A, Iaia FM, *et al*. Physiological and Performance Effects of Generic versus Specific Aerobic Training in Soccer Players. *Int J Sports Med.* 2006;27:483-92.
58. Little Th, Williams AG. Measures of exercise intensity during soccer training drills with professional soccer players. *J Strength Cond Res.* 2007; 21:367-71.
59. Hill-Hass SV, Dawson B, Impellizzeri FM, Coutts AJ. Physiology of small-sided games training in football: a systematic review. *Sports Med.* 2011;41:199-220.
60. Spencer M., Bishop D, Dawson B, Goodman C. Physiological and metabolic responses of repeated-sprint activities: specific to field-based team sports. *Sports Med.* 2005;35:1025-44.
61. Bravo DF, Impellizzeri FM, Rampinini E, Castagna C, Bishop D, WisloffU. Sprint *vs*. Interval training in football. *Int J Sports Med*. 2008;29:668-74.
62. Dellal A, Varliette C, Owen A, Chirico EN, Pialoux V. Small-sided games *versus* interval training in amateur soccer players: effects on the aerobic capacity and the ability to perform intermittent exercises with changes of direction. *J Strength Cond Res.* 2012;26:2712-20.
63. Wong P-l, Chaouachi A, Chamari K, Dellal A, Wisloff U. Effect of preseason concurrent muscular strength and high-intensity interval training in professional soccer players. *J Strength Cond Res.* 2010;24:653-60.
64. Zafeiridis A, Sarivasiliou H, Dipla K, Vrabal IS. The effects of heavy continuous versus long and short intermittent aerobic exercise protocols on oxygen consumption, heart rate, and lactate responses in adolescents. *Eur J Appl Physiol.* 2010;110:17-26.
65. Vergauwen L, Spaepen AJ, Lefevre J, Hespel P. Evaluation of stroke performance in tennis. *Occup Health Ind Med.* 1998;39:238-9.
66. Haydar B, Haddad HA, Ahmaidi S, Buchheit M. Assesing inter-effort recovery and change of direction ability the 30-15 intermittent fitness test. *J Sports Sci Med.* 2011;10:346-54.
67. Buchheit M, Al Haddad H, Millet GP, Lepretre PM, Newton M, Ahmaidi S. Cardiorespiratory and cardiac autonomic responses to 30-15 intermittent fitnestes in team sports players. *J Strength Cond Res.* 2009;3:93-100.
68. Kang J, Mangine GT, Ratamess NA, Faigenbaum AD, Hoffman JR. Influence of intensity fluctuation on exercise metabolism. *Eur J Appl Physiol.* 2007;100:253-60.
69. Girard O, Miller GP. Neuromuscular fatigue in racquet sports. *Phys Med Rehabil.* 2009;20:161-73.
70. Hamar D, Komadel L, Tkac M, Kuthanova O. Cinética de los parámetros ventilatorios y de intercambio de gases durante el ejercicio intermitente. *Arch Med Deporte.* 1989;21:11-5.

MANUAL DE LA TÉCNICA DE LOS EJERCICOS PARA EL ENTRENAMIENTO DE LA FUERZA

Por: NSCA (National Strength and Conditioning Association)
Edita: Ediciones Tutor-Editorial El Drac.
Impresores 20. P.E. Prado del Espino. 28660 Boadilla del Monte. Madrid.
Telf. 915 599 832 - Fax: 915 410 235
E-mail: info@edicionestutor.com Web: www.edicionestutor.com
Madrid 2018, 288 páginas, P.V.P: 49,95 euros

Desarrollado por la NSCA, este manual es un recurso práctico, tanto para los que aspiran a ser profesionales de la fuerza y el acondicionamiento y entrenadores personales, como para los que ya ejercen como tales. Con inigualables demostraciones visuales de una serie de ejercicios con pesos libres o máquinas, este libro es una valiosa herramienta para quienes preparan sus certificaciones por la NSCA y un recurso excelente para los que diseñan programas para deportistas y clientes de cualquier edad y nivel de forma física.

En el libro se describe, paso a paso y con fotografías en color, la técnica adecuada de 54 ejercicios con peso libre y 16 con máquina, para todos los grupos musculares, e incluye: un vídeo online demostrativo de cada ejercicio de entrenamiento de fuerza; la identificación de los músculos implicados y el agarre correcto, así como la postura y el rango de movimiento de cada ejercicio; la descripción de las acciones articulares, sugerencias sobre la participación de ayudantes y consejos para prevenir lesiones; y una sección especial sobre modalidades de trabajo e implementos no tradicionales, entre ellos las *kettlebells*.



TÉCNICA DE CARRERA

Por: Owen Anderson
Edita: Ediciones Tutor-Editorial El Drac.
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Telf. 915 599 832 - Fax: 915 410 235
E-mail: info@edicionestutor.com Web: www.edicionestutor.com
Madrid 2018, 240 páginas, P.V.P: 19,95 euros

Para muchos corredores, la técnica de carrera es algo en lo que no piensan hasta que una lesión o un estancamiento en su progresión les impide alcanzar sus objetivos. Este libro recalca la importancia de la técnica correcta y enseña a mejorar el rendimiento y prevenir el riesgo de lesión. El autor describe los problemas más comunes de los corredores: frenan a cada paso que dan, adoptan posturas ineficaces o se arriesgan a sufrir lesiones por su excesivo impacto contra el suelo.

A continuación, detalla los componentes de la técnica correcta: apoyo del pie, ángulo de la tibia y el muslo, tiempo de apoyo, cadencia, inclinación del cuerpo y postura; para ayudar al lector a entender dónde puede hacer pequeños cambios que logren mejoras significativas. Además, con la ayuda de una cámara de vídeo básica o un teléfono móvil, se puede analizar la propia técnica y poner en práctica entrenamientos y ejercicios específicos para corregir posibles deficiencias.

MI ENTRENADOR DE MUSCULACIÓN

Por: David Costa
Edita: Ediciones Tutor-Editorial El Drac.
Impresores 20. P.E. Prado del Espino. 28660 Boadilla del Monte. Madrid.
Telf. 915 599 832 - Fax: 915 410 235
E-mail: info@edicionestutor.com Web: www.edicionestutor.com
Madrid 2018, 288 páginas, P.V.P: 29,95 euros

El autor de la presente obra, entrenador en contacto permanente con practicantes de musculación de todos los niveles, debe hacer frente a diario a numerosas preguntas sobre el entrenamiento, los estiramientos, el cardio, la pérdida de grasa, el aumento de masa, la alimentación y los suplementos nutricionales. Con un enfoque práctico y su gran experiencia, David Costa responde a más de 160 preguntas basándose en los estudios científicos más recientes. Así, podrá el lector aumentar su fuerza y musculatura, y perderá grasa más rápidamente. Tendrá acceso a numerosos consejos prácticos para progresar respetando su cuerpo.

La obra muestra una presentación inédita de más de 90 ejercicios ilustrados y descritos con gran detalle. Se podrá corregir y mejorar la técnica gracias a instrucciones simples, y comprender los posibles errores de posicionamiento. Así mismo, multiplicar las sensaciones durante los movimientos y descubrir referencias precisas para reclutar los músculos con precisión y eficacia.

2019		
I Congreso Internacional de Ciencias de la Actividad Física y el Deporte, "Retos actuales y futuros de la Actividad Física y el Deporte"	24-26 Enero Torrent (Valencia)	web: https://www.ucv.es/
BKAM 2019: Barcelona associated Knee Meeting	6-9 Febrero Barcelona	web: www.bkam.info
9th Annual Sports Medicine Winter Summit	6-10 Marzo Park City, Utah (EEUU)	web: https://www.cmxtravel.com/conferences/sports-medicine-summit-2/
XVI Congreso Nacional de Psicología de la Act. Física y del Deporte	13-16 Marzo Zaragoza	web: www.psicologiadeporte.org
7th International Conference & Exhibition on Physiotheraphy & Physical Rehabilitation	25-26 Marzo Roma (Italia)	web: https://physiotherapy.annualcongress.com/
8th World Congress on Physical Medicine and Rehabilitation	25-26 Marzo Sidney (Australia)	web: https://rehabilitation.conferenceseries.com/
XXXVI Congresso FMSI: "Biological age, chronological age"	27-29 Marzo Roma (Italia)	web: www.fmsi.it/
XVII Congreso de la Asociación Argentina de Traumatología del Deporte	11-12 Abril Buenos Aires (Argentina)	web: http://aatd.org.ar/
2019 AMSSM Annual Meeting	12-17 Abril Houston (EEUU)	web: https://www.amssm.org/
40 Years of Comparative Sport and Physical Education	22-24 Abril Maia-Porto (Portugal)	web: http://iscpes.pt/portal/
XIII Congreso de SETRADE	25-26 Abril Palma de Mallorca	E-mail: sanicongress@setrade.org web: http://www.setrade.org/
XXVIII Isokinetic Medical Group Conference: "Football Medicine meets the universe of sport"	27-29 Abril Londres (Reino Unido)	web: http://www.footballmedicinestrategies.com/en/2019-wembley/3988/482/
The International Conference on Sport, Education & Psychology	2-3 Mayo Bucarest (Rumanía)	web: www.futureacademy.org.uk
International Conference on Medicine and Science in Athletics	3-5 Mayo Doha (Qatar)	web: www.aspetar.com
1er Congreso Internacional de Podología Deportiva	10-11 Mayo Plasencia (Cáceres)	web: www.sepod.es
3rd International Conference Sport, Recreation, Health	10-11 Mayo Belgrado (Serbia)	E-mail: conference@vss.edu.rs
12th Biennial ISAKOS	12-16 Mayo Cancún (México)	web: www.isakos.com
22nd International Symposium on Adapted Physical Activity (ISAPA)	14-18 Junio Charlottesville (EE.UU.)	web: http://isapa2019.org

2019 AIESEP International Conference	19-22 Junio Nueva York (EE.UU.)	web: https://aiesep2019.adelphi.edu
XL Juegos Mundiales de la Medicina-International Sports Medicine Symposium	22-29 Junio Budva (Montenegro)	web: http://www.medigames.com
VIII Congreso Iberoamericano de Nutrición	3-5 Julio Pamplona	web: http://www.academianutricionydietetica.org/congreso.php?id=7#
24th Annual Congress of the European College of Sport Science	3-6 Julio Praga (Rep. Checa)	E-mail: office@sport-science.org
13th Congreso Mundial de la International Society of Physical and Rehabilitation Medicine	9-13 Julio Kobe (Japón)	web: http://www.isprm.org
2nd International Conference on Physical Education, Sports Medicine and Doping Studies	15-16 Julio Sídney (Australia)	web: https://sportsmedicine.conferenceseries.com/
15th European Congress of Sport nd Exercise Psychology	15-20 Julio Münster (Alemania)	web: https://www.fepsac2019.eu
9th VISTA Conference	4-7 Septiembre Amsterdam (Países Bajos)	web: www.paralympic.org/news/amsterdam-host-vista-2019
Congress on Healthy and Active Children	11-14 Septiembre Verona (Italia)	Web. http://i-mdrc.com/fourth-assembly/
14th International Congress of shoulder and elbow surgery (ICSES)	17-20 Septiembre Buenos Aires (Argentina)	web: www.icses2019.org
IX Congreso de la Sociedad Cubana de Medicina Física y Rehabilitación	1-4 Octubre La Habana (Cuba)	web: http://www.rehabilitacioncuba.com
11th European Congress on Sports Medicine	3-5 Octubre Portorose (Eslovenia)	web: http://www.efsma.eu
5th World Conference on Doping in Sport	5-7 Noviembre Katowice (Polonia)	web: http://www.wada-ama.org
26th Word Congress TAFISA	13-17 Noviembre Tokyo (Japón)	web: www.tafisa.org
10th Annual International Conference: Physical Education Sport & Health	23-24 Noviembre Pitesti (Rumanía)	web: http://sportconference.ro/
2020		
14th ISPRM World Congress – ISPRM 2020	4-9 Marzo Orlando (EE.UU.)	web: http://www.isprm.org/congress/14th-isprm-world-congress
IOC World Conference Prevention of Injury & Illness in Sport	12-14 Marzo Mónaco (Principado de Mónaco)	web: http://ioc-preventionconference.org/
25th Annual Congress of the European College of Sport Science	1-4 Julio Sevilla	E-mail: office@sport-science.org

International Congress of Dietetics	15-18 Septiembre Cape Town (Sudáfrica)	web: http://www.icda2020.com/
XXXVI Congreso Mundial de Medicina del Deporte	24-27 Septiembre Atenas (Grecia)	web: www.globalevents.gr
26th TAFISA World Congress	13-17 Noviembre Tokyo (Japón)	web: www.icsspe.org/sites/default/files/e9_TAFISA%20World%20Congress%202019_Flyer.pdf
2021		
26th Annual Congress of the European College of Sport Science	7-10 Julio Glasgow (Reino Unido)	E-mail: office@sport-science.org
22nd International Congress of Nutrition (ICN)	14-19 Septiembre Tokyo (Japón)	web: http://icn2021.org/
European Federation of Sports Medicine Associations (EFSMA) Conference 2021	28-30 Octubre Budapest (Hungría)	web: http://efsma.eu/
Congreso Mundial de Psicología del Deporte	Taipei (Taiwan)	
Congreso Mundial de Podología	Barcelona	web: https://cgcop.es/newweb/eventos/
2022		
XXXVII Congreso Mundial de Medicina del Deporte FIMS	Guadalajara (México)	web: www.femmede.com.mx

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Curso "ALIMENTACIÓN, NUTRICIÓN E HIDRATACIÓN EN EL DEPORTE"

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

Curso "ALIMENTACIÓN Y NUTRICIÓN EN EL DEPORTE"

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

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

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Curso dirigido a 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.

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1. Clegg DO, Reda DJ et al. Glucosamine, chondroitin sulfate, and the two in combination for painful knee osteoarthritis. N Engl J Med. 2006 Feb 23;354(8):795-808. 2. Márcia Uchôa de Rezende, Riccardo Gomes Gobbi. Drug therapy in knee osteoarthrosis. Rev Bras Ortop. 2009;44(1):14-9. 3. André Kahan, Daniel Uebelhart, et al. Long-Term Effects of Chondroitins 4 and 6 Sulfate on Knee Osteoarthritis. Arthritis Rheum. 2009 Feb;60(2):524-33. doi: 10.1002/art.24255. 4. B. Zegels, P. Crozes, et al. Equivalence of a singledose (1200mg) compared to a three time a day dose (400mg) of chondroitin 4&6 sulfate in patients with kneeosteoarthritis. Results of a randomized double blind placebo controlled study. OsteoarthritisCartilage.2013-Jan;21(1):22-7. 5. Mariko Oe, Toshiyuki Tashiro, et al. Oral hyaluronan relieves knee pain: a review. Oe et al. Nutrition Journal (2016) 15:11. 6. OVOMET egg membrane for the treatment of knee and hip associated joint pain and stiffness in Runners. Eggnovo. January 2015. 7. OVOMET egg membrane for the treatment of knee, hip and upper extremity associated joint pain and stiffness in CrossFit practitioners. Eggnovo. January 2015. 8. OVOMET egg membrane for the treatment of knee and hip associated joint pain and stiffness. A human efficacy pilot study. Eggnovo. January 2015. 9. Eudald Toralles. The efficacy in osteoarthritic dogs. Sentmenat Veterinary Clinic. March 2016. Eggnovo